

Investigating the Relationship between Cognitions, Pacing Strategies and Performance in 16.1 km Cycling Time Trials Using a Think Aloud Protocol.

Authors and affiliations

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4 **1 Investigating the Relationship between Cognitions, Pacing Strategies and Performance in 16.1**
5 **2 km Cycling Time Trials Using a Think Aloud Protocol.**

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8 **4 Abstract**

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10 **5 Objectives** Three studies involved the investigation of concurrent cognitive processes and pacing
11 behaviour during a 16.1km cycling time trial (TT) using a novel Think Aloud (TA) protocol. Study 1
12 examined trained cyclist's cognitions over time whilst performing a real-life 16.1km time trial (TT),
13 using TA protocol. Study 2, included both trained and untrained participants who performed a 16.1 km
14 TT in a laboratory whilst using TA. Study 3 investigated participants' experiences of using TA during
15 a TT performance.

16
17 **11 Method:** Study 1 involved 10 trained cyclists performing a real life 16.1km TT. Study 2 included 10
18 trained and 10 untrained participants who performed a laboratory-based 16.1km TT. In both studies, all
19 participants were asked to TA. Time, power output, speed and heart rate were measured. Verbalisations
20 were coded into the following themes (i) internal sensory monitoring, (ii) active self-regulation, (iii)
21 outward monitoring (iv) distraction. Cognitions and pacing strategies were compared between groups
22 and across the duration of the TT. In study 3 all participants were interviewed post TT to explore
23 perceptions of using TA.

24
25 **18 Results:** Study 1 and 2 found cognitions and pacing changed throughout the TT. Active self-regulation
26 was verbalised most frequently. Differences were found between laboratory and field verbalisations and
27 trained and untrained participants. Study 3 provided support for the use of TA in endurance research.
28 Recommendations were provided for future application.

29
30 **22 Conclusion:** Through the use of TA this study has been able to contribute to the pacing and cycling
31 literature and to the understanding of endurance athletes' cognitions.

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33 **24 Key words:**

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35 Pacing, Cognition, Think Aloud, Cycling, Endurance, Decision Making.
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63 **Introduction**
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65 27 Pacing strategies during endurance performance, and particularly within cycling exercise, has
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67 28 become an increasingly popular area of study within the last decade. It is widely acknowledged that
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69 29 setting an optimal pacing strategy is crucial in determining the success or failure of a performance
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71 30 (Hettinga, De Koning & Hulleman, 2012). Pacing is defined as the regulation of effort during exercise
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73 31 that aims to manage neuromuscular fatigue (Edwards & Polman, 2012). It prevents excessive
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75 32 physiological harm and maximizes goal achievement (Edwards & Polman, 2012). Strategic decisions
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77 33 must be made to select a work-rate that will result in an optimal performance outcome (Renfree, Martin
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79 34 & Micklewright, 2014). The aim of pacing research is to determine the relative importance of internal
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81 35 and external factors in explaining how pacing decisions are made and how performance can ultimately
82
83 36 be improved. However, research efforts to-date have provided limited insight into the temporal
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85 37 characteristics of how endurance athletes engage in specific cognitive strategies which underpin these
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87 38 decisions.

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89 39 Decisions to increase, decrease or maintain pace are made continuously throughout an exercise
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91 40 bout and are a dynamic and complex cognitive process that is yet to be fully understood. It has been
92
93 41 acknowledged that athlete cognitions have an important influence on effort, physiological outcomes
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95 42 and accordingly, endurance performance (Brick, MacIntyre & Campbell, 2016). Recent research has
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97 43 applied decision-making and metacognitive theories to this pacing field to provide a framework by
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99 44 which these cognitive processes can be explored (see Brick et al., 2016; Renfree et al., 2014; Smits,
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101 45 Pepping & Hettinga, 2014). Research has supported the influence of previous experience
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103 46 (Micklewright, Papadopoulou, Swart & Noakes, 2010), competitor influence (Corbett, Barwood,
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105 47 Ouzounoglou, Thelwell, & Dicks, 2012; Williams, Jones, & Sparks, et al., 2015) and performance
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107 48 feedback (Jones, Williams & Marchant, et al., 2016; Smits, Polman & Otten, Pepping & Hettinga, 2016;
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109 49 Mauger, Jones & Williams, 2009b) on pacing decisions and provided further mechanistic support of
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111 50 constructs such as perceived exertion (Marcora & Staiano, 2010) and affect (Jones, Williams &
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113 51 Marchant, et al., 2014; Renfree et al., 2014). However, intermittent measures of such constructs do not
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115 52 provide the sensitivity of measurement to identify the continuous changes in cognition that occur during
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117 53 a competitive endurance task. Recently, more focus has been directed towards examining decision-

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123 54 making and athletes' thought processes during endurance events (Renfree, et al., 2014; Renfree, Crivoi
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125 55 do Carmo & Martin, 2015). Methods for collecting this cognitive data seem to be mainly retrospective
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127 56 in nature, for example, via the use of video footage to assist with the recall of cognitive information
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129 57 (Baker, Côté, & Deakin, 2005; Morgan & Pollock, 1977), or post trial interviews to highlight key
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131 58 thought processes during an event (Brick, et al., 2015; Williams et al., 2016). Nevertheless, such
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133 59 methodology has significant limitations given that retrospective recall is associated with memory decay
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135 60 bias and added meaning (Whitehead, Taylor & Polman, 2015).

137 61 Think Aloud (TA) protocol analysis (Ericsson & Simon, 1993; 1980) has been used in the last
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139 62 decade to collect cognitive thought processes in sports such as golf (Calmeiro & Tenenbaum, 2011;
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141 63 Whitehead, Taylor & Polman, 2016b), trap shooting, (Calmeiro, Tenenbaum & Eccles, 2014) and tennis
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143 64 (McPherson & Kernodle, 2007). However, this method has mainly been utilised in studies investigating
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145 65 expertise (Whitehead et al., 2015), and has seldom been used in endurance sports. TA requires
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147 66 participants to actively engage in the process of verbalising their thoughts throughout the duration of a
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149 67 task (Ericsson & Simon, 1993). Ericsson and Simon (1993; 1980) identified three distinct levels of
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151 68 verbalisation, with each being representative of the amount of cognitive processing required. Level one
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153 69 verbalisation requires vocalisation of task relevant thoughts only. Level two verbalisation requires
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155 70 participants to recode visual stimuli, not regularly verbalised, prior to providing verbalisation on the
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157 71 task. Verbalisations should reflect stimuli affecting the focus of the participant through the task, for
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159 72 example, a participant providing vocalisation of stimuli within a task including sight, sound and smell.
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161 73 Eccles (2012) indicated that level one and level two verbalisations are a result of conscious thought
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163 74 processing in short-term memory (STM) during the execution of a task, providing concurrent
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165 75 verbalisation during or immediately after a task has been completed. Verbalisations occur most often
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167 76 in environments where participants are provided with undirected probes' to think aloud naturally during
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169 77 the execution of a task (Ericsson & Simon, 1980). Lastly, level three verbalisation requires participants
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171 78 to provide explanation, justification and reasoning for cognitive thoughts throughout the task.

172 79 What appears to be the earliest research using TA in an endurance setting was conducted by
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174 80 Schomer (1986). Schomer and colleagues (Schomer & Connolly, 2002; Schomer, 1987; 1986) have
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176 81 previously used what was described as 'on-the-spot' data recording to collect mental strategy
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183 82 recordings. Using cassette recorders, mental strategies adopted by differing levels of marathon runners
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185 83 were investigated (Schomer, 1986). Within this study, findings revealed a relationship between
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187 84 associative mental strategy and perception of effort. Further research also identified gender differences
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189 85 in these cognitive strategies employed during marathon running, using an early version of TA (Schomer
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191 86 & Connolly, 2002). Although it was argued that there are limitations with the use of retrospective
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193 87 reports within this type of research, very little research has since employed an in-event method such as
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195 88 TA. More recently, having acknowledged mechanistic limitations of endurance performance research,
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197 89 Samson, Simpson, Kamphoff & Langlier (2015) used TA to capture real-time cognitions in long-
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199 90 distance running. Verbalisations were grouped under three primary themes; Pain and Discomfort, Pace
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201 91 and Distance, and Environment, with Pace and Distance emerging as the dominant theme. These authors
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203 92 concluded that the use of TA can provide a greater understanding of thought processes during an
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205 93 endurance activity. Although this study was novel in its application of a TA protocol in endurance
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207 94 performance and authors were able to identify key internal and external factors that influence during-
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209 95 event cognitions, it is unknown how these cognitions may change over the duration of an exercise bout.
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211 96 Whitehead et al. (2017) recently extended this research by using TA to monitor the cognitions of cyclists
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213 97 over a 16.1 km time trial (TT) and demonstrated that cyclists process and attend to different information
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215 98 throughout the TT. Specifically, thoughts relating to fatigue and pain were verbalised more during the
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217 99 initial quartiles of the event. Conversely, thoughts relating to distance, speed and heart rate increased
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219 100 throughout the event and were verbalised most during the final quartile. However, neither of these
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221 101 previous studies collected any during-event performance data (e.g. heart rate, speed, time) and therefore,
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223 102 the relationship between cognitions and pacing behaviour could not be determined. Cona et al. (2015)
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225 103 state that whilst it is possible to observe expert performance, the cognitive processes contributing to
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227 104 performance are less clear. Therefore, exploring how cognitions relate to pacing decisions and
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229 105 performance is of interest in the study of performance enhancement.

230 106 Another perspective that has yet to be fully explored within the field of endurance performance
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232 107 and pace regulation is the expert-novice paradigm; how experts and novices attend to and process
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234 108 information during an event such as cycling. Expertise differences have been consistently demonstrated
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236 109 across learning and performance settings, supporting differences in attentional focus strategies

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243 110 (Castaneda & Gray, 2007), cognition (Arsal, Eccles & Ericsson, 2016; Baker et al., 2005; Whitehead et
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245 111 al., 2016b) and emotion regulation (Janelle, 2002). Evidence demonstrates how individuals in the later
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247 112 stages of development may centre their thoughts around external variables such as their environment
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249 113 and use procedural knowledge during performance, whereas novices focus on more technical, internal
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251 114 cognitions and use declarative knowledge (Whitehead et al., 2016b; Fitts & Posner, 1967). These
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253 115 findings however are specific to skill development within motor tasks as opposed to pacing strategy
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255 116 and regulation. Within the pacing literature, the majority of previous research has investigated pacing
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257 117 behaviours of expert performers solely using trained athletes (Mauger, Jones & Williams, 2009a;
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259 118 Micklewright et al., 2010). Furthermore, a direct comparison of cognitions and pacing behaviours
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261 119 between experts and novices has not been made in the pacing field to date.

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263 120 Baker et al. (2005) investigated the cognitive characteristics of triathletes and identified
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265 121 differences in cognitive verbalisations between expert/trained and novice/untrained athletes. Trained
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267 122 triathletes reported a greater emphasis and focus on performance and untrained participants' thoughts
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269 123 were more passive and re-active. However, this study used a retrospective approach to data collection
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271 124 by asking participants to verbalise how they felt during different points of a race when watching a video
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273 125 montage of video sequences from a world championship event to cue memories of similar events
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275 126 participants might have experienced. The retrospective nature of the study is a key limitation due to the
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277 127 risk of bias and whereby recall of information may not accurately represent the situation (Hassan, 2005).

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279 128 Although some researchers have argued that asking participants to TA may result in unreliable
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281 129 data and affect performance (Nisbett & Wilson, 1977), more recent research has tested this potential
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283 130 impact in sport and found this not to be the case (Whitehead et al., 2015). Furthermore, Fox, Ericsson
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285 131 and Best's (2011) meta-analysis of 94 studies using concurrent verbalisation methods reported an
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287 132 negligible effect of think aloud and supported the protocol as a legitimate method for capturing
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289 133 cognitive processes. There is also a paucity of research that has looked at individual's perceptions of
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291 134 using TA.

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293 135 In this article, we aimed to investigate the relationship between concurrent cognitive processes
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295 136 and pacing behaviour during cycling endurance performance using a novel TA protocol. Three separate
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297 137 studies are presented. In study 1, trained cyclists used TA whilst performing a real-life, outdoor 16.1

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303 138 km TT and changes in cognitions were assessed over time. In study 2, both trained and untrained
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305 139 participants performed a 16.1 km cycling TT in a laboratory whilst thinking aloud. Cognitions and
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307 140 pacing strategies were compared between groups and across the duration of the TT. Finally, study 3
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309 141 presents a qualitative analysis of the participants' experiences of using TA during a TT performance,
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311 142 via interviews conducted with the participants from study 1 and 2.
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315 144 **Study 1 – Investigating the relationship between cognitions, pacing strategies and performance**
316
317 145 **in a 16.1 km cycling time trial in the field.**

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319 146 To further develop previous Think Aloud pacing research (Samson et al., 2015; Whitehead et
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321 147 al., 2017) this study aimed to identify changes in trained cyclists' cognitions and pacing strategies within
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323 148 a real-life, competitive 16.1 km TT. Previous research has yet to account for performance changes
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325 149 (Whitehead et al., 2017) and therefore, this study aims to determine whether athletes' verbalisations are
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327 150 associated with physiological responses or performance parameters, such as speed, power output and
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329 151 heart rate. It was predicted that the nature of the cyclists' cognitions would change over the duration of
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331 152 the TT.

332 153 **Material and Methods**

333
334 154 *Participants*

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336 155 Seven male and three female cyclists (M age = 40.2 ± 6.6 years, M experience = 6.1 ± 2.7 years)
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338 156 were recruited from North Yorkshire cycling clubs. Participants were required to have 1) at least 12
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340 157 months of experience in competitive 16.1 km TT's at the time of the study, 2) two or more years of
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342 158 competitive cycling experience, and 3) to have prior experience of training and/or competing with a
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344 159 power meter. Institutional ethical approval was secured by the first author's institution and informed
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346 160 consent obtained from all participants prior to testing.

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348 161 *Materials*

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350 162 An Olympus Dictaphone was used to capture in-event thoughts that were verbalised throughout
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352 163 a 16.1 km competitive TT. The small microphone attached to the Dictaphone was fitted to the
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354 164 participants' collar to ensure clarity of sound. In order to minimise the awareness of the recording
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356 165 device, the wire was placed inside the shirt and connected to the recording device, which was placed in

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363 166 the back pocket of the cycling jersey. All participants fitted a GPS device (Garmin Edge 510) and power
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365 167 meter (Garmin Vector 2S Power Meter, Keo Pedals) to their bikes to continuously record speed, time,
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367 168 distance and power output throughout the TT. A heart rate monitor (Garmin Premium Heart Rate
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369 169 Monitor) also recorded heart rate data for each participant.
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371 170 *Procedure*

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373 171 Participation required the cyclists to perform a single 16.1 km cycling TT in an outdoor
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375 172 environment. The TT was organised by a conglomerate of cycling clubs under the jurisdiction of the
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377 173 Cycling Time Trials Association in England and official timers and marshals were present. All
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379 174 participants performed this TT on the same occasion, between 19:00 and 20:00, and in dry weather
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381 175 conditions with a temperature of approximately 20 degrees. The wind was approximately 14 km/h and
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383 176 the road surface was standard asphalt material.

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385 177 Prior to the day of the TT, participants were required to complete a video-based TA training
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387 178 exercise which was sent to all participants one week prior to the task. This included three different TA
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389 179 tasks to ensure that they could adequately engage in the TA protocol (Ericsson & Simon, 1993); (1) an
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391 180 alphabet exercise, (2) counting the number of dots on a page, and (3) verbal recall. Participants were
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393 181 asked to arrive at the TT location one hour before the start of the event to be briefed further using
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395 182 Ericsson and Kirk's (2001) adapted directions for giving TA verbal reports. This required participants
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397 183 to provide verbal reports during a warm-up task containing non-cycling problems (Eccles, 2012). As
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399 184 not to disrupt the cyclists' normal pre-race routines, they performed a self-selected warm up. Similarly,
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401 185 fluid and nutritional intake were not controlled. Dictaphones and power meters were fitted prior to the
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403 186 warm-up and checked again before the start of the TT, along with the participants' GPS device and
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405 187 heart rate monitor.

406 188 Once participants confirmed that they were fully comfortable with the task of thinking aloud,
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408 189 they were instructed to "please Think Aloud and try to say out loud anything that comes into your head
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410 190 throughout the trial". Stickers were also placed on visible areas of their bicycle, which stated "Please
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412 191 think aloud". Performance times were retrieved from official race records and power output, speed and
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414 192 heart rate data were retrieved from the participants' GPS devices. No technical or physical problems
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416 193 were reported to have occurred during the TT which may have affected performance.
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423 194 *Data Analyses*
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425 195 Think Aloud data were transcribed verbatim, analysed using both inductive and deductive
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427 196 content analysis and grouped into primary themes. Where deductive analysis was used, Brick et al.,
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429 197 (2014) metacognitive framework was adopted. Using this modified version of Brick et al's (2014)
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431 198 metacognitive framework, these themes were then allocated to one of four secondary themes: (i) Internal
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433 199 Sensory Monitoring, (ii) Active Self-Regulation, (iii) Outward Monitoring, (iv) Distraction (see Table
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435 200 1). The number of verbalisations were also grouped by distance quartile of the TT, for both the primary
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437 201 and secondary themes. In keeping with the majority of research in TA (e.g., Whitehead, et al., 2017;
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439 202 Aarsal, Eccles & Ericsson, 2016; Calmerio & Tenenbaum, 2011; Nicholls & Polman, 2008) a post-
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441 203 positivist epistemology informed this study. Consistent with this, inter-rater reliability was calculated
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443 204 to ensure rigour. This involved a second author coding a 10% sample of the transcripts using the
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445 205 framework provided (Table 1). This framework was used to guide the second authors coding process,
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447 206 as recommended by MacPhail, Khoza and Ablar (2016). An 86% agreement was found, following this
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449 207 a discussion regarding the following 14% difference was conducted and agreements were made.

450 208 All analyses were conducted using IBM SPSS Statistics 22 (SPSS Inc., Chicago, IL) and
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452 209 descriptive sample statistics for TA data are reported as frequency percentages. Two-tailed statistical
453
454 210 significance was accepted as $p < 0.05$ and effect sizes are reported using partial eta squared (η^2) and
455
456 211 Cohen's d values (δ). Where data was non-normally distributed, appropriate non-parametric inferential
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458 212 statistical tests were conducted. To explore within-trial differences in verbalisations, Friedman's
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460 213 repeated-measures tests were conducted for primary and secondary themes over distance quartile. Post
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462 214 hoc analysis using Wilcoxon Signed Rank tests was performed where significant distance quartile
463
464 215 effects were found. One-way repeated measures ANOVAs were conducted for speed, power output,
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466 216 heart rate and cadence data and Bonferroni adjusted post hoc analyses were performed where significant
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468 217 distance quartile effects were found.

470 218 **Results**

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472 219 *TA Data*
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474 220 On average, cyclists verbalised a total of 84.20 thoughts throughout the 16.1 km TT. The theme
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476 221 Active Self-Regulation was the most predominantly verbalised for the whole trial with 63% of the total
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483 222 number of verbalisations, followed by Distraction with 20% of the verbalisations (see Table 2).
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485 223 Within-group analyses were conducted to explore the differences in cognitions across distance
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487 224 quartile (see Table 3). A main effect for distance was found for the secondary theme Outward
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489 225 Monitoring ($\chi^2(3, n = 10) = 16.79, p = .001$) with post-hoc analysis identifying a significant large
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491 226 increase in verbalisations across the duration of the TT. There were significantly fewer verbalisations
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493 227 at quartile 1 (Mean Rank = 1.75) than at quartile 2 (Mean Rank = 2.40) ($Z = -2.75, p = .006, \delta = 1.24$)
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495 228 and at quartile 3 (Mean Rank = 2.40) ($Z = -2.72, p = .006, \delta = 2.05$). No significant effects were found
496
497 229 over quartile for the secondary themes Internal Sensory Monitoring, Active Self-Regulation, and
498
499 230 Distraction ($p > .05$).

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501 231 As evidenced in Table 3, significant effects were found over distance quartile for the primary
502
503 232 themes Maintaining Pace, Motivation, Technique, Distance and Competition. No significant effects
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505 233 were found over distance quartile for the primary themes Breathing, Pain and Discomfort, Thirst,
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507 234 Fatigue, Temperature, Heart Rate, Cadence, Speed, Increase Pace, Decrease Pace, Controlling
508
509 235 Emotions, Time and Course Reference ($p > .05$).

510 236 *Performance Data*

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512 237 Speed ($F(1.32) = 24.27, p < .001, \eta^2 = 0.73$), power output ($F(3) = 7.85, p = .001, \eta^2 = 0.47$)
513
514 238 and heart rate ($F(1.4) = 14.03, p = .004, \eta^2 = 0.70$) all significantly changed over distance quartile with
515
516 239 large effect sizes. Results from post hoc analyses are shown in Table 4. Cadence did not differ
517
518 240 significantly across the distance of the TT ($p = 0.17, \eta^2 = 0.18$) although the effect size was moderate.

520 241 **Discussion Study 1**

521
522 242 As expected the findings of this study demonstrate that trained cyclists' cognitions changed
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524 243 over time during an outdoor competitive 16.1 km TT. Cyclists' predominant thoughts related to the
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526 244 theme Active Self-Regulation (63%) followed by thoughts related to Distraction (20%). Internal
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528 245 Sensory Monitoring and Outward Monitoring thoughts were less common (8% and 9%, respectively)
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530 246 although Outward Monitoring verbalisations were found to change over time, with significantly fewer
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532 247 verbalisations in the first quartile.

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534 248 Cognitions were found to change over the duration of the TT, with significant differences over
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536 249 distance quartile for the primary themes Maintaining Pace, Motivation, Technique, Distance and

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250 Competition. There was a significant increase in the number of motivational thoughts over time, with
251 the greatest number of verbalisations recorded in the final quartile which also coincided with the trend
252 for an increase in power output, i.e. an end-spurt. The augmentation of work-rate in this final stage was
253 exerted despite athletes' perceptions of effort known to be at their highest at this stage of an event, as
254 previously demonstrated by a linear increase across exercise duration (Taylor & Smith, 2013). This
255 suggests that these motivational verbalisations may represent the cyclists' use of positive cognitive
256 strategies to cope with the increased effort perceptions whilst attempting to increase pace and optimise
257 performance (Brick et al., 2016). This extends recent findings demonstrating how motivational self-talk
258 can reduce perceptions of effort and improves endurance performance (Barwood, Corbett, Wagstaff,
259 McVeigh & Thelwell, 2015; Blanchfield, Hardy, De Morree, Staiano, & Marcora, 2014). As
260 metacognitive judgements are made throughout an exercise bout, an athlete may proactively deem their
261 current attentional focus as no longer appropriate in-line with goal attainment and the changing demands
262 of the task, for example the distance remaining or behaviour of a competitor (Brick et al., 2016; Bertollo,
263 di Fronso & Filho et al., 2015). Alternatively, this may also stem from a bottom-up process driven by
264 the increased perceptions of effort (Balagué, Hristovski & Garcia, et al., 2015) resulting in a greater
265 need for active cognitive control to optimise pace. Consequently, as proposed by Brick et al. (2016),
266 the data suggests a combination of reactive and proactive cognitive control becomes more evident as
267 athletes attempt to deal with increasing demands and maintain an optimal pacing strategy to achieve
268 goal attainment. Reflecting this, greater use of positive, motivational verbalisations was also associated
269 with a trend for an increase in power output in the final quartile of the TT, this suggests that this
270 proactive strategy was facilitative and supported an enhanced performance when physical and
271 perceptual demands were highest.

272 Outdoor, competitive exercise with more environmental stimuli, external influences (e.g.,
273 traffic, road conditions, gradient) and the presence of competitors incur more unexpected events than
274 respective indoor environments. Whilst participants in the current study verbalised more self-regulatory
275 thoughts relating to their performance during the initial quartile (i.e., Technique and Maintaining Pace),
276 unexpected events require athletes to adapt their cognitions in order to maintain positive affect and
277 prevent suboptimal performance (Brick et al., 2016). The changing patterns of verbalisations found

278 across the duration of the TT therefore support the cyclists' use of reactive cognitive control and the
279 importance of this metacognition (Brick et al., 2016). For example, Outward Monitoring thoughts,
280 relating to Competition and Distance, were verbalised more in the mid-late stages of the TT than in the
281 initial quartile. The increased number of distance verbalisations, as also demonstrated in a recent TA
282 study in cycling (Whitehead et al., 2017), may be indicative of the cyclists seeking information to
283 support the effective regulation of effort. Alongside the use of motivational strategies, this attentional
284 flexibility and reactive control supports the changing importance of performance-related information
285 and the athlete's need to actively seek new information to inform pacing decisions once their proactive
286 starting strategy is over.

287 This study uses a more novel approach (TA) to collect participant pacing data and cognitions
288 during an endurance event. With the addition of performance data, this research has been able to support
289 and extend previous research (Whitehead et al., 2017), by finding relationships between cognition and
290 performance (e.g. power output). It is important to acknowledge potential external variables that may
291 affect verbalisations, cognitions and performance during a real-life event in the comparison of these
292 findings to laboratory-based research. Therefore, it is important that in order to develop this research
293 further, evidence is also provided from a more contained environment, such as a laboratory.

294

295 **Study 2 – Investigating the relationship between cognitions, pacing strategies and performance**
296 **in 16.1 km cycling time trials with trained and untrained cyclists in the lab.**

297 To extend the work conducted within study 1 as well as previous research by Samson et al.
298 (2015) and Whitehead et al. (2017), this study aimed to 1) investigate the differences in cognitions
299 between trained and untrained cyclists during a 16.1 km TT in a laboratory setting, and 2) identify
300 changes in cognitions over time in relation to changes in pacing strategy (i.e. speed). It was predicted
301 that cognitions would differ between trained and untrained individuals and both groups' cognitions
302 would also change across the duration of the TT.

303 **Material and Methods**

304 *Participants*

305 Ten trained male cyclists (M age = 36.9 ± 7.0 years, M height = 179.2 ± 5.6 cm, M body mass

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663 306 = 76.9 ± 10.3 kg) and ten untrained, physically active males (M age = 32.3 ± 9.7 years, M height = 179.3
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665 307 ± 6.5 cm, M weight = 87.2 ± 14.2 kg) volunteered to participate in the study. In accordance with recent
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667 308 guidelines (De Pauw et al., 2013), trained participants were required to have a minimum of 2 years
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669 309 competitive cycling experience and a current training load of at least 5 hours and/or 60 km a week.
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671 310 Furthermore, trained participants were required to have a personal best time of sub 25 min in a 16.1 km
672
673 311 road TT within the last 3 years. Untrained participants were healthy and physically active but had no
674
675 312 prior experience in competitive cycling or TTs. Written informed consent was obtained prior to
676
677 313 participation and the study was approved by the first author's institutional research ethics committee.

678 314 *Materials*

680
681 315 Each participant performed one 16.1 km laboratory-based cycling TT on an
682
683 316 electromagnetically-braked cycle ergometer (CompuTrainer Pro™, RacerMate, Seattle, USA). Trained
684
685 317 cyclists rode on their own bicycles which were fitted to the CompuTrainer rig and the untrained group
686
687 318 performed the trial on the same, standard road bicycle with a 51-cm frame, adjusted for saddle and
688
689 319 handlebar position. The CompuTrainer was calibrated according to manufacturer's guidelines and rear
690
691 320 tyre pressures were inflated to 100 psi. A 240 cm x 200 cm screen was positioned in front of the
692
693 321 participants which displayed a flat, visual TT course and performance feedback (power output, speed,
694
695 322 time elapsed, distance covered and heart rate) was provided continuously throughout the trial. The
696
697 323 participants' speed profile was also represented by a simulated, dynamic avatar riding the TT course
698
699 324 using the ergometry software (RacerMate Software, Version 4.0.2, RacerMate).

700 325 As with study 1 an Olympus Dictaphone was used to capture in event thoughts that were
701
702 326 verbalised throughout. All participants were fitted with a Polar heart rate monitor (Polar Team System,
703
704 327 Polar Electro, Kempele, Finland) which recorded heart rate throughout the TT at a 5 s sampling rate.

706 328 *Procedure*

708 329 All participants were required to attend a single testing session and perform a self-paced 16.1
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710 330 km cycling TT in a laboratory-based environment. As with study 1 all participants were required to
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712 331 complete a video-based TA training exercise which was sent to all participants one week prior to the
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714 332 task and were given extra TA training exercises on arrival and prior to the testing session (see Study 1
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716 333 for details).

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334 Participants' height and body mass were recorded and each was fitted with the microphone and
335 Dictaphone before performing a 10-minute warm-up at 70% of their age-predicted maximal heart rate.
336 Participants were instructed to verbalise their thoughts throughout the warm-up for an additional
337 familiarisation of the TA protocol in the testing environment. As with study 1 participants were
338 instructed to "please Think Aloud and try to say out loud anything that comes into your head throughout
339 the trial". During the TT, researchers were positioned out of sight but if participants were silent for a
340 sustained period of 30 seconds, the researcher prompted them to resume TA. Two signs were also placed
341 either side of the projection screen as written reminders to TA. Water was consumed *ad libitum* and a
342 fan was positioned to the front-side of the bike. Participants were instructed to perform the TT in the
343 fastest time possible but no verbal encouragement was provided. A self-paced cool down was performed
344 upon completion of the trial.

345 *Data Analysis*

346 Think Aloud data were transcribed verbatim, analysed using deductive content analysis and
347 grouped into primary and secondary themes using a modified version of Brick et al. (2016)
348 metacognitive framework, as discussed in Study 1 (see Table 1). The same analysis strategy was
349 adopted in study 1 and a 90% agreement in coding was found between the two researchers. A 100%
350 agreement was achieved following discussions between the researchers. The number of verbalisations
351 were grouped by distance quartile of the TT for the primary and secondary themes for both the trained
352 and untrained groups and descriptive data is represented as frequency percentages and absolute counts
353 (Table 5). To explore between-group differences in the number of verbalisations for whole trial data,
354 Mann Whitney-U tests were used. To explore within-group differences over distance quartile,
355 Friedman's repeated-measures tests were conducted. In the event of significant differences, post hoc
356 analysis was conducted using Wilcoxon Signed Rank tests.

357 Speed, power output and heart rate data were analysed over distance quartile and as whole trial
358 averages. To normalise speed, quartile values are expressed as a percentage deviation from the
359 individual's average trial speed. Means and standard deviations (SD) are reported for power output,
360 speed and heart rate data and repeated-measures ANOVA's were used to explore within- and between-
361 group differences. Bonferroni adjusted post-hoc analyses were performed where significant main and

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783 362 interaction effects were found. Two-tailed statistical significance was accepted as $p < .05$ and effect
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785 363 sizes are reported using partial eta squared (η^2) and Cohen's d values (δ).
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787 364 **Results**

788 789 365 *Think Aloud Data*

791 366 The total number of verbalisations did not significantly differ between the trained ($M = 106.2$)
792
793 367 and untrained groups ($M = 123.2$) ($p = .44$). Internal associative verbalisations made up 80% of the
794
795 368 trained groups' overall thoughts with 62% relating to Active Self-Regulation thoughts and 18% to
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797 369 Internal Sensory Monitoring. The untrained group also predominantly verbalised Internal Associative
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799 370 thoughts, with 52% and 14% of verbalisations relating to Active Self-Regulation and Internal Sensory
800
801 371 Monitoring, respectively. The untrained group verbalised Outward Monitoring thoughts for 27% of the
802
803 372 trial whereas this was 17% of the trained groups' verbalisations. Distraction thoughts were the least
804
805 373 verbalised themes for both groups (see Table 5).

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807 374 A between-group comparison of the secondary themes verbalised identified that the untrained
808
809 375 group verbalised more Outward Monitoring thoughts than the trained group at quartile 1 (M Rank =
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811 376 13.40 and 7.60; $U = 21.50$, $p = .03$; $\delta = .99$) and quartile 2 (M Rank = 13.35 and 7.65; $U = 9.50$, $p =$
812
813 377 $.002$; $\delta = 1.87$). The untrained group also verbalised significantly more Distraction thoughts than the
814
815 378 trained group at quartile 2 (M Rank = 14.00 and 7.00; $U = 15.00$, $p = .002$; $\delta = 1.01$). All differences
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817 379 had a large effect size.

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819 380 Between-group comparisons of the primary themes analysed by whole trial found that the
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821 381 untrained group verbalised more time (M Rank = 14.40 and 6.60; $U = 11.00$, $p = .003$; $\delta = 1.56$),
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823 382 irrelevant (M Rank = 14.05 and 6.95; $U = 14.50$, $p = .005$; $\delta = 0.84$) and pain and discomfort (M Rank
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825 383 = 13.10 and 7.90; $U = 24.00$, $p = .047$; $\delta = 0.93$) thoughts. The trained group verbalised more thoughts
826
827 384 of power (M Rank = 13.50 and 7.50; $U = 20.00$, $p = .02$; $\delta = 0.96$) and cadence (M Rank = 13.40 and
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829 385 7.60; $U = 21.00$, $p = .02$; $\delta = 0.73$). No other significant differences in primary themes were found
830
831 386 between the trained and untrained groups. Significant between-group differences of primary themes
832
833 387 across distance quartile are presented in Table 6.

834 388 Within-group analyses were also conducted to explore the differences in cognitions across
835
836 389 distance for each group. For the trained group, a main effect for distance was found for the secondary
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841
842
843 390 theme Outward Monitoring ($\chi^2(3, n = 10) = 16.81, p = .001$) with post hoc analysis identifying a
844
845 391 significant increase in verbalisations across the duration of the TT. There were significantly more
846
847 392 verbalisations at quartile 3 (M Rank = 9.15) and 4 (M Rank = 8.65) than at quartile 1 (M Rank = 7.60)
848
849 393 ($Z = -2.27, p = .02, \delta = .98$ and $Z = -2.20, p = .03, \delta = 1.25$, respectively) and at quartile 2 (M Rank =
850
851 394 7.65) ($Z = -2.68, p = .007, \delta = 1.51$ and $Z = -2.67, p = .008, \delta = 1.83$ respectively). The untrained group
852
853 395 verbalised significantly more Distraction thoughts at quartile 1 (M Rank = 10.70) and quartile 2 (M
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855 396 Rank = 11.30) than at quartile 4 (M Rank = 10.10) ($Z = -2.04, p = .04, \delta = 0.68$ and $Z = -2.03, p = .04,$
856
857 397 $\delta = .55$, respectively). No significant differences were found across distance for the secondary themes
858
859 398 Internal Sensory Monitoring, Active Self-Regulation and Internal Dissociation for either group ($p >$
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861 399 $.05$).

862
863 400 Within-group analyses for primary themes identified significant distance main effects for
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865 401 Motivation and Distance for the trained group, and Motivation and CompuTrainer Scenery for the
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867 402 untrained group (see Table 7). Both groups verbalised significantly more thoughts relating to
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869 403 Motivation across the duration of the TT and the trained group also verbalised more about Distance.
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871 404 The untrained group verbalised fewer thoughts relating to the CompuTrainer Scenery across the TT
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873 405 distance. No other significant differences were found across distance for the primary themes in either
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875 406 group ($p > .05$).

876 407 *Pacing Data*

877 408 The trained group performed the TT in a significantly faster time than the untrained group (MD
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879 409 = 3.88 min, $t(10.4) = -3.68, p = .004, \delta = 1.64$) (see Table 8). As speed was analysed as a percentage of
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881 410 the trial average, a main effect for group was not applicable. No significant effects for quartile ($F(1.9,$
882
883 411 $18) = 2.72, p = .08, \eta^2 = 0.13$) or group x quartile ($F(1.9, 18) = 2.71, p = .08, \eta^2 = 0.13$) were found
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885 412 for speed (see Figure 1).

887 413 For power output, a significant main effect for group was found ($F(1, 18) = 27.09, p < .001,$
888
889 414 $\eta^2 = 0.60$), where the trained group's power output was significantly higher than the untrained (mean
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891 415 difference (MD) = 74.1, CI = 44.21, 104.05). A quartile main effect was also found ($F(1.6, 18) = 4.49,$
892
893 416 $p = .027, \eta^2 = 0.20$), with post-hoc analysis demonstrating that power output in quartile 4 was
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895 417 significantly higher than in quartile 3 (MD = -12.29, $p = .001, CI = -20.34, -4.84$). The quartile by group

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902
903 418 interaction was not statistically significant ($F(1.61, 18) = 1.81, p = .18, \eta^2 = 0.09$).

905 419 For heart rate, there were significant main effects for group ($F(1, 18) = 4.90, p = .04, \eta^2 =$
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907 420 0.22) and quartile ($F(1.9, 18) = 60.36, p < .001, \eta^2 = 0.78$). The trained group had a higher heart rate
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909 421 than the untrained group ($MD = 13.3, CI = .45, 25.67$) and heart rate was significantly different between
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911 422 each quartile ($p < .05$). There was no significant effect for the group x quartile interaction ($F(1.9, 18) =$
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913 423 $2.48, p = .10, \eta^2 = 0.13$).

915 424 **Discussion Study 2**

917 425 The main findings demonstrate that trained cyclists' cognitions differ from the cognitions of
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919 426 untrained cyclists, as demonstrated by differences in verbalisations recorded using a TA protocol.
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921 427 Despite no differences in the total number of verbalisations throughout the TT, the nature of the
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923 428 verbalisations was found to vary between the groups. On average, untrained participants verbalised
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925 429 significantly more Outward Monitoring thoughts (27% vs 17%) and Distraction thoughts (7% vs 3%)
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927 430 than the trained group. For the primary themes, the untrained group verbalised significantly more
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929 431 thoughts about Time, Irrelevant Information, and Pain and Discomfort than the trained group.
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931 432 Conversely, trained participants verbalised more about Power and Cadence than the untrained group.
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933 433 As expected, the trained group performed the TT in a significantly faster time although pacing strategies
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935 434 were not found to significantly differ between the groups, despite the appearance of their dissimilar
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937 435 distribution of speed.

938 436 The trained groups' thoughts were predominantly related to internal associative cues (Internal
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940 437 Sensory Monitoring and Active Self-Regulation) (80%) which is comparable to previous research in
941
942 438 endurance running which found that 88% of competitive runners' thoughts were focussed internally on
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944 439 the monitoring of bodily processes and task-related management strategies (Nietfeld, 2003).
945
946 440 Furthermore, Baker et al. (2005) also demonstrated that 86% of expert triathletes' thoughts related to
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948 441 active performance-related cues. The untrained groups' prevalence of 27% outward monitoring
949
950 442 verbalisations is also comparable to findings of a 28% share of external thoughts for recreational runners
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952 443 (Samson et al., 2015).

954 444 Over the duration of the trial, the untrained group verbalised more about Pain and Discomfort
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956 445 than the trained group, with significant differences found between the groups during the second and
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962
963 446 third quartiles of the TT. These verbalisations from the untrained group also occurred concurrently with
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965 447 a drop-in pace following a faster first quartile and therefore could be a result of increasing salience of
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967 448 physiological disturbance causing a subsequent associative attentional focus (see Balagué et al., 2012;
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969 449 Hutchinson & Tenenbaum, 2007; Tenenbaum & Connolly, 2008). This supports recent evidence that
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971 450 recreational endurance athletes consistently report experiences of unpleasant exercise-induced
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973 451 sensations such as pain, fatigue, exertion and discomfort during exercise (McCormick, Meijen &
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975 452 Marcora, 2016). The differences between trained and untrained athletes may be in their appraisals of
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977 453 these experiences and this, in turn, may partially explain the resultant differences in performance. For
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979 454 example, Rose and Parfitt (2010) proposed that low-active exercisers have a negative interpretation of
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981 455 interoceptive cues, represented by perceptions of fatigue or discomfort, which causes affective
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983 456 responses to suffer. On the other hand, trained endurance runners will accept and embrace feelings of
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985 457 pain and discomfort and consider it as essential in the accomplishment of goals, instead describing
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987 458 discomfort as ‘positive pain’ (Bale, 2006; Simpson, Post & Young, 2014). Similarly, since elite
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989 459 performers can monitor their bodily sensations more effectively than untrained (Raglin & Wilson,
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991 460 2008), the trained participants’ perceptions of pain and discomfort may not have necessitated as much
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993 461 attention. Instead, trained athletes can effectively appraise these sensations based on previous
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995 462 experience which allows them to more accurately interpret and inform the active self-regulation of effort
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997 463 (Brewer & Buman, 2006).

998 464 The untrained group verbalised more distractive thoughts, i.e. irrelevant, task-unrelated
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1000 465 thoughts. This dissociative attentional focus has also been demonstrated in running, whereby low-active
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1002 466 women used more deliberate dissociative strategies compared to high-active women (Rose & Parfitt,
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1004 467 2010). This was suggested to be an adaptive coping strategy to make the task appear less daunting and
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1006 468 reduce perceptions of effort. However, despite reductions in perceived effort, this type of distractive
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1008 469 strategy has been linked with a slower-than-optimal pace (Brick et al., 2016; Connolly & Janelle, 2003),
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1010 470 poorer performance and lower levels of arousal and pleasantness (Bertollo et al., 2015). In the current
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1012 471 study, the untrained group’s pace dropped during the second quartile of the TT where verbalisations of
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1014 472 irrelevant thoughts were significantly greater than the trained group, supporting this possible
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1016 473 relationship between cognitions and performance (Brick et al., 2016).

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1023 474 In contrast, the trained group verbalised very few irrelevant thoughts and significantly more
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1025 475 thoughts relating to power, breathing and controlling emotions than the untrained group in the second
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1027 476 and third quartiles. In fact no irrelevant thoughts were verbalised from any trained participant in the
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1029 477 second quartile, further supporting that attention was instead directed to the task itself and aligned with
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1031 478 the regulation of emotions and performance goals. Brick, et al, (2015) also demonstrated how
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1033 479 competitive runners actively avoid distractive thoughts in order to maintain a task focus that supports
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1035 480 the regulation of effort perceptions and the optimisation of pace during competition. The present results
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1037 481 of the trained cyclists verbalising about associative, active self-regulatory themes (power output and
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1039 482 control of emotion thoughts) in the middle section of the TT supports such previous demonstrations.
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1041 483 These observations also agree with those previously found in other sporting disciplines in which high-
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1043 484 skilled golfers verbalised more strategic, performance-related thoughts than less-skilled golfers (Arsal
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1045 485 et al., 2016). The focus on active self-regulatory strategies has been linked with improvements in
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1047 486 movement economy and pacing accuracy in the absence of elevated perceptions of effort (Brick et al.,
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1049 487 2016). This pattern of verbalisations in the mid-section of the TT also coincided with a sustained
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1051 488 exertive effort and more even pace in the trained group. On the other hand, the untrained group dropped
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1053 489 their pace following a faster start that may have exceeded their ventilatory threshold and resulted in
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1055 490 negative affective valence (Ekkekakis, Hall & Petruzzello, 2008). Therefore, without the experience-
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1057 491 primed ability to regulate and effectively deal with these unpleasant sensations as demonstrated by the
1058
1059 492 trained group, their behavioural response was to reduce work rate.

1060 493 The second study looked to identify if cognitions changed over the duration of the TT. Both the
1061
1062 494 trained and untrained groups verbalised significantly more motivational thoughts across the duration of
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1064 495 the TT, with the percentage of verbalisations increasing by 24% and 18%, respectively. These positive
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1066 496 motivational statements may be indicative of a self-talk strategy, warranted more towards the end of the
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1068 497 TT where the task becomes more challenging and it becomes more salient to overcome greater levels
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1070 498 of perceived discomfort and maintain a target pace (Brick et al., 2016). This change in verbalisations
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1072 499 also coincides with the increase in pace in the final quartile demonstrated by both groups (i.e., an end-
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1074 500 spurt), indicating a greater need for cognitive strategies to enable this increase in pace to achieve goal
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1076 501 attainment. Furthermore, research has also demonstrated that long-distance runners utilise strategies

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1083 502 such as positive self-talk, goal-setting and attentional focus strategies to maintain and manage their pace
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1085 503 (Samson et al., 2015; Simpson et al., 2014).
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1087 504 In addition, the trained group verbalised more distance-related thoughts across the TT which
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1089 505 supports the previous pattern demonstrated in Study 1 and in our recent work with trained cyclists
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1091 506 (Whitehead et al., 2017). Whilst distance was a consistently prominent theme in the untrained group,
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1093 507 this change and adaptation of focus seen in the trained group may suggest that they are better able to
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1095 508 appraise this distance information in a reactive manner such that it will inform their regulatory efforts
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1097 509 (Brewer & Buman, 2006). In response to the situational characteristics of the TT, these findings suggest
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1099 510 that the trained group demonstrated more reactive cognitive control and used this distance information
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1101 511 to maintain goal attainment (Brick et al., 2016). On the other hand, the inexperienced group will lack
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1103 512 effective schema to interpret this distance information and related bodily sensations, resulting in
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1105 513 negative affect and effort withdrawal.

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1107 514 This study has provided evidence for differences between trained and untrained participants in
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1109 515 both cognitive processes and pacing behaviours during TT performance. There is evidence to support
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1111 516 that different cognitive strategies may be used to deal with the pain and discomfort experienced during
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1113 517 endurance exercise and that experience and training level determines the types of strategies used
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1115 518 (Bertollo et al., 2015). Trained participants were more task-focussed using active self-regulatory
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1117 519 strategies, whereas untrained participants used distractive strategies to avert their attention from these
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1119 520 interoceptive cues.

1120 521 **Study 3 – An evaluation of the feasibility of using Think Aloud protocol during a 16.1 km time**
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1122 522 **trial performance from a participant perspective.**
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1124 523 It is argued that to better understand cognition in sporting events researchers much employ the
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1126 524 most appropriate and reliable methods (Whitehead et al., 2015). To date, very little research has
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1128 525 examined the social validation of the use of TA with athletes. Previous research has looked at the effect
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1130 526 of TA on performance or the difference between TA and other data collection methods within self-
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1132 527 paced sports such as golf (Whitehead et al., 2015). Similarly, Fox, Ericsson, and Best (2011) compared
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1134 528 performance on tasks that involved concurrent verbal reporting conditions with matching silent control
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1136 529 conditions, concluding that instructing participants to merely verbalise their thoughts during a task did
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1143 530 not alter performance. However, participants' thoughts and feelings about thinking aloud and their own
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1145 531 perceptions of whether TA affects their performance is yet to be investigated. Nicholls and Polman
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1147 532 (2008) suggested that a possible reason for the lack of empirical TA research within endurance sports
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1149 533 is due to the challenges athletes may face in concurrently thinking aloud during an aerobically
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1151 534 challenging event. Therefore, if the TA protocol is to be used within an endurance sport setting then it
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1153 535 is important to investigate participant's perceptions of using this protocol. Traditionally, social
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1155 536 validation procedures have been used to measure participant perceptions and satisfaction related to an
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1157 537 intervention (e.g., Mellalieu, Hanton & O'Brien, 2006). However, it is also important to investigate
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1159 538 perceptions of new and innovative methodological procedures, which in turn will inform the
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1161 539 employment, or otherwise, of such methodologies in future research. Furthermore, social validation
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1163 540 procedures have been suggested to strengthen the external validity of technical and practical action
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1165 541 research by offering a personal insight into the intervention through the experiences of the participants
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1167 542 (Newton & Burgess, 2008; Whitehead et al., 2016a).

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1169 543 One recent study which conducted both immediate and post eight-week social validation
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1171 544 interviews of TA as an aid to reflective learning amongst rugby league coaches, was the aforementioned
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1173 545 workings of Whitehead et al. (2016a). Results illustrated that coaches developed an increased
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1175 546 awareness, enhanced communication, and perceived pedagogical development. The participants also
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1177 547 suggested TA as being a valuable tool for collecting in-event data during a coaching session, and
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1179 548 developing and evidencing reflection for coaches. Whilst these findings relate to the perceived utility
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1181 549 of TA within coach education, they represent the first participant social validation of the TA protocol,
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1183 550 implying that further research into this area is warranted across other populations. In light of the lack
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1185 551 of research that has used TA within an endurance setting, specifically cycling, this study aimed to assess
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1187 552 participant's perceptions of being asked to think aloud during a 16.1 km TT performance. In doing so,
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1189 553 this study not only seeks to obtain participant views on the utility of the TA protocol in relation to their
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1191 554 TT performance, it also provides a potential indicator of the validity and reliability of the data obtained
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1193 555 in studies 1 and 2, reflecting whether or not participants knowingly changed their behaviours or
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1195 556 cognitions in accordance with the TA protocol.

1196 557 **Material and Methods**

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558 *Participants*

559 Twenty-seven male and three female cyclists (M age = 36.87; M experience = 5.27) were
560 recruited from North Yorkshire and Liverpool cycling clubs. All participants consisted of those who
561 had previously taken part in study 1 and study 2. Written informed consent was attained prior to
562 participation and the study was approved by an institutional research ethics committee.

563 *Materials*

564 An Olympus Dictaphone was used to record all interviews.

565 *Procedure*

566 Semi-structured, telephone interviews were conducted with all 30 participants within 48 hours
567 following the completion of their TTs. These interviews lasted between 10 and 20 minutes and provided
568 an opportunity for the participants to discuss their experiences of using the TA protocol immediately
569 after their individual TT had taken place. Recent publications have highlighted the potential utility of
570 telephone interviews as an alternative to the ‘default mode’ of face-to-face interviewing (Holt, 2010;
571 Stephens, 2007), in that they allow for participants to control the privacy and practicalities of the
572 conversation as they deem appropriate. In this light, telephone interviewing was deemed an appropriate
573 method of data collection here as it allowed for contact to be established at the participant’s earliest
574 convenience following their participation in the TT.

575 Interview questions focussed primarily on the participants’ experiences of using the Think
576 Aloud protocol, and included questions such as; how easy or difficult was it was to articulate your
577 thoughts during this particular time trial?; to what extent do you consider think aloud to be an acceptable
578 means of assessing your thoughts during performance?; did your use of the protocol enable you to
579 reflect on performance as it was occurring in any way, and if so, are there any examples you could
580 offer? All the interviews were audio-recorded so that they could be transcribed verbatim prior to the
581 subsequent data analysis taking place.

582 *Data Analysis*

583 Inductive content analysis was used as a means of analysing the interview data obtained from
584 the participants (Scanlan, Stein, & Ravizza, 1989). Given that this is the first study to consider
585 participant perceptions about thinking aloud and whether it affects their performance, inductive

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1262
1263 586 reasoning was employed with a view to allowing themes to emerge from the raw data. Biddle, Markland
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1265 587 and Gilbourne (2001) suggested that within content analysis methodologies, raw data represents the
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1267 588 basic unit of analysis and usually comprises of quotes that clearly identify an individual's subjective
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1269 589 experience. The 'clustering' of these raw data extracts in turn establishes first-order themes, with the
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1271 590 comparing and contrasting of individual quotes being undertaken to unite those with similar meanings
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1273 591 and to separate those which differed (Scanlan et al., 1989). This same analytical process is then repeated
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1275 592 and built upwards to create higher order themes until it is not possible to locate further underlying
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1277 593 uniformities to create a higher theme level. In keeping with the mixed-methods design of this multi-
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1279 594 study series, an *expansion* approach (Gibson, 2016) was adopted, with a view to exploring participant's
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1281 595 thoughts and feelings on the use of TA during time trial cycling. A subjective epistemology and
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1283 596 relativist ontology was adopted, recognising participant experiences as local and constructed. More
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1285 597 specifically, a double hermeneutic was undertaken, wherein researchers tried to make sense of
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1287 598 participants own sense making. Consistent with this position the potential limitations of inter-rater
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1289 599 reliability, as highlighted by Smith and McGannon (2017) were acknowledged. As a result a critical
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1291 600 friend was used, not to vouch for an objective truth but to critically ensure data collection and analysis
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1293 601 was plausible and defensible (Smith & McGannon, 2017).

1294 602 As a result of this inductive content analysis process, Table 9 depicts both first- and second-
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1296 603 order themes for the 'general dimensions' or themes which are apparent within the interview data. As
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1298 604 a result of this process, a total of 142 data extracts were selected and analysed (a selection of which are
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1300 605 included within Table 9). Two general dimensions emerged from this data, the first of which was
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1302 606 comprised of data regarding the participants' views on how TA and race performance were linked.
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1304 607 Primary themes identified here relate to the perceived impact of thinking aloud on performance
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1306 608 (positive, negative or neutral), and the perceived purpose of TA within the race itself (i.e. reflection,
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1308 609 goal-setting, strategizing etc.). The second general dimension contains data regarding participants'
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1310 610 views on the process of thinking aloud within the race, and includes data regarding perceived barriers
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1312 611 and enablers to utilising the TA protocol. Both of these general dimensions are extrapolated further
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1314 612 below.

1316 613 **Results**

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1323 614 For the findings of Study 3, see Table 9.
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1325 615 **Discussion Study 3**
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1327 616 Social validation was used to explore participant perceptions of being asked to TA and the
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1329 617 feasibility of this methodological approach within endurance exercise. Findings revealed that asking
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1331 618 participants to TA was viewed as both a potential barrier and/or an enabler to performance. From a
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1333 619 performance perspective, previous research by Whitehead et al. (2015) supported that using TA at level
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1335 620 2 does not negatively affect performance. Whitehead et al. (2015) found that thinking aloud did not
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1337 621 pose a negative effect on performance and in fact, golfers engaged more time in actively seeking
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1339 622 solutions and planning, which may have resulted in the development of strategies to enhance
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1341 623 performance. This was also evident within the current study, in that participants identified how TA
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1343 624 enabled them to think more positively in addition to providing motivation to push harder within their
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1345 625 performance.

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1347 626 A number of seemingly positive functions of TA were identified which included; within-race
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1349 627 reflection, goal-setting, strategizing and increasing focus and concentration. Previous research in sports
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1351 628 coaching has identified how asking coaches to verbalise their thoughts in an event may increase their
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1353 629 awareness of their own thought processes (Whitehead et al., 2016a). Coaches reported being more aware
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1355 630 of what they were doing and in turn this enabled reflection-in-action. Gagne and Smith (1962) also
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1357 631 demonstrated how asking participants to verbalise their reasoning when completing the Tower of Hanoi
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1359 632 produced more efficient solutions (taking fewer moves), and suggested that the instruction to verbalise
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1361 633 the reasons for their moves induced more deliberate planning. This raising of awareness could be a
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1363 634 limitation when using TA during natural sporting performance as it may redirect thought processes
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1365 635 elsewhere away from what they would usually do. However, participants in this study highlighted how
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1367 636 this could also be interpreted as a positive influence, with TA seeming to make them more aware of
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1369 637 their thought process, allowing for a higher level of concentration on the information that they deem
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1371 638 most important (e.g., active self-regulatory thoughts), as evidenced in Table 1.

1372 639 In addition to acknowledging the perceived links between TA and subsequent performance
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1374 640 outcomes, participants also provided their thoughts on the process of utilising the TA protocol within
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1376 641 the race itself. Some of the barriers included those regarding the physically demanding nature of the
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1383 642 sport and how it impacted on their ability to articulate their thoughts (cf. Nicholls & Polman, 2008), as
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1385 643 well as personal preferences for remaining quiet during a race and not wanting to be seen talking out
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1387 644 loud. In contrast to this however, a number of participants also suggested that they adjusted well to the
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1389 645 process of TA, with some stating a willingness to continue to utilise the protocol outside of the research
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1391 646 study itself, mirroring the findings of similar research by Whitehead et al. (2016a). Furthermore, and in
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1393 647 accordance with the positioning of this data within this current multi-study project, participants also
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1395 648 offered a range of perspectives regarding their perceived awareness of the ongoing data collection that
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1397 649 was occurring during the TA process. Whilst there was no direct influence of any members of the
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1399 650 research team during either the lab or field studies described in this paper, a number of participants
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1401 651 discussed how their awareness that they were being recorded during the race impacted on what was
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1403 652 said. For some participants, there was no perceived change in articulated thoughts as a result of being
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1405 653 recorded, however, others suggested that they felt a pressure to speak during the ride as they knew they
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1407 654 were being recorded. These findings seemingly indicate that further social validation research regarding
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1409 655 participant perceptions of being asked to TA during performance are warranted as research into the area
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1411 656 continues to develop in the future.

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1413 657 Conversely, some participants highlighted that TA could have a potentially negative effect on
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1415 658 their performance, as they reported holding back in terms of energy expenditure in order to enable them
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1417 659 to TA. This is an important point to consider and relates to the suggestion that a possible reason for the
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1419 660 lack of empirical concurrent TA research within endurance sports is due to the challenges athletes may
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1421 661 face in concurrently thinking aloud during an aerobically challenging event (Nicholls & Polman, 2008).

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1423 662 Although this study found TA to have both positive and negative perceived effects on
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1425 663 participants' performance, it is important to acknowledge that this is the first time this kind of protocol
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1427 664 has been evaluated to inform the future utilisation of TA. Through recommendations of how to develop
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1429 665 the methodology further, this will create a more robust and valid method of data collection. One
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1431 666 potential area for development could be the amount of time and tasks dedicated to the training of TA.
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1433 667 Although Ericsson and Simon (1980) recommend specific guidelines, which were followed within this
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1435 668 collection of studies, more specific training could be employed within an endurance activity. For
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1437 669 example, allowing participants to become more familiar and comfortable with the process may lead to

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670 a more naturalistic set of data. Research often includes familiarisation periods for the exercise protocols
671 adopted (Williams et al., 2014; Wass, Taylor & Matsas, 2005) therefore it is reasonable to expect that
672 methodological protocols may also need this same level of familiarisation. Consequently, future
673 research using TA protocol should consider extending the length of the TA training process to ensure
674 familiarisation with the protocol.

675 Although it is evident that not all participants view engaging in TA positively, it is important
676 to acknowledge the growing body of research that has used this method of data collection. The TA
677 protocol is a means of collecting concurrent data, where other methods (e.g., retrospective interviews)
678 cannot. This social evaluation study provides evidence that the data obtained in study 1 and 2 are valid
679 and reliable.

680 **General Discussion**

681 Given the limited insight into the temporal characteristics of endurance athletes' specific
682 cognitive strategies, this research provides valuable insight using TA. This discussion will bring
683 together both study 1 and 2 in order to make valuable comparisons between the results found in both
684 the lab and field based studies.

685 *Lab Vs Outdoor Environmental Conditions*

686 In both laboratory and field TT conditions, Active Self-Regulation was the most verbalised
687 theme. Given the goal-directed nature of the task this is to be expected, but that participants were able
688 to verbalise these cognitive efforts supports the utility of TA in these settings. Further similarities were
689 seen in the use of motivational strategies as the trend for an increase in verbalisations across the TT was
690 evident for all participant groups regardless of environmental condition. These findings support
691 Blanchard, Rodgers and Gauvin (2004) who demonstrated that cognitions and feeling states during
692 running in a track environment were comparable to those observed in a laboratory. In contrast however,
693 there were more verbalisations relating to the distraction thoughts during the field TT than the lab TT.
694 This is in support of Slapsinskaite, Garcia and Razon et al., (2016) findings that outdoor environments
695 result in a greater prevalence of external thoughts and use of a dissociative attentional strategy compared
696 to indoor environments. Future research should consider the transferability of these findings and
697 acknowledge the importance of environmental differences.

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1503 698 *Expertise Differences*
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1505 699 Both the lab and field studies included groups of trained cyclists with TT experience. Similar
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1507 700 trends in verbalisations were observed between these groups, with an increasing number of
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1509 701 verbalisations relating to external associative cues, Motivation and Distance across the TT. There were
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1511 702 differences observed in the prevalence of Outward Monitoring themes of Distance and Time, with
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1513 703 Distance verbalised less during the field TT than the laboratory TT.
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1515 704 Although distance was a consistently prominent theme in the untrained group in Study 2,
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1517 705 distance-related verbalisations increased across the TT for the trained cyclists in both the lab and field
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1519 706 groups. This is a similar finding to that observed in previous cycling TT research (Whitehead et al.,
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1521 707 2017) and could support the assertion that trained athletes employ both proactive and reactive cognitive
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1523 708 control of focus of attention to facilitate performance, and most specifically near the end of the race
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1525 709 (e.g., Brick et al., 2016). This change and adaptation of focus was not present in the untrained group
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1527 710 and is suggestive of the ability of experienced athletes to self-regulate attentional focus in response to
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1529 711 internal and external distractors during performance (Bertollo et al., 2015).

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1531 712 Overall, it is clear that expertise influences thought processes and use of cognitive strategies
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1533 713 during TT performance. In particular, expertise appears to be associated with the ability to cope with
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1535 714 negative feedback information (e.g., in relation to fatigue and pain). Having an experience-derived
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1537 715 pacing schema better enables effective cognitive control through accurate appraisal of pain and
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1539 716 discomfort in relation to the remaining distance and task goals (Addison, Kremer & Bell, 1998; Brewer
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1541 717 & Buman, 2006).

1542 718 *Limitations*
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1544 719 Whilst TA has been used to provide evidence for during-task changes in individual cognitive
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1546 720 processes, it is not possible to measure what is unconscious due to an inability for individuals to
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1548 721 verbalise decisions that are made unconsciously. Therefore, studies can only measure what is in the
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1550 722 conscious thought process. Similarly, and as suggested previously by Nicholls and Polman (2008),
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1552 723 individuals may also report a greater number of verbalisations for what they believe is expected or
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1554 724 perceive is of importance to the investigation. Further limitations, relating to familiarity must be
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1556 725 acknowledged, as Study 3 highlighted how some participants may have benefitted from further training,
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1563 726 therefore better familiarisation of the protocol may have allowed them to feel more comfortable with
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1565 727 the TA process. Furthermore, gender differences were not taken into account within this research. A
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1567 728 previous study identified how female runners are more likely to engage in ‘personal problem solving’
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1569 729 during marathon training (Schomer & Connolly, 2002). Kaiseler, Polman and Nicholls (2013) identified
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1571 730 cognitive differences in stress and coping between males and females using TA, therefore it would be
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1573 731 of interest to investigate cognitive differences between males and females within cycling and pacing.
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1575 732 **Although the data analysis of study 1 and 2 involved inter-rater reliability to ensure rigor, it is**
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1577 733 **important to acknowledge the potential limitations of this, in that different coders may utilize the same**
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1579 734 **text differently (Campbell, Quincy, Osserman, & Pedersen, 2013). For example, during the data**
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1581 735 **analysis some themes experienced this subjectivity of coding, indicated by the 10-14% discrepancies**
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1583 736 **found between coders, specifically with the theme distraction. In addition to the conceptual clarity**
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1585 737 **provided by Brick et al. (2014), the present study has highlighted that the task itself is a critical**
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1587 738 **consideration in thought categorisation. For example, some thoughts within a laboratory setting (e.g.,**
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1589 739 **"eyes on the road") would be considered active distraction due to the arbitrary information provided by**
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1591 740 **the road simulation, whereas the same thought when cycling on the road would be task-relevant outward**
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1593 741 **monitoring. Therefore, for future reflection,** we would like to acknowledge the recommendations of
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1595 742 Smith and McGannon (2017) surrounding the analysis approach taken with the TA data. In studies 1
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1597 743 and 2, we, like others in TA literature, have taken a post-positivist/cognitivist perspective approach.
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1599 744 Future TA researchers could however consider adopting a constructionist lens. As Eccles and Aarsal
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1601 745 (2017) quite rightly suggest, the results from these positions would be different, albeit not better or
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1603 746 worse. Thus, TA is an area that offers opportunities and would benefit from researchers with different
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1605 747 theoretical and philosophical lenses.

1606 748 *Conclusion*

1608 749 The findings of this study extend previous research within pacing and endurance athlete
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1610 750 cognitions through utilising TA. In addition, it has extended previous work by accounting for
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1612 751 performance data (speed, power, time, heart rate), which has allowed for inferences to be made between
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1614 752 participant verbalisations and the performance parameters. As previously recommended by Whitehead
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1616 753 et al., (2017), this study has acknowledged participant perceptions of thinking aloud on pacing
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754 performance and has also adopted a more thorough coding scheme (Brick et al., 2014). It is hoped that
755 this data can support the use of TA in future pacing and endurance research. Further, this study provides
756 further evidence that thought processes change throughout an event and gives an insight into how
757 athletes may respond cognitively to different performance and physiological experiences. This in turn
758 could inform coaches, athletes and psychologists in understanding how their athletes pace during
759 performance, and what variables they attend to at difference stages. Importantly, the third study
760 provided evidence that TA is a valid and reliable methodology to collect in-event data during endurance
761 activities. Providing participants with enhanced practice prior to performance might help in making TA
762 easier to execute. In addition, more studies are required to compare the different levels of TA with no
763 TA in TT performance.

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References

- Addison, T., Kremer, J., & Bell, R. (1998). Understanding the psychology of pain in sport. *The Irish Journal of Psychology, 19*(4), 486-503. doi:10.1080/03033910.1998.10558209.
- Arsal, G., Eccles, D. W., & Ericsson, K. A. (2016). Cognitive mediation of putting: Use of a think-aloud measure and implications for studies of golf-putting in the laboratory. *Psychology of Sport and Exercise, 27*(1), 18-27. doi:10.1016/j.psychsport.2016.07.008.
- Baker, J., Côté, J., & Deakin, J. (2005). Cognitive characteristics of expert, middle of the pack, and back of the pack ultra-endurance triathletes. *Psychology of Sport and Exercise, 6*(5), 551-558. doi:10.1016/j.psychsport.2004.04.005.
- Balagué, N., Hristovski, R., Aragonés, D., & Tenenbaum, G. (2012). Nonlinear model of attention focus during accumulated effort. *Psychology of Sport and Exercise, 13*(5), 591-597. doi:10.1016/j.psychsport.2012.02.013.
- Balagué, N., Hristovski, R., Garcia, S., Aragonés, D., Razon, S., & Tenenbaum, G. (2015). Intentional thought dynamics during exercise performed until volitional exhaustion. *Journal of Sports Sciences, 33*(1), 48-57. doi:10.1080/02640414.2014.921833.
- Bale, J. (2006). The place of pain in running. In S. Loland, B. Skirstad, & I. Waddington (Eds.), *Pain and Injury in Sport: Social and ethical analysis*. Oxon: Routledge.
- Barwood, M., Corbett, J., Wagstaff, C., McVeigh, D., & Thelwell, R. (2015). Motivational self-talk improves 10 km time trial cycling compared to neutral self-talk. *International Journal of Sports Physiology and Performance, 10*(2), 166-171. doi:10.1123/ijsp.2014-0059.
- Bertollo, M., di Fronso, S., Filho, E., Lamberti, V., Ripari, P., Reis, V. M., Comani, S., Bortoli, L., & Robazza, C. (2015). To focus or not to focus: Is attention on the core components of action beneficial for cycling performance? *The Sport Psychologist, 29*(2), 110-119. doi:10.1123/tsp.2014-0046.
- Biddle, S. J., Markland, D., Gilbourne, D., Chatzisarantis, N. L., & Sparkes, A. C. (2001). Research methods in sport and exercise psychology: Quantitative and qualitative issues. *Journal of Sports Sciences, 19*(10), 777-809. doi:10.1080/026404101317015438.
- Blanchard, C., Rodgers, W., & Gauvin, L. (2004). The influence of exercise duration and cognitions during running on feeling states in an indoor running track environment. *Psychology of Sport and Exercise, 5*(2), 119-133. doi:10.1016/S1469-0292(03)00006-2.
- Blanchfield, A. W., Hardy, J., De Morree, H. M., Staiano, W., & Marcora, S. M. (2014). Talking yourself out of exhaustion: the effects of self-talk on endurance performance. *Medicine & Science in Sports & Exercise, 46*(5), 998-1007. doi:10.1249/MSS.0000000000000184.
- Brewer, B. W., & Buman, M. P. (2006). Attentional focus and endurance performance: review and theoretical integration. *Kinesiologicala Slovenica, 12*(2), 82-97.
- Brick, N., MacIntyre, T., & Campbell, M. (2014). Attentional focus in endurance activity: new

1741
1742
1743 801 paradigms and future directions. *International Review of Sport and Exercise Psychology*, 7(1),
1744 106-134. doi:10.1080/1750984x.2014.885554.
1745 802
1746 803 Brick, N. E., Campbell, M. J., Metcalfe, R. S., Mair, J. L., & MacIntyre, T. E. (2015). Altering Pace
1747 Control and Pace Regulation: Attentional Focus Effects during Running. *Medicine & Science*
1748 804 *in Sports & Exercise*, 48(5), 879-886. doi:10.1249/MSS.0000000000000843.
1749 805
1750 806 Brick, N. E., MacIntyre, T. E., & Campbell, M. J. (2016). Thinking and Action: A Cognitive Perspective
1751 on Self-Regulation during Endurance Performance. *Frontiers in Physiology*, 7.
1752 807 doi:10.3389/fphys.2016.00159.
1753 808
1754 809 Calmeiro, L., & Tenenbaum, G. (2011). Concurrent verbal protocol analysis in sport: illustration of
1755 thought processes during a golf-Putting task. *Journal of clinical sport psychology.*, 5(3), 223-
1756 810 236. doi:10.1123/jcsp.5.3.223.
1757 811
1758 812 Calmeiro, L., Tenenbaum, G., & Eccles, D. W. (2014). Managing pressure: patterns of appraisals and
1759 coping strategies of non-elite and elite athletes during competition. *Journal of Sports Sciences*,
1760 813 32(19), 1813-1820. doi:10.1080/02640414.2014.922692.
1761 814
1762 815 Castaneda, B., & Gray, R. (2007). Effects of focus of attention on baseball batting performance in
1763 816 players of differing skill levels. *Journal of sport and Exercise Psychology*, 29(1).
1764 817 doi:10.1123/jsep.29.1.60.
1765 818
1766 819 Cona, G., Cavazzana, A., Paoli, A., Marcolin, G., Grainer, A., & Bisiacchi, P. S. (2015). It's a Matter
1767 of Mind! Cognitive Functioning Predicts the Athletic Performance in Ultra-Marathon Runners.
1768 820 *PLoS One*, 10(7), e0132943. doi:10.1371/journal.pone.0132943.
1769 821
1770 822 Connolly, C., & Janelle, C. (2003). Attentional strategies in rowing: Performance, perceived exertion,
1771 823 and gender considerations. *Journal of Applied Sport Psychology*, 15(3), 195-212.
1772 824 doi:10.1080/10413200305387.
1773 825
1774 826 Corbett, J., Barwood, M. J., Ouzounoglou, A., Thelwell, R., & Dicks, M. (2012). Influence of
1775 827 competition on performance and pacing during cycling exercise. *Medicine & Science in Sports*
1776 828 *& Exercise*, 44(3), 509-515. doi:10.1146.1897.
1777 829
1778 830 De Pauw, K., Roelands, B., Cheung, S. S., de Geus, B., Rietjens, G., & Meeusen, R. (2013). Guidelines
1779 831 to Classify Subject Groups in Sport-Science Research. *International Journal of Sports*
1780 832 *Physiology and Performance*, 8(2), 111-122. doi:10.1123/ijsp.8.2.111.
1781 833
1782 834 Eccles, D. (2012). Verbal reports of cognitive processes. In G. Tenenbaum, R. C. Eklund, & A. Kamata
1783 835 (Eds.), *Handbook of measurement in sport and exercise psychology*. (pp. 103-117): Champaign,
1784 836 IL: Human Kinetics.
1785 837
1786 838 Eccles, D.W. & Arsal, G. (2017). The think aloud method: What is it and how do I use it? *Qualitative*
1787 839 *Research in Sport, Exercise and Health*, 9, 514-531.
1788 840
1789 841 Ekkekakis, P., Hall, E. E., & Petruzzello, S. J. (2008). The relationship between exercise intensity and
1790 842 affective responses demystified: to crack the 40-year-old nut, replace the 40-year-old
1791 843 nutcracker! *Annals of behavioral medicine*, 35(2), 136-149. doi:10.1007/s12160-008-9025-z.
1792 844
1793
1794
1795
1796
1797
1798
1799
1800

- 1801
1802
1803 838 Ericsson, K. A., & Kirk, E. (2001). *Instructions for giving retrospective verbal reports*. Unpublished
1804 manuscript. Florida State University. Department of Psychology.
1805 839
1806 840 Ericsson, K. A., & Simon, H. A. (1980). Verbal reports as data. *Psychological review*, 87(3), 215.
1807
1808 841 Ericsson, K. A., & Simon, H. A. (1993). *Verbal reports as data*. Cambridge: MIT Press.
1809 842 Fitts, P. M., & Posner, M. I. (1967). *Human Performance*. Oxford: Brooks/Cole Human Performance.
1810
1811 843 Fox, M. C., Ericsson, K. A., & Best, R. (2011). Do procedures for verbal reporting of thinking have to
1812 844 be reactive? A meta-analysis and recommendations for best reporting methods. *Psychological*
1813 845 *bulletin*, 137(2), 316. doi:10.1037/a0021663.
1814
1815 846 Gagne, R. M., & Smith, E. C. (1962). A study of the effects of verbalization on problem solving. *Journal*
1816 847 *of experimental psychology*, 63(1), 12. doi:10.1037/h0048703.
1817
1818 848 Gibson, K. (2016). Mixed methods research in sport and exercise. In B. Smith & A. C. Sparkes (Eds.),
1819 849 *Routledge Handbook of Qualitative Research Methods in Sport and Exercise*. (pp. 382–396):
1820 London: Routledge.
1821 850
1822 851 Hassan, E. (2005). Recall Bias can be a Threat to Retrospective and Prospective Research Designs. *The*
1823 852 *Internet Journal of Epidemiology*, 3(2), 1-7. From [https://print.ispub.com/api/0/ispub-](https://print.ispub.com/api/0/ispub-article/13060)
1824 853 [article/13060](https://print.ispub.com/api/0/ispub-article/13060).
1825
1826 854 Hettinga, F. J., De Koning, J. J., Hulleman, M., & Foster, C. (2012). Relative importance of pacing
1827 855 strategy and mean power output in 1500-m self-paced cycling. *British journal of sports*
1828 856 *medicine*, 46(1), 30-35. doi:10.1136/bjism.2009.064261.
1829
1830 857 Holt, A. (2010). Using the telephone for narrative interviewing: a research note. *Qualitative research*,
1831 858 10(1), 113-121. doi:10.1177/1468794109348686.
1832
1833 859 Hutchinson, J. C., & Tenenbaum, G. (2007). Attention focus during physical effort: The mediating role
1834 860 of task intensity. *Psychology of Sport and Exercise*, 8(2), 233-245.
1835 861 doi:10.1016/j.psychsport.2006.03.006.
1836
1837 862 Janelle, C. M. (2002). Anxiety, arousal and visual attention: A mechanistic account of performance
1838 863 variability. *Journal of Sports Sciences*, 20(3), 237-251. doi:10.1080/026404102317284790.
1839
1840 864 Jones, H. S., Williams, E. L., Marchant, D., Sparks, A., Bridge, C. A., Midgley, A. W., & McNaughton,
1841 865 L. R. (2016). Improvements in cycling time trial performance are not sustained following the
1842 866 acute provision of challenging and deceptive feedback. *Frontiers in Physiology*, 7(399).
1843 867 doi:10.3389/fphys.2016.00399.
1844
1845 868 Jones, H. S., Williams, E. L., Marchant, D., Sparks, S. A., Midgley, A. W., Bridge, C. A., &
1846 869 McNaughton, L. (2014). Distance-dependent association of affect with pacing strategy in
1847 870 cycling time trials. *Medicine and Science in Sports and Exercise*, 47(4), 825-832.
1848 871 doi:10.1249/MSS.0000000000000475.
1849
1850 872 Kaiseler, M., Polman, R. C., & Nicholls, A. R. (2013). Gender differences in stress, appraisal, and
1851 873 coping during golf putting. *International Journal of Sport and Exercise Psychology*, 11(3), 258-
1852 874 272. doi:10.1080/1612197X.2013.749004.
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875 MacPhail, C., Khoza, N., Abler, L., & Ranganathan, M. (2016). Process guidelines for establishing
876 Intercoder Reliability in qualitative studies. *Qualitative Research, 16*, 198–212.

877 Marcora, S. M., & Staiano, W. (2010). The limit to exercise tolerance in humans: mind over muscle?
878 *European Journal of Applied Physiology, 109*(4), 763-770. doi:10.1007/s00421-010-1418-6

879 Mauger, A., Jones, A., & Williams, C. (2009a). Influence of feedback and prior experience on pacing
880 during a 4-km cycle time trial. *Medicine and Science in Sports and Exercise, 41*(2), 451.
881 doi:10.11453.3645.

882 Mauger, A. R., Jones, A. M., & Williams, C. A. (2009b). The effect of non-contingent and accurate
883 performance feedback on pacing and time trial performance in 4-km track cycling. *British*
884 *Journal of Sports Medicine.* doi:10.1136/bjism.2009.062844.

885 McCormick, A., Meijen, C., & Marcora, S. (2016). Psychological demands experienced by recreational
886 endurance athletes. *International Journal of Sport and Exercise Psychology, 1*-16.
887 doi:10.1080/1612197X.2016.1256341

888 McPherson, S. L., & Kernodle, M. (2007). Mapping two new points on the tennis expertise continuum:
889 tactical skills of adult advanced beginners and entry-level professionals during competition.
890 *Journal of Sports Sciences, 25*(8), 945-959. doi:10.1080/02640410600908035.

891 Mellalieu, S. D., Hanton, S., & O'Brien, M. (2006). The effects of goal setting on rugby performance.
892 *Journal of Applied Behavior Analysis, 39*(2), 257-261. doi:10.1901/jaba.2006.36-05.

893 Micklewright, D., Papadopoulou, E., Swart, J., & Noakes, T. (2010). Previous experience influences
894 pacing during 20 km time trial cycling. *British Journal of Sports Medicine, 44*(13), 952-960.
895 doi:10.1136/bjism.2009.057315.

896 Morgan, W. P., & Pollock, M. L. (1977). Psychologic characterisation of the elite distance runner.
897 *Annals of the New York Academy of Sciences, 301*(1), 382-403. doi:10.1111/j.1749-
898 6632.1977.tb38215.x.

899 Newton, P., & Burgess, D. (2008). Exploring types of educational action research: Implications for
900 research validity. *International Journal of Qualitative Methods, 7*(4), 18-30.
901 doi:10.1177/160940690800700402.

902 Nicholls, A. R., & Polman, R. C. (2008). Think aloud: acute stress and coping strategies during golf
903 performances. *Anxiety Stress Coping, 21*(3), 283-294. doi:10.1080/10615800701609207

904 Nietfeld, J. (2003). An examination of metacognitive strategy use and monitoring skills by competitive
905 middle distance runners. *Journal of Applied Sport Psychology, 15*(4), 307-320.
906 doi:10.1080/714044199.

907 Raglin, J. S., & Wilson, G. S. (2008). Psychology in endurance performance. In R. J. Shephard & P. O.
908 Astrand (Eds.), *The Encyclopaedia of Sports Medicine* (2nd ed., pp. 211-219). New York: John
909 Wiley & Sons.

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916 911 Renfree, A, Crivoi do Carmo, E, & Martin, L. (2016). The Influence of Performance Level, Age and

1921
1922
1923 912 Gender on Pacing Strategy During a 100-km Ultramarathon. *European Journal of Sport*
1924 913 *Science*, 16(4), 409-415.

1926 914 Renfree, A., Martin, L., Micklewright, D., & St Clair Gibson, A. (2014). Application of decision-
1927 915 making theory to the regulation of muscular work rate during self-paced competitive endurance
1928 916 activity. *Sports Medicine*, 44(2), 147-158. doi:10.1007/s40279-013-0107-0.

1930 917 Rose, E. A., & Parfitt, G. (2010). Pleasant for some and unpleasant for others: a protocol analysis of the
1931 918 cognitive factors that influence affective responses to exercise. *International Journal of*
1932 919 *Behavioural Nutrition and Physical Activity*, 7, 15. doi:10.1186/1479-5868-7-15.

1935 920 Samson, A., Simpson, D., Kamphoff, C., & Langlier, A. (2015). Think aloud: An examination of
1936 921 distance runners' thought processes. *International Journal of Sport and Exercise Psychology*,
1937 922 1-14. doi:10.1080/1612197x.2015.1069877.

1939 923 Scanlan, T. K., Stein, G. L., & Ravizza, K. (1989). An In-depth Study of Former Elite Figure Skaters:
1940 924 II. Sources of Enjoyment. *Journal of Sport & Exercise Psychology*, 11(1).
1941 925 doi:10.1123/jsep.11.1.65.

1942 926 Schomer, H. H., & Connolly, M. J. (2002). Cognitive strategies used by marathoners in each quartile
1943 927 of a training run. *South African Journal for Research in Sport, Physical Education and*
1944 928 *Recreation*, 24(1), 87-100.

1948 929 Schomer, H. H. (1987). Mental strategy training programme for marathon runners. *International*
1949 930 *Journal of Sport Psychology*, 18, 133-151.

1950 931 Schomer, H. H. (1986). Mental strategies and the perception of effort of marathon runners. *International*
1951 932 *Journal of Sport Psychology*, 17, 41-59.

1953 933 Simpson, D., Post, P. G., Young, G., & Jensen, P. R. (2014). "It's not about taking the easy road": the
1954 934 experiences of ultramarathon runners. *The Sport Psychologist*, 28(2), 176-185.
1955 935 doi:10.1123/tsp.2013-0064.

1958 936 Slapsinskaite, A., García, S., Razon, S., Balagué, N., Hristovski, R., & Tenenbaum, G. (2016). Cycling
1959 937 outdoors facilitates external thoughts and endurance. *Psychology of Sport and Exercise*, 27, 78-
1960 938 84. doi:10.1016/j.psychsport.2016.08.002.

1962 939 Smith, B., & McGannon, K.R. (2017). Developing rigor in qualitative research: problems and
1963 940 opportunities within sport and exercise psychology. *International Review of Sport and Exercise*
1964 941 *Psychology*, DOI: 10.1080/1750984X.2017.1317357

1966 942 Smits, B., Polman, R., Otten, B., Pepping, G-J., & Hettinga, F.J. (2016). Cycling in the absence of task-
1967 943 related feedback: Effects on pacing and performance. *Frontiers of Physiology: Exercise*
1968 944 *Physiology*, 7, 348. doi:10.3389/fphys.2016.00348

1971 945 Smits, B. L., Pepping, G-J., & Hettinga, F. J. (2014). Pacing and decision making in sport and exercise:
1972 946 the roles of perception and action in the regulation of exercise intensity. *Sports Medicine*, 44(6),
1973 947 763-775. doi:10.1007/s40279-014-0163-0.

1974 948 Stephens, N. (2007). Collecting data from elites and ultra elites: telephone and face-to-face interviews
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949 with macroeconomists. *Qualitative Research*, 7(2), 203-216. doi:10.1177/1468794107076020.

950 Taylor, D., & Smith, M. F. (2013). Scalar-linear increases in perceived exertion are dissociated from
951 residual physiological responses during sprint-distance triathlon. *Physiology and Behavior*,
952 118, 178-184. doi:10.1016/j.physbeh.2013.05.031

953 Tenenbaum, G., & Connolly, C. T. (2008). Attention allocation under varied workload and effort
954 perception in rowers. *Psychology of Sport and Exercise*, 9(5), 704-717.
955 doi:10.1016/j.psychsport.2007.09.002.

956 Wass, E., Taylor, N. F., & Matsas, A. (2005). Familiarisation to treadmill walking in unimpaired older
957 people. *Gait & Posture*, 21(1), 72-79. doi:10.1016/j.gaitpost.2004.01.003.

958 Whitehead, A., Jones, H., Williams, E., Dowling, C., Morley, D., Taylor, J., & R., P. (2017). Changes
959 in Cognition over a 16.1 km Cycling Time Trial using Think Aloud Protocol: Preliminary
960 Evidence. *International Journal of Sport and Exercise Psychology*.
961 doi:10.1080/1612197X.2017.1292302.

962 Whitehead, A. E., Cropley, B., Miles, A., Huntley, T., Quayle, L., & Knowles, Z. (2016a). 'Think
963 Aloud': Towards a framework to facilitate reflective practice amongst rugby league coaches.
964 *International Sport Coaching Journal*, 3(3), 269-286. doi:10.1123/iscj.2016-0021.

965 Whitehead, A. E., Taylor, J. A., & Polman, R. C. (2015). Examination of the suitability of collecting in
966 event cognitive processes using Think Aloud protocol in golf. *Frontiers in Psychology*, 6, 1083.
967 doi:10.3389/fpsyg.2015.01083.

968 Whitehead, A. E., Taylor, J. A., & Polman, R. C. (2016b). Evidence for Skill Level Differences in the
969 Thought Processes of Golfers During High and Low Pressure Situations. *Frontiers in*
970 *Psychology*, 6, 1974. doi:10.3389/fpsyg.2015.01974.

971 Williams, E. L., Jones, H. S., Sparks, A., Marchant, D., Micklewright, D., & McNaughton, L. (2014).
972 Deception studies manipulating centrally acting performance modifiers: a review. *Medicine*
973 *and Science in Sports and Exercise*, 46(7), 1441-1451. doi:10.1249/MSS.0000000000000235.

974 Williams, E. L., Jones, H. S., Sparks, S. A., Marchant, D. C., Midgley, A. W., & Mc Naughton, L. R.
975 (2015). Competitor presence reduces internal attentional focus and improves 16.1 km cycling
976 time trial performance. *Journal of Science and Medicine in Sport*, 18(4), 486-491.
977 doi:10.1016/j.jsams.2014.07.003.

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Table 1: Primary and secondary themes identified from TA data

Secondary Themes	Primary Themes	Description	Example of raw data quotes
Internal Sensory Monitoring	Breathing	Reference to breathing or respiratory regulation	“Pretty smooth, just keep the deep breaths” (S1 P4) “Control my breathing” (S2 Trained P3) ”Breathe in and breathe out” (S2 Untrained P5)
	Pain and Discomfort	Reference to physical injury, pain or general discomfort during the task	“Just my legs burning a bit.” (S1 P3) “This is hurting now” (S2 Trained P7) “The saddle is getting a bit uncomfortable” (S2 Untrained P3)
	Hydration	Reference to taking or needing a drink	“Going to use this opportunity to get a drink.” (S1 P6) “Thirsty again” (S2 Trained P1) “Taking a drink, realised I forgot” (S2 Untrained P4)
	Fatigue	Reference to tiredness, including mental and physical fatigue but not associated with pain or discomfort	“I just feel exhausted” (S1 P1) “Legs getting tired” (S2 Trained P10) “Oh I’m exhausted” (S2 Untrained P7)
	Temperature	Reference to the temperature of the room, feeling hot/cold, sweat rate.	“I’m hot” (S1 P9) “I’m sweating now” (S2 Trained P7) “It’s too hot to be above 190” (S2 Untrained P9)
	Heart Rate	Increasing or decreasing of heart rate, or statement of heart rate value.	“Heart rate’s at 94 already” (S1 P9) “Pulse is rising to 170” (S2 Trained P9) “My pulse is going down” (S2 Untrained P6)
	Active Self-Regulation	Cadence	Verbalisations relating to pedal stroke
Speed		Reference relating specifically to speed	“Steady between 33 and 34. Try and pick it up to 35” (S1 P2) “Speed is still down a bit” (S2 Trained P10) “Kilometres still over 30, that’s good” (S2 Untrained P10)
Power		Reference relating to power output or watts	“Watts below 300” (S1 P3) “Bring the power down a touch” (S2 Trained P1) “Definitely got less power at this point” (S2 Untrained P4)
Pace		Reference to purposeful strategy or action-based changes to pace	“Nice long straight to come off. Keep pushing constantly.” (S1 P6) “I’ll settle for a mile and then push up because that will be 8k” (S2 Trained P6) “I’m conscious that I don’t want to go too fast too early” (S2 Untrained P9)

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	Increase Pace	Direct reference to actively increasing pace	“Last two kilometres I’ll try and pick it up.” (S1 P2) “Take it up nice and easy, not too much” (S2 Trained P2) “A sprint then to the corner” (S2 Untrained P4)
	Maintain Pace	Direct reference to maintaining current pace	“Don’t let it drop. Keep pushing. Try and keep it constant.” (S1 P6) “Trying to keep this pace now” (S2 Trained P9) “Just look to maintain this now” (S2 Untrained P8)
	Decrease Pace	Direct reference to purposefully reducing pace or involuntarily slowing down	“It has cost speed and power” (S1 P3) “Come on, you’re letting the power drop” (S2 Trained P7) “My pace is dropping to 23 now” (S2 Untrained P2)
	Controlling Emotions	Reference to controlling emotions	“Come on, just focus.” (S1 P2) “Relax. That’s it relax” (S2 Trained P2) ”Stay in control, stay in control” (S2 Untrained P7)
	Gear use	Reference to gear change or gear selection	“Ease off the gears just a little bit.” (S1 P10) “Just trying to get in the right gear to start with” (S2 Trained P1) “I’ve found another gear, it’s a lot easier” (S2 Untrained P4)
	Motivation	Verbalisations relating to self-motivation or positive encouragement	“Keep going, keep going, it’s looking good” (S1 P7) “That’s it, you can do this” (S2 Trained P2) “Come on, you can do it” (S2 Untrained P6)
	Technique ^a	Reference to technique including body position and coaching points	“Keep my head down. Relax shoulders.” (S1 P1)
Outward Monitoring	Time	Reference to time, time elapsed or expected finish time	“Half way, just, aiming for 20 minutes” (S1 P4) “Another minute, just turning it over” (S2 Trained P6) “Ok, we’re up to 3 minutes 30” (S2 Untrained P10)
	Distance	Any reference to distance covered or distance remaining	“Two kilometres done.” (S1 P2) “Distance is ticking away slowly” (S2 Trained P1) “6.15 completed” (S2 Untrained P6)
	Competition ^a	Reference to both the performance of other cyclists or being caught/catching another cyclist	“On target though slightly over, but more prepared to catch him” (S1 P4)
Distraction	Irrelevant Information	Verbalisations not relevant to the given task	“I need a haircut, it’s getting in my way.” (S1 P2) “My watch has fallen on the floor” (S2 Trained P8) “I can’t wait for lunch” (S2 Untrained P1)

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CompuTrainer Scenery ^b	Reference to the visual display of the simulated course, avatar or scenery.	“There’s a big mountain over there” (S2 Trained P3) “That’s a nice tree on the right” (S2 Untrained P8)
Course Reference ^a	Any reference identifying specific distractions from the course.	“There’s a lot of cars about today” (S1 P6)

^a *Field study only.* ^b*Lab study only*
S1 = Study 1, S2 = Study 2.

Table 2: Percentage (absolute count) of verbalisations for secondary themes for a field-based time trial

Secondary Themes	Whole-trial verbalisations	Verbalisations per quartile			
		1	2	3	4
Internal Sensory Monitoring	8% (77)	9% (23)	10% (19)	9% (21)	6% (14)
Active Self-Regulation	63% (573)	71% (179)	56% (113)	58% (144)	62% (137)
Outward Monitoring	9% (81)	2% (6)	11% (22)	10% (24)	13% (29)
Distraction	20% (179)	18% (43)	20% (38)	24% (58)	18% (40)

Table 3. A within-group comparison of the significant secondary themes verbalised over distance quartile for a field-based time trial

Secondary theme	Primary theme	Quartile difference	Post-hoc analysis		
			Wilcoxon Rank Z	Cohen's δ	Sig. Diff P
Active Self-Regulation	Maintaining pace	Quartile 1 * – Quartile 2	-2.46	1.18	.014
		Quartile 1 * – Quartile 4	-2.26	1.18	.024
	Motivation	Quartile 1 – Quartile 4 *	-2.72	0.37	.007
		Quartile 2 – Quartile 4 *	-2.51	0.48	.012
		Quartile 3 – Quartile 4 *	-2.15	0.25	.031
Technique	Quartile 1 * – Quartile 2	-2.26	0.86	.024	
Outward Monitoring	Distance	Quartile 1 – Quartile 4 *	-2.81	1.93	.005
	Competition	Quartile 1 – Quartile 2 *	-2.53	0.93	.011
		Quartile 1 – Quartile 3 *	-2.23	-1.10	.026

* denotes significantly more verbalisations

Table 4. Mean (SD) time-trial performance data across distance quartile for the field-based time trial

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Speed	39.00 (4.02)	38.41 (4.83)	34.94 (2.78) *	32.97 (2.70) **
Power	261.51 (64.62) ‡	245.77 (63.70)	245.46 (63.73)	255.34 (63.49)
Heart Rate	164.29 (11.44) □	170.27 (9.84)	171.49 (8.99)	172.99 (8.20)
Cadence	86.42 (7.87)	83.90 (10.25)	84.33 (9.80)	83.85 (7.50)

*denotes significantly lower than quartile 1 ($p = .007$)

**denotes significantly lower than all other quartiles ($p \leq .009$)

‡denotes significantly higher than quartile 2 ($p = .01$)

□ denotes significantly lower than all other quartiles ($p \leq .047$)

Table 5. Percentage (absolute count) of verbalisations for secondary themes for trained and

untrained participants during a lab-based time trial

Secondary Themes	Whole-trial verbalisations		Verbalisations per quartile							
	Trained	Untrained	Trained				Untrained			
			1	2	3	4	1	2	3	4
Internal Sensory Monitoring	18% (196)	14% (194)	21% (50)	23% (55)	17% (51)	13% (40)	14% (43)	13% (51)	16% (57)	12% (43)
Active Self-Regulation	62% (670)	52% (704)	62% (146)	63% (151)	61% (184)	63% (189)	43% (137)	49% (186)	51% (180)	56% (201)
Outward Monitoring	17% (183)	27% (186)	13% (30)	12% (28)	19% (58)	22% (67)	28% (88)	25% (96)	25% (90)	27% (96)
Distraction	3% (33)	7% (98)	4% (10)	3% (7)	3% (9)	2% (6)	10% (30)	10% (36)	5% (18)	3% (14)

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Table 6: A between-group comparison of primary themes verbalised across distance quartile during a lab-based time trial

Secondary theme	Primary theme	Quartile	Mann-Whitney U	Cohens δ	Sig. diff P	Mean Rank data	
						Trained	Untrained
Internal Sensory Monitoring	Breathing	2	23.00	0.76	.021	13.20 *	7.80
	Pain and Discomfort	3	47.00	1.01	.038	7.85	13.15 *
	Fatigue	3	30.00	1.09	.029	8.50	12.50 *
Active Self-Regulation	Cadence	3	27.50	0.77	.044	12.75 *	8.25
		3	21.00	1.00	.024	7.60	13.40 *
		2	24.00	0.79	.039	13.10 *	7.90
	Pace	3	22.00	0.99	.029	13.30 *	7.70
		4	24.00	0.77	.040	13.10 *	7.90
		2	22.50	0.92	.034	7.75	13.25 *
	Controlling Emotions	2	28.50	0.99	.044	12.65 *	8.35
Outward Monitoring	Time	1	14.50	1.36	.005	6.95	14.05 *
		2	6.00	2.19	<.001	6.10	14.90 *
		3	20.00	1.00	.020	7.50	13.50 *
		4	24.50	1.05	.004	7.95	13.05 *
	Distance	2	18.50	1.24	.016	7.35	13.65 *
Distraction	Irrelevant information	2	15.00	1.01	.002	7.00	14.00 *

* denotes significantly more verbalisations than the other group

Table 7: A within-group comparison of primary themes verbalised across distance quartile during a lab-based time trial

Secondary theme	Primary theme	Group	Quartile difference	Post-hoc analysis				
				Wilcoxon Rank Z	Cohen's δ	Sig. diff <i>p</i>		
Active Self-Regulation	Motivation	Trained	Quartile 1 – Quartile 3 *	-2.81	1.44	.005		
			Quartile 1 – Quartile 4 *	-2.81	1.99	.005		
			Quartile 2 – Quartile 4 *	-2.20	0.76	.028		
		Untrained	Quartile 1 – Quartile 2 *	-2.33	0.05	.020		
			Quartile 1 – Quartile 3 *	-2.00	0.57	.046		
			Quartile 1 – Quartile 4 *	-2.71	1.23	.007		
Outward Monitoring	Distance	Trained	Quartile 1 – Quartile 3 *	-2.45	1.12	.014		
			Quartile 1 – Quartile 4 *	-2.45	1.58	.014		
			Quartile 2 – Quartile 3 *	-2.53	1.16	.011		
		Untrained	Quartile 2 – Quartile 4 *	-2.68	1.66	.007		
			Distraction	CompuTrainer Scenery	Quartile 1 * – Quartile 4	-2.04	0.68	.041
					Quartile 2 * – Quartile 4	-2.03	0.55	.042

*denotes significantly more verbalisations

Table 8: Mean (SD) whole-trial performance data for trained and untrained groups during a lab-based time trial

	Trained	Untrained
Time (mins)	25.94 (0.89)*	29.82 (3.22)
Speed (km.hr⁻¹)	37.46 (1.41)*	32.63 (2.97)
Power Output (W)	267.90 (24.07)*	195.68 (37.52)
Heart Rate (beats.min⁻¹)	165.62 (9.64)*	151.20 (15.67)

*denotes significantly faster/greater values than the untrained group

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Table 9. Primary and secondary themes identified from the TA social validation interviews.

General Dimension	Secondary Themes	Primary Themes	Example Raw Data Extracts		
TA and Performance	Perceived Impact on Performance	Negative Impact on Performance: “It slowed me down slightly”	<p>“...you had to hold yourself back a little bit more to make sure you could actually speak.” (L3)</p> <p>“...it slowed me down slightly simply because I’m having to do something that I don’t normally do” (L7)</p> <p>“...when I was thinking aloud...I had less concentration in my legs so all my speed dropped” (L8)</p> <p>“I underperformed a little bit. I don’t know what I would have done if I hadn’t been thinking aloud” (L19)</p>		
		No Perceived Impact on Performance: “It was probably as per normal”	<p>“I don’t think thinking aloud per se actually affects performance” (L17)</p> <p>“I wouldn’t say it hindered me and I wouldn’t say it helped me, it is probably, you know, it was probably as per normal I would think.” (F8)</p> <p>“I’m not too sure if it benefited me in my race yesterday “ (F9)</p>		
		Positive Impact on Performance: “Made me push a bit more	<p>“...maybe made me push a bit more because I was like shouting...or concentrating more on my speed.” (L11)</p> <p>“...it made me push myself, sort of as someone else was talking to me but it was me in my head.” (L11)</p> <p>“...the think aloud, I think, was helping me to maybe sustain as I wasn’t sure whether I was going to finish” (L15)</p> <p>“...my performance definitely improved...thinking out loud made me much more aware.” (F3)</p>		
	Perceived Purpose of TA	Within-Race Reflection: “You are giving yourself feedback almost”	<p>“...it can be positive because you’re self-assessing...but it can be negative because you are thinking about it and concentrating on it too much.” (L13)</p> <p>“...verbalising it is a way of synthesising that and then turning it into something a bit more concrete.” (L17)</p> <p>“...you are giving yourself feedback almost...about how you can correct some of that.” (F1)</p> <p>“...it certainly encouraged me, I would say, to reflect a little bit more on what I was doing at the moment.” (F9)</p>		
		Goal-Setting: “Create little goals for myself”	<p>“... when you say a goal...you are more motivated to do it than just thinking that and let it fade away.” (L10)</p> <p>“...it made me sort of in a way create little goals for myself as I knew I had to say something.” (L12)</p> <p>“...I had a 2Km goal, a 4Km goal...So, I was using the think aloud I suppose as a way to re-affirm goals” (L15)</p>		
		Strategizing: “It helped me to pace myself better”	<p>“I was also working out a strategy...it helped me to pace myself better than I expected.” (L8)</p> <p>“I seemed to kind of almost regulate it a little bit better cos I was talking it through in my mind and talking it out loud...so it made me kind of think through a strategy as I was doing it really.” (L19)</p> <p>“...you’re kind of committing yourself to a strategy and when you see that strategy going you have to talk yourself right...So it does keep you more focussed.” (L5)</p>		
		Increased Focus and Concentration: “It puts you in the present doesn’t it?”	<p>“...verbalising it just keeps that focus...the more you got into that habit the more useful it would become.” (L4)</p> <p>“...it puts you in the present doesn’t it? There’s a lot of stimuli and...actually I think think aloud just gets rid of a lot of that and moves it to the back...” (L15)</p> <p>“I suppose you take in more what you’re thinking because you’re saying it out loud...” (L16)</p> <p>“...by thinking aloud I think it tends to kind of relax you a little bit.” (F1)</p> <p>“I think doing the think aloud made me actually more aware...whereas sometimes I think you just switch off” (F3)</p>		
		General Dimension	Secondary Themes	Primary Themes	Example Raw Data Extracts

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Process of TA	Perceived Barriers	Personal Preferences: “I like to shut up and get on with it”	“...in a race with others you probably would look quite odd...I think it is the self-conscious aspect” (L4) “I’m probably quite quiet on the bike...it’s a bit weird talking to yourself.” (L6) “I don’t talk a lot anyway...I have that commentary in my head.” (L7) “I like to shut up and get on with it.” (L18)
		Perceived Difficulties: “You can’t verbalise sometimes because you under so much strain”	“...you are sort of pushing that hard that you can’t really speak anyway.” (L3) “...it was kind of hard to think out loud then as I was catching my breath” (L11) “...by virtue of needing to breathe, you talk less...” (L14) “I had all these thoughts going all at the same time so obviously you can’t say them all...” (L17) “...you can’t verbalise sometimes because you are under so much strain because of the exertion” (F1) “It was quite hard at some points because I was literally blowing out of my backside” (F7) “...it felt like quite an effort to keep talking and thinking about things to talk about” (F11)
		Prior Tendencies: “I talk to myself a lot when I’m on there anyway”	“I’m always thinking in my head when I’m on my bike...it does help when you’re thinking whether it is out loud or in your head” (L5) “I found it quite good actually but I talk to myself a lot when I’m on there anyway.” (L8) “...I would have done it but the only difference is that I am speaking it out loud” (L17)
	Perceived Enablers	Adjusting to the Process: “It came fairly naturally”	“...it came fairly naturally...more naturally than I thought it probably would have done.” (L4) “...it made it a bit more interesting to just cycling and having thoughts in my head...” (L16) “... when I actually started doing the bloody thing, I felt it was quite good.” (L17)
		Openness to TA: “I’ll try it at the weekend”	“I think it works really well for cycling and I think that would be really quite useful” (L8) “...it wasn’t intrusive in any way and I think that would be important, to retain that element” (F9) “I’ll try it, at the weekend I’ll try it and see what happens.” (L14) “I personally wouldn’t use it but I think...it can be used as an internal coaching mechanism” (F7) “I think that I would use it on the training side but not use it in a race.” (F8) “...I’d be happy to do it again without it having a detrimental effect to my performance.” (F9) “I’d be happy to do it again, erm, primarily for the reason I don’t see why not.” (F10)
		Social Desirability: “You know you’re being recorded”	“...it’s a strange one because you know you’re being recorded...” (L11) “...I don’t think there is any particular change in the way I approached it. I sort of went about it how I would normally, it was just obviously talking out loud.” (L11) “You could argue that maybe a lot of it is forced under the circumstances.” (F2) “I think I was thinking more about the fact that I should be sort of speaking...” (F4) “...I think also when you realise you are being recorded you tend to be a bit more positive...” (F7) “...I was a bit quiet and I was thinking I should be saying something” (F8)

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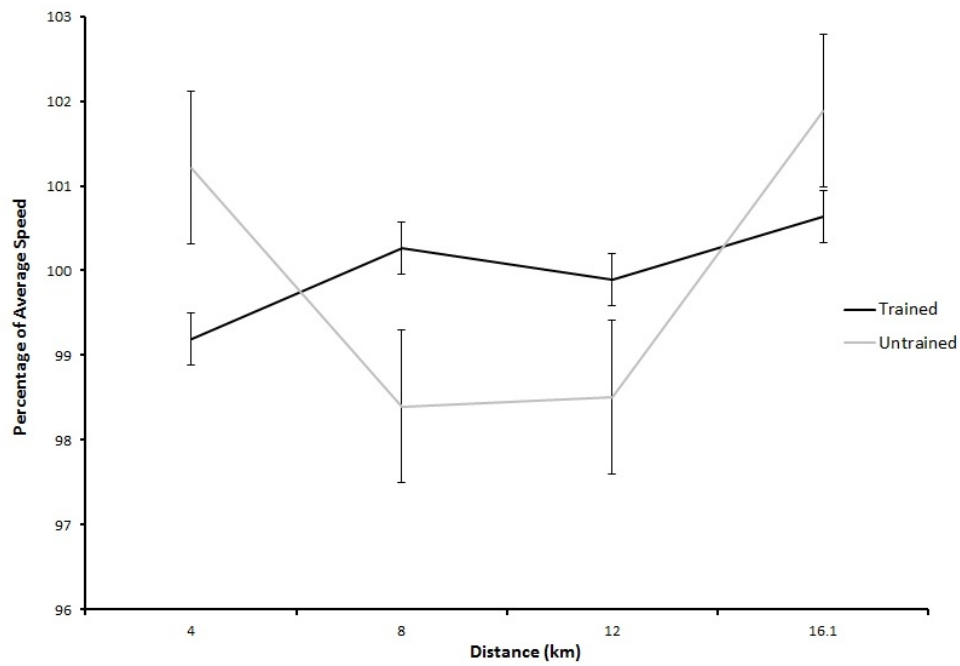


Figure 1: Mean (standard error) pacing profiles for both trained and untrained groups during a lab-based time trial.