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Analysing experienced and inexperienced cyclists' attentional focus and self-regulatory strategies during varying intensities of fixed perceived effort cycling: A mixed method study

C.A. O'Malley [a,b,*], C.L. Fullerton [a,c], A.R. Mauger [a]

[a] School of Sport and Exercise Sciences, University of Kent, Canterbury, CT2 7PE, UK
[b] Faculty of Health and Life Sciences, University of Exeter, Exeter, EX1 2LU, UK
[c] Faculty of Health Sciences and Sport, University of Stirling, Stirling, FK9 4LA, UK

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ABSTRACT

Using a think aloud approach during fixed perceived effort exercise is a unique method to explore the decision-making processes that guide the self-regulation of perceived effort during endurance-based activity. In a two-part study, authors investigated the attentional focus and self-regulatory strategies associated with: Part A - perceived effort corresponding to (RPE_{GET}) and above gas exchange threshold ($RPE_{+15\%GET}$); Part B - between experienced and inexperienced cyclists during fixed perceived effort cycling tasks. Eighteen (15 male, 3 female) healthy, active individuals completed three visits (visit 1 – ramped incremental test and familiarisation, visit 2 and 3–30-min fixed perceived effort cycling). During which, power output, heart rate, lactate, think aloud, and perceptual markers were taken. Random-intercepts linear mixed-effects models assessed the condition, time, and condition × time interactions on all dependent variables. Power output, heart rate, lactate and instances of internal sensory monitoring ($t_{195} = 2.57, p = .011, \beta = 0.95$ [0.23, 1.68]) and self-regulation ($t_{195} = 4.14, p = .001, \beta = 1.69$ [0.89, 2.49]) were significantly higher in the $RPE_{+15\%GET}$ versus RPE_{GET} trial. No significant differences between inexperienced and experienced cyclists for internal sensory monitoring ($t_{196} = -1.78, p = .095, \beta = -1.73$ [−3.64, 0.18]) or self-regulatory thoughts ($t_{196} = -0.39, p = .699, \beta = -1.06$ [−6.32, 4.21]) were noted but there were significant condition × time interactions for internal monitoring ($t_{196} = 2.02, p = .045, \beta = 0.44$ [0.01, 0.87]) and self-regulation ($t_{196} = 3.45, p = .001, \beta = 0.85$ [0.37, 1.33]). Seemingly, experienced athletes associatively attended to internal psychophysiological state and subsequently self-regulate their psychophysiological state at earlier stages of exercise than inexperienced athletes. This is the first study to exhibit the differences in attentional focus and self-regulatory strategies that are activated based on perceived effort intensity and experience level in cyclists.

1. Introduction

Engagement in self-regulated physical exercise is naturally effortful (Marcora, 2008, 2019), requiring individuals to voluntarily allocate physical *and* mental resources towards the task (Preston & Wegner, 2009). When exercising, individuals formulate a subjective awareness of their resource allocation known as the perception of effort (Marcora, 2008; Pageaux, 2014, 2016).

Marcora's (2008) Psychobiological Model identifies that an individual's effort perception is a primary component of effort-based decision-making processes (Pageaux, 2014) which determine whether an individual opts to continue investing resources towards a task (Marcora, 2010a). Therefore, perceived effort factors largely into the engagement, continuation, and termination of any exercise activity (Inzlicht & Marcora, 2016; Marcora, 2008; Marcora & Staiano, 2010; Staiano, Bosio, de Morree, Rampinini, & Marcora, 2018). Consequently, it is of wide interest how perceived effort is self-regulated.

In aim of understanding effort-based decision-making and its impact on exercise behaviour, most previous studies have utilised time-trial (e.g., Barwood, Thelwell, & Tipton, 2008, 2015) or time-to-exhaustion (e.g., Blanchfield, Hardy, de Morree, Staiano, & Marcora, 2014) task paradigms. Granted, using these task paradigms suffices to explain the role of perceived effort towards a maximal exercise capacity. However, a key characteristic of normal activities of daily living and typical exercise pursuits is that they are conducted at submaximal levels throughout

* Corresponding author. Chipperfield Building, School of Sport and Exercise Sciences, University of Kent, Canterbury, CT2 7PE, UK.
E-mail address: cao36@kent.ac.uk (C.A. O'Malley).

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Abbreviations

+15%GET –	15 % above gas exchange threshold
GET –	Gas exchange threshold
LMM –	Linear mixed models regression
RPE –	Rating of perceived effort
RPE_{GET} –	Rating of perceived effort corresponding to gas exchange threshold
$RPE_{+15\%GET}$ –	Rating of perceived effort corresponding to 15 % above gas exchange threshold

(Eston, Lamb, Parfitt, & King, 2005; Marcora & Staiano, 2010; Mauger & Sculthorpe, 2012).

Furthermore, effort (actual resource allocation) and perceived effort (the subjective awareness of resource allocation) are not the same thing (Pageaux, 2016). Importantly, numerous findings show that effort is directly scaled to the task demands (Brehm & Self, 1989; Richter, 2013; Richter, Friedrich, & Gendolla, 2008, 2016; Richter & Gendolla, 2009; Wright, 1996) which a task like a time-to-exhaustion test can easily illustrate. However, during these tasks, perceived effort does not always scale directly towards the task demands (Apps, Grima, Manohar, & Husain, 2015; Chong et al., 2017, 2018; Frömer, Lin, Dean Wolf, Inzlicht, & Shenhav, 2021; Manohar et al., 2015) due to the varying self-regulatory strategies an individual can activate to affect the central processing of effort-driving sensory signals (Brick, MacIntyre, & Campbell, 2014; de Morree, Klein, & Marcora, 2012, 2014; McCormick, Meijen, Anstiss, & Jones, 2019). Interestingly, the self-regulatory approach an individual adopts towards a task could be affected by the intensity of an exercise (Venhorst, Micklewright, & Noakes, 2018) or prior experience (Elferink-Gemser & Hettinga, 2017). As a result, task paradigms which involve maintaining a fixed perceived effort can better illustrate the ways in which the perception of effort and its associated psychophysiological indices are self-regulated during exercise (Eston et al., 2005; Eston & Williams, 1988; O'Malley, Fullerton, & Mauger, 2023).

Self-regulatory processes consist of a metacognitive awareness of, and an exercising of control over, psychophysiological state (Brick, Campbell, Metcalfe, Mair, & Macintyre, 2016; Brick et al., 2014; Brick, MacIntyre, & Campbell, 2016; McCormick et al., 2019). Previous models of attentional focus (e.g., Morgan & Pollock, 1977) indicate that individuals attend towards associative (e.g., paying attention towards interoceptive sensory cues) or dissociative (e.g., looking at the environment, daydreaming) information (Brick et al., 2014; Lind, Welch, & Ekkekakis, 2009; Morgan & Pollock, 1977).

Studies indicate that during exercise of a higher intensity, individuals are disposed to an associative focus due to the presence of more salient sensory signals informing of a greater disruption from resting homeostatic state (Ekkekakis, Parfitt, & Petruzzello, 2011; Zenko, Ekkekakis, & Ariely, 2016). In addition, there is an individual element to attentional focus (Hutchinson & Tenenbaum, 2007). For example, experienced athletes have also been found to attend to more internal/associative *and* task-relevant cues (McCormick, Meijen, & Marcora, 2015, 2019). Meanwhile, inexperienced athletes have demonstrated a greater dissociative *and* task-irrelevant focus than experienced counterparts (Brick, MacIntyre, & Campbell, 2016; Whitehead et al., 2018). Relatedly, in performance-based settings, an associative focus is linked to superior outcomes as individuals gain a competitive advantage from being more attuned towards psychophysiological states (Hutchinson & Tenenbaum, 2007; Masters & Ogles, 1998) and can activate more appropriate self-regulatory states (Lind et al., 2009). Whether this relationship also pertains to more normal everyday exercise activities remains to be seen, but the same premise could be argued that being more attuned towards inner states leads to more appropriate self-regulatory strategies and therefore, a prolonged engagement in an exercise (Evans, Boggero, & Segerstrom, 2016).

Evidently, what individuals are attuned to influences the ensuing regulatory processes that are activated (Brick et al., 2014). Using Carver and Scheier's (1982) Cybernetics Control Theory as a basis (see supplementary materials), researchers can understand how individuals constantly entertain self-control loops to adapt their behaviour/self in relation to a specific standard/constant. In the context of a fixed perceived effort trial, a set rating of perceived effort (RPE) is a constant. Prolonged engagement in exercise naturally elicits changes in psychophysiological state (Venhorst et al., 2018), instigates the onset of fatigue (Enoka & Duchateau, 2016), and subsequently impacts the prevalence and processing of effort driving signals (Behrens et al., 2023; Pageaux, 2016). Thus, prolonged exercise is expected to stimulate changes in perceived effort and its self-regulation (Pageaux, 2016). To bring perceived effort back into accord with the required RPE individuals activate self-regulatory techniques (Carver & Scheier, 1982, 2000; McCormick et al., 2019; Pageaux, 2014). This regulation is primarily achieved through the alterations of physical output (de Morree et al., 2012) *and/or* use of cognitive strategies that alter the neurological processing of effort-driving signals (Marcora & Staiano, 2010; McCormick et al., 2019).

Importantly, the athlete must feel efficacious in their ability to use these strategies (McCormick et al., 2019) and deem them useful to the situation (Renfree, Martin, Micklewright, & St Clair Gibson, 2014; Zimmerman, 2000). To illustrate, behavioural changes like lowering power output involves a reduction in central drive and subsequent production and processing of efferent copies (corollary discharge) which generate perceived effort (Pageaux, 2016). Meanwhile, cognitive strategies such as reappraisal (Giles et al., 2018; Grandjean da Costa et al., 2022; Sammy et al., 2017; Urry, 2009) and self-talk (Barwood et al., 2008, 2015; Blanchfield et al., 2014) can moderate perceived effort in the face of underlying neuro-psychophysiological changes during physical endurance-based exercise. Mainly, reappraisal and self-talk are theorised to alter the neuronal processing of corollaries either via changes in the hedonic (Brand & Ekkekakis, 2021; Ekkekakis & Brand, 2019; Grandjean da Costa et al., 2022; Gross, 2002, 2013) or motivational (Barwood et al., 2008, 2015; Blanchfield et al., 2014) affective experience. Associatively, studies have documented a reduced activity at cerebral centres involved with effort perception such as the anterior cingulate cortices when individuals engage in reappraisal compared to without reappraisal (Giles et al., 2018; Robinson, Montgomery, Swettenham, & Whitehead, 2021). Finally, purposeful dissociation and distraction techniques can also mitigate perceptions of effort as other information/signals take up a portion of a finite 'bandwidth' causing less effort-generating signals to be processed, leading to reduced perceived effort (Brick et al., 2014).

It has been widely accepted that employing strategies that come under the wider term of 'self-regulation' are vital to increasing the likelihood of success within any goal-directed pursuit (Evans et al., 2016). However, current methodologies (e.g., questionnaires and interviews) lack the capacity to track the full extent of an individual's metacognitive and self-regulatory processes (McCormick et al., 2019). Any cognitions or feelings that an athlete has entertained during an event may be missed or forgotten when using *post hoc* data collection methods (Eccles & Arsal, 2017; Ericsson & Simon, 1980). However, a recent introduction of a "think aloud" approach into the exercise domain enables researchers to monitor the active cognitions and feelings an athlete entertains *during* a task (Samson, Simpson, Kamphoff, & Langlier, 2017; Whitehead et al., 2018). As such, researchers can retrospectively analyse segments of an athlete's verbalisations to discern the cognitive processes (including attention and self-regulation) that operated to moderate decisions during endurance-based exercise (Eccles & Arsal, 2017).

Emerging within the exercise science field, a collection of studies have probed the regulation of pace whilst utilising a think aloud protocol during endurance-based cycling and running time-trials (e.g., Massey, Whitehead, Marchant, Polman, & Williams, 2020; Samson, 2014; Samson et al., 2017; Whitehead et al., 2018, 2019). Whitehead et al. (2018) observed that 63 % of all verbalisations during a 16.1 km time-trial pertained to active self-regulation, highlighting the significance of self-regulatory processes during endurance-based activity. Furthermore, the authors determined that the experienced athletes within the cohort would entertain more self-regulatory thoughts in earlier phases of the time-trial whilst internal sensory monitoring (e.g., focusing on pain) and distraction (e.g., focusing on irrelevant information) prevailed in the earlier phases for inexperienced athletes (Whitehead et al., 2018). Consequently, differences in focus allow experienced athletes to engage in a more directed and functional regulation of perceived effort for endurance-based motor performance benefits (Whitehead et al., 2018) whilst distraction techniques used by inexperienced athletes are linked to suboptimal perceived effort regulation and performance-based results (Brick, Campbell, et al., 2016).

Resultantly, this paper comprises two parts with two primary aims.

Part A – Investigating the attentional focus and self-regulation of perceived effort at different fixed perceived effort intensities.

To further the recent explorations of self-regulatory processes and their influence on behaviour, *Part A* investigated the differences in attentional focus and self-regulatory processes at varying fixed perceived effort intensities across a healthy, active population. It was hypothesised that participants would entertain more self-regulatory thoughts in the harder intensity compared to lower intensity fixed perceived effort trial.

Part B – Investigating the differences in attentional focus and self-regulation of perceived effort between experienced and inexperienced cyclists during a fixed perceived effort cycling task.

Successively, *Part B* aimed to probe the potential differences in attentional focus and self-regulatory processes between experienced and inexperienced populations that have been identified in previous studies (Whitehead et al., 2018). It was hypothesised that experienced cyclists would entertain more self-regulatory cognitions compared to inexperienced counterparts whilst inexperienced cyclists would entertain more distractive thoughts compared to experienced counterparts.

2. Methods

2.1. Participants

The present study consisted of 20 (15 male, 5 female) healthy, active individuals (Table 1). All participants were currently physically active engaging in at least 150 min.week^{-1} as well as engaging in some form of cycling-based activity (e.g., outdoor rides, ergometer rides, spin classes) during their week. Participants were allocated to specific performance level groups according to previous research (de Pauw et al., 2013). Namely, those who were: (1) currently active in cycling for over 150 min per week; (2) had over three years cycling experience; (3) demonstrated a $\dot{V}O_2$ max over 53 mL kg^{-1}.min^{-1} were considered level P3 and made up the 'experienced' group. All other participants who were considered physically active (>150 min prolonged physical activity per week) but did not have at least three cycling experience and/or had a $\dot{V}O_2$ max below 53 mL kg^{-1}.min^{-1} were considered level P2 and made up the 'inexperienced' group. For Part A, the sample included all 20 participants across both participation levels. For Part B, participants were equally split according to their participation level (10n experienced = P3, 10n inexperienced = P2). Due to failure to comply with the think aloud protocol, two participants were removed (one from each group, both female) leaving nine participants in each of the experienced/inexperienced groups. At the time of data collection for this study, no prior research had been conducted of this nature (i.e., using fixed perceived effort trials), therefore there were no effect size estimates available for an α-priori calculation. Furthermore, prior studies utilising time-trial tasks (e.g., Massey et al., 2020; Whitehead et al., 2018, 2019) had not reported any α-priori calculations with similar or less participants (n = ~12–20). Nevertheless, a post-hoc analysis using G:Power 3.1 found that to detect a large effect ($f = 0.3$, $\alpha = 0.05$, groups = 2, measurements = 6, n = 18) our sample of 18 participants resulted in an achieved power ($1 - \beta$ err prob) of 0.93. Since the onset and write-up of this study, a pilot by Robinson et al. (2021) demonstrated a similar approach.

None of the participants suffered from any underlying cardiorespiratory, metabolic, neurological or other pre-existing medical conditions or were taking any form of medication. The study was ethically approved (Prop 52_2019_20) and all procedures were in accordance with scientific standards outlined by the Declaration of Helsinki. All research sessions were scheduled at the same time of day (± 2 hours), and participants abstained from food (2 hours), caffeine (4 hours), alcohol (24 hours), intense exercise (48 hours) and were asked to replicate eating habits in the 24 hours leading up to each session. All female participants were eumenorrheic and were scheduled to conduct all procedures during their luteal phase to minimise any confounding effects due to the stage of menses in the study (McNulty et al., 2020).

Table 1
Mean ± SD of participant anthropometrics and performance markers.

Group	Study 1	Study 2	
	All	Experienced	Inexperienced
Age (years)	27 ± 5	28 ± 5	25 ± 3
Activity (hours·week^{-1})	8.3 ± 4.4	10.4 ± 5.5	6.2 ± 1.8
Cycling experience (years)	7.8 ± 6.5	11.2 ± 7.1	4.4 ± 3.6
$\dot{V}O_2$ (mL.kg^{-1}.min^{-1})	54.3 ± 8.4	61.1 ± 6.7	47.6 ± 3.1
RPE_{GET}	13.2 ± 0.6	13.3 ± 0.4	12.9 ± 0.6
$RPE_{+15\%GET}$	15.1 ± 0.5	15.0 ± 0.7	15.3 ± 0.5

2.2. Measures

All scales were explained during recruitment and repeated explanations were provided at the start of every experimental session. Participants were informed that they could provide decimalised answers and reminded that there were no right/wrong answers but that they should provide responses that were most truthfully reflective of their current psychophysiological state.

2.3. Ratings of perceived effort

Both parts of the study used the Borg 15-point RPE scale (Borg, 1970, 1982) which denoted "How hard, heavy and strenuous does the exercise feel to drive the working muscles and your breathing?" (Marcora, 2010b). To maximise the measurement validity of the RPE scale the semantic representation of perceived effort that researchers provided was precise and consistent according to the aforementioned definition (Halperin & Emanuel, 2020). Additionally, the same anchors for the minimum (6 – "like when you are sitting, doing absolutely nothing") and maximum (20 – "like giving everything you have got at the end of a $\dot{V}O_2$ max test") ratings were provided (Malleron, Har-Nir, Vigotsky, & Halperin, 2023). Moreover, added scales that encapsulated similar psychophysiological phenomena were used in this study.

2.4. Affective valence

Responses for affective valence were collected via the single-item, 11-point feeling scale (Hardy & Rejeski, 1989) denoting "How are you feeling at the current moment of the exercise". Responses ranged from

+5 "I feel very good" to −5 "I feel very bad" with a median of 0 denoting "Neutral".

2.5. Self-efficacy

Responses for self-efficacy were collected via an adapted single-item scale from Bandura's social-cognitive framework (Bandura, 1997) denoting "How confident are you that you can tolerate the physical and mental effort associated with the task to maintain your current performance level". Responses ranged from 10 "extremely confident" to 0 "not at all confident" with a median of 5 denoting "moderately confident".

2.6. Think aloud protocols

During all sessions a think aloud protocol was employed to capture the participants' conscious thought processes during the fixed perceived effort cycling exercises. All think aloud data from all visits were recorded through a microphone which was fixed on the handlebars of the cycle ergometer. Later, the audio files were transcribed *verbatim* and underwent content analysis post-data collection (*see Analysis*). Recent guidelines (Birch & Whitehead, 2020; Eccles & Arsal, 2017) were adhered to so that the quality of information disclosed by participants was maximised. Furthermore, this study emphasised the disclosure of level two think aloud data as this captures the ongoing focus and cognitions (Birch & Whitehead, 2020; Ericsson & Simon, 1993) which were central to this study's aims. In turn, the think aloud instructions deterred level three think aloud data disclosure, emphasising that participants did not need to elaborate on their thoughts (Birch & Whitehead, 2020).

Firstly, in the week prior to any testing, a clear instructional set (see supplementary materials) including practice exercises was provided to participants. Exercises include practising a think aloud protocol for assigned tasks (e.g., anagram task) as well as a transference of this protocol to everyday tasks such as unpacking shopping. Finally, participants then progressed towards conducting a think aloud protocol during their general physical activity exercise (e.g., a recreational cycle).

During experimental data collection sessions, participants were always instructed to "Please think aloud by trying to say out loud anything that comes into your head throughout the trial. You do not need to try to explain your thoughts and you should speak as often as you feel comfortable in doing so". To aid the participants, instructional cues were placed on the handlebars to prompt athletes. The lead researcher also provided a prompt by reemphasising the instructions relating the think aloud protocol should participants fall silent for more than 2 min. Finally, throughout all data collection, the researcher positioned themselves out of sight of the participant to minimise any intrusion. All these measures taken by the researchers are in keeping with previous research utilising and advising on think aloud protocols (Birch & Whitehead, 2020; Eccles & Arsal, 2017; Ericsson & Simon, 1980; Massey et al., 2020; Samson, 2014; Samson et al., 2017; Whitehead et al., 2018, 2019).

2.7. Mixed-methods approach

Quantitative and qualitative data were collected simultaneously during this study. Prior to data collection, authors adopted a clear post-positivist epistemological and objectivist ontological view as think aloud data were to be entered into pre-set themes via an adapted framework from Brick et al. (2014). This is similar to previous research using an identical framework and exercise tasks (Massey et al., 2020; Robinson et al., 2021; Whitehead et al., 2018, 2019). Adaptations to the framework were made to adapt the framework to the exercise task (fixed perceived effort trials) and were based on an initial inductive analysis of the think aloud data (see *Think Aloud Content Analysis*).

Therefore, qualitative think aloud data were quantified for the number of times they appeared within a pre-set theme so that all data was analysed together (Bryman, 2006). Likewise, this ensured that our analysis of the qualitative data was consistent with our post-positivist and objectivist philosophical views (Cresswell & Piano Clark, 2007).

2.8. Procedures

This study implemented a randomised cross-over repeated measures design in which participants were required to visit the same laboratory (mean ± SD temperature, 18.9 ± 2.5 °C; humidity, 33 ± 9%; barometric pressure, 780 ± 6 mmHg) on three separate occasions (Figure 1). After arrival, participants were provided with a heart rate monitor (Cyclus2: ANT+, Leipzig, Germany) which recorded heart rate on a beat-by-beat basis and provided a 20 μL resting blood lactate sample from the right index finger assessed using an automated lactate analyser (Biosen: *C*-Line, EKF Diagnostics, GmbH, Barlaben, Germany).

After initial preparation, participants were required to perform a 10-min self-selected warm-up on the same cycle ergometer (Cyclus2, Leipzig, Germany). After completion the researcher provided a final explanation of the upcoming protocol and measures. After confirmation of understanding, participants provided a 'resting' value for each scale before remounting the cycle ergometer to begin the respective exercise tasks for each session. Within *Visit 1* only, participants were fitted to the gas analyser system (Cortex Metalyser: Model 3 B, Leipzig, Germany) to assess pulmonary ventilation on a breath-by-breath basis to determine specific gas exchange parameters (e.g., gaseous exchange threshold [GET]) for the derivation of the fixed perceived effort intensities in subsequent visits (*Visit 2 and 3*). The gas analyser was pre-calibrated using a fixed 3 L syringe (Hans Rudolph, Kansas, USA) and known gas concentrations.

2.9. Visit 1 - ramped incremental test and familiarisation

After preparation and a warm-up, participants cycled for an initial 3-min period at 80 % of the starting intensity Watts (W) so that gas parameters could stabilise before commencing the ramped incremental test. In accordance with previous pilot work to ensure that $\dot{V}O_2$ max was reached within 8 - 10 min (Iannetta et al., 2020), the starting intensity was set at 100 W for males and 50 W for females. During this time, participants were asked to cycle at a comfortable cadence of ~80 revolutions.min^{-1} and were recommended to gradually increase cadence over the course of the incremental test. At the commencement of the ramped incremental test power output increased incrementally by 25 W.min^{-1}. At each minute (including at the starting intensity), RPE was recorded. Task cessation occurred when the participant believed they had reached volitional exhaustion or if cadence fell below 60 revolutions.min^{-1} for more than five seconds despite strong verbal encouragement. An additional RPE measurement was taken at exhaustion alongside a final blood lactate sample.

After the incremental test, participants had a 15-min passive recovery. Once ready, participants then completed a 10-min familiarisation at two pre-selected fixed perceived effort exercises (5 min each) corresponding to 13 "somewhat hard" and 15 "hard" on the 15-point Borg scale (Borg, 1970, 1982). These values were selected based on estimated values from previous research to correspond to intensity conditions for *Part A* (Cochrane-Snyman, Housh, Smith, Hill, & Jenkins, 2019; O'Malley et al., 2023). In addition, participants were also asked to practice the think aloud protocol during the familiarisation. During the fixed perceived effort cycling, all performance-related variables – except cadence - were blinded so that participants regulated performance according to a constant perceptual marker without any extraneous influence. During the fixed perceived effort trials (familiarisation and experimental sessions), participants could change their power output at any point by using the virtual gears on the Cyclus2 console to ensure that they maintained the same perceived effort throughout the trial.

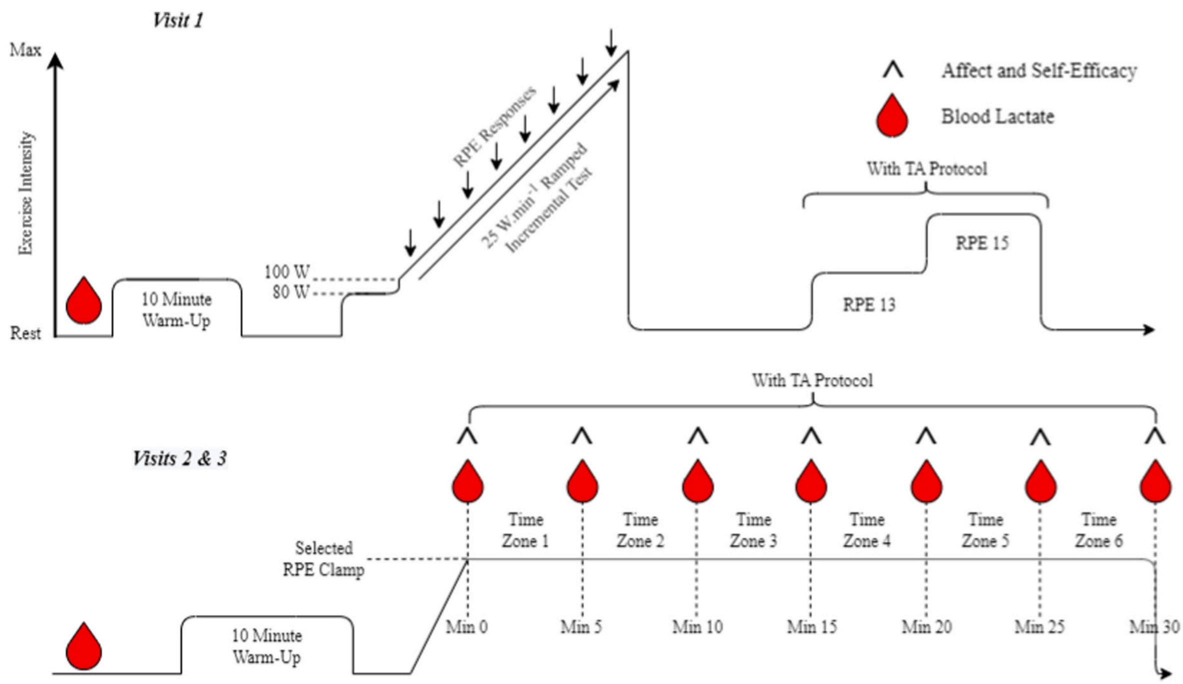

Figure 1. Visual representation of study protocols. W represents power output. ∧ indicates affective valence and self-efficacy measurements. ● represents blood lactate measurements. ↓ represent rating of perceived effort (RPE) measurements. TA represents the think aloud protocol.

2.10. Determination of RPE_{GET} and $RPE_{+15\%GET}$

Individual's GET was determined by utilising a $\dot{V}-$ slope method (Beaver, Wasserman, & Whipp, 1986) whereby GET corresponded to the point at which $\dot{V}O_2$ values above and below the breakpoint with $\dot{V}CO_2$ diverged from the intersection of the two linear regression lines. For validation, $\dot{V}-$ slope was used in conjunction with secondary criteria including: ventilatory equivalents; end-tidal volumes and respiratory exchange ratio. A secondary researcher was used to confirm that GET was assigned at the same place. Once GET was determined, $\dot{V}O_2$ values that were 15 % above GET were also calculated. Using these values, the power output that was exerted over the course of the ramped incremental test was plotted against the $\dot{V}O_2$ and a linear regression equation ($y = mx + c$) derived the power output that corresponded to GET and 15 % above GET. Finally, the ramped incremental power output data were plotted against the obtained RPE values in which an identical linear regression equation was used to identify RPE at GET (RPE_{GET}) and 15 % above GET ($RPE_{+15\%GET}$). These RPE values were rounded to the nearest whole number and used as reference values for the subsequent experimental visits (Table 1).

2.11. Visit 2 and 3 – fixed perceived effort cycling with think aloud

After an identical preparation and warm-up to other visits, participants completed a 30-min fixed perceived effort cycle whilst adhering to the think aloud protocol. Conditions (i.e., RPE intensity) were randomised for each participant.

Initially, participants were asked to cycle at an RPE 10 between "very light" and "light") for 2 min. Participants were asked to select a cadence between 80 and 90 revolutions.min^{-1} that was maintained throughout the cycle (± two revolutions.min^{-1}) and replicated between both sessions. Participants received the same think aloud instructions and were asked to begin thinking aloud. Once the 2 min elapsed, participants were afforded up to 2 min to ramp to the required RPE (mean time taken = 35 seconds) that corresponded to the given condition (i.e., RPE_{GET} or $RPE_{+15\%GET}$) by changing the virtual gears on the Cyclus2. When this intensity was reached, the timer was started. Hereon, participants could alter their power output as they wished via the virtual gears to ensure they maintained the same perceived effort throughout. During fixed perceived effort cycling, power output and heart rate were extracted continuously (each second) throughout the 30-min exercise. Every 5 min, including Minute 0, blood lactate, affective valence and self-efficacy were recorded until completion of the trial. Participants could drink *ad libitum* throughout but were asked to consume the same amount of water between conditions. A prior study has established the test-retest reliability of this protocol for both intensities at a physiological (e.g., cardiorespiratory measures) and performance (e.g., power output) level (O'Malley et al., 2023).

2.12. Think Aloud Content Analysis

Consistent with the post-positivist and objectivist philosophical position, the researchers of this study chose an established framework to categorise think aloud data (Brick et al., 2014). This is identical to previous research in the field (Massey et al., 2020; Samson et al., 2017; Whitehead et al., 2018, 2019).

Prior to final allocation of think aloud data to themes, an inductive analysis was completed to ensure that all think aloud data could be appropriately allocated to a relevant theme. In doing so, adaptations to the framework (Brick et al., 2014) were made after inductive analysis that accounted for the difference in exercise task (time-trial vs fixed perceived effort) from previous studies (Brick et al., 2014; Massey et al., 2020; Whitehead et al., 2018) by removing irrelevant themes that did not present in any of the participant's think aloud verbalisations (e.g., distance as no distance markers were measured during this study) and adding relevant themes that were present in the think aloud data but did not fit a select theme (e.g., monitoring of RPE) to this study. Deductive, content analysis then followed this adapted version of the metacognitive framework (Brick et al., 2014) as used in previous studies (Whitehead et al., 2018). First, all verbalisations were grouped into a primary theme which was further allocated to one of the four secondary themes: internal sensory monitoring; outward monitoring; active self-regulation; distraction/miscellaneous (see Table 2).

Set rules were pre-registered by the authors to denote one single

Table 2
Example *verbatim* quotes coded according to primary and secondary themes and their descriptors.

Secondary Themes	Primary Theme	Description	Example
Internal Sensory Monitoring	Breathing	Reference to breathing or respiratory-related signals	"I am thinking about my breathing a lot" (N11-UT5) "The breathing is quite rapid" (N18-T9)
	Pain/Discomfort	Reference to actual or potential tissue damage perceptions or general discomfort during the task	"Saddle is getting kind of painful" (N16-UT9) "Just concentrating on the pain, legs feel loaded" (N5-T3) "A little back pain as well as the legs" (N9-T6)
	Hydration	Reference to, or actual noting of needing and/or taking drink	"Time for my first bit of water" (N16-UT9) "Oh, I cannot wait to get a drink" (N14-UT8) "Mouth is a little dry, have some water" (N5-T3)
	Fatigue	Reference to mental or physical tiredness or difficulty to complete the task but independent of pain.	"Really heavy legs today" (N1-T1) "Feel tired and the legs are definitely worse than last time (N12-UT6) "Actually feel very rested coming into this" (N6-T4)
	Temperature	Reference to the self or room feeling hot/neutral/cold. Also included references to sweat.	"I can feel my face going really red" (N11-UT5) "I am dripping with sweat like a waterfall" (N14-UT8)
	Perceived Effort	Reference to remaining at a set perceived effort rating	"Maintaining that rating of 14 [RPE]" (N7-T5)
	Heart Rate	Reference to any acknowledgement of heart rate or speculation on its value	"Wonder what my heart rate is, 160's?" (N7-T5) Can definitely feel my heart beating" (N13-UT7) "Heart rate feels like it is maxing out" (N17-T8)
	Psychological State	Reference to any past, current, or future psychological state	"Probably passing into the negatives for affective valence now" (N8-UT3) "I am motivated, I am alert, but I am bored" (N6-T4)
	Physiological State (Miscellaneous)	Reference to any physiological state not included in previous themes	"I wonder what my lactate concentration is at, around 2?". (N4-T2) "Absolutely starving now" (N8-UT3)
Outward Monitoring	Time	Reference to time elapsed/remaining	"I underestimated how long this task feels it would take" (N9-T6) "Around 5 min passed, break it into those chunks" (N2-UT1)
	Cycling Movement	Reference to the movement of the cycle ergometer that are not related to technique	"The frame is a bit wavy" (N9-T6) "The bike frame makes you feel very upright" (N6-T4)
	Researcher Behaviour	Reference to the researcher's behaviour	"Will the researcher be able to get blood out of that finger prick?" (N16-UT9)
Active Self-Regulation	Cadence	Reference to pedal strokes and its value	"Cadence is high, but I have kept it stable" (N15-T7)
	Gears	Reference to the past, current, or planned gear selections	"This gear is good, comfortable" (N13-UT7) "Changing a gear could disrupt the rhythm" (N4-T2)
	Power (no direction)	Reference to the power output without note of its direction	"If I was to guess, I am in the 218 to 220 Watts range now" (N1-T1) "Reckon it feels like 320 Watts" (N17-T8)
	Power (increase)	Reference to increasing the power output	"Actually, I am going to put the power up a bit on this section, to not drop the RPE" (N2-UT1) "Do you know what, I can bump it [power] up as the end is in sight" (N1-T1)
	Power (decrease)	Reference to decreasing the power output	"I am going to have to lower it [power], as I am just really sore" (N10-UT4) "Think I will decrease the intensity a bit to keep the RPE at 15" (N4-T2)
	Power (remain constant)	Reference to maintaining the current power output	"Just try and see it through, see it out at this intensity now" (N12-UT6)
	Emotional Control/ Appraisal	Reference to altering current perception of the situation or emotions	"It is just RPE 15, I have done much worse before, like a 40 km time-trial" (N2-UT1) "Change the way you think about things, that is all you can do" (N1-T1)
	Self-Talk	Reference to any talk directed to the self	"Great job, keep it going, keep the legs turning" (N3-UT2)
	Technique/Form	Reference to the movement and execution of the task on the ergometer	"Keep those legs ticking, tuck in, find that nice rhythm" (N3-UT2) "Keep the legs aligned with the pedal" (N4-T2) "Keeping a relaxed position with my arms, neck and shoulders" (N15-T7)
	Imagery	Reference to imagined experience related to the task	"Imagine … you are at Belvedere now, only 5 min from home" (N16-UT9) "Imagine like a nice long ride around the country lane" (N14-UT8)
Distraction	Distraction	Reference to specifically trying to ignore or forget about the present task	"My head wants to avoid it, or get outside the thought of the exercise" (N18-T9) "It is pleasurable to not think about the exercise" (N14-UT8) "I am going to start counting to distract myself" (N11-UT5)
	Miscellaneous	Reference to any irrelevant information or other verbalisations that do not match any other theme.	"Today made me realise I really need a haircut" (N8-UT3) "Think I will pick some chestnuts later" (N10-UT4)

Legend: N = Participant's number; T = Trained participant; UT = Untrained participant 'verbalisation'. Any single verbalisation was considered as any speech that occurred with a minimum of 2 seconds prior to non-verbalisation. Exceptions to this rule had to meet the following criteria: 1a) the verbalisation was disrupted by the researcher due to protocol-based measures; 1 b) *or* from exercise-induced behaviour (e.g., heavy breathing/ drinking water) 2) *and* clearly followed the narrative of the previous verbalisation. If one verbalisation consisted of numerous themes it was allocated to all relevant themes. The number of verbalisations was calculated over the entire 30-min ('Overall') and for each time zone (*see Analysis*).

2.13. Analysis

All continuous data (power output, physiological [except blood lactate, coded think aloud data) were averaged across six, 5-min time zones (TZ) (e.g., TZ1 = minute 0–5). Perceptual markers such as affective valence and self-efficacy, as well as $[La^-]_b$ were analysed according to the minute they were taken (e.g., minute 0, 5, etc). Absolute counts were also calculated as percentages of total verbalisations according to each TZ and overall. The mean values for continuous data across the group, experienced group, and inexperienced group were used in subsequent analysis.

All data were exported to Jamovi (JAMOVI: v 2.3, Sydney, Australia). All data were assessed for normality and symmetry using Q-Q plots and a Shapiro-Wilk test before any further analysis. Any data that exceeded 2SD from the group mean was excluded from further analysis. A series of *t* tests were conducted to assess differences in resting responses for perceptual markers and blood lactate. A Wilcoxon signed ranks test was reported with a rank biserial correlation (*r*) denoting effect size if data violated normality.

A random-intercepts linear mixed-effects models (LMM) was conducted to assess the condition and time effects, and condition × time interactions on all dependent variables data. The condition main effect for *Part A* was the intensity of the fixed perceived effort exercise (RPE_{GET} versus $RPE_{+15\%GET}$). The condition main effect for *Part B* was the training status of the participants (experienced versus inexperienced). The variable of *condition* and *time* were set as fixed effects. Models were fitted according to the group intercept and clustered for each participant. Results from the LMM were reported as *t* values (RPE_{GET} versus $RPE_{+15\%GET}$ or experienced versus inexperienced) as time was entered as a continuous variable. Another benefit to this method is that reporting of estimated marginal means (β-coefficient) denotes the raw mean differences between the two conditions as an effect size with supplementary 95 % confidence intervals. A normality test was conducted on the residual values and if they violated normality, a Wilcoxon signed ranks test was reported with a rank biserial correlation (*r*) denoting effect size.

3. Results

3.1. Resting values and standardisation

Resting values for blood lactate ($t_{17} = 1.85, p = .082, d = .44$) and affective valence ($Z = 45.00, p = .076, r = .64$) demonstrated no significant differences between fixed perceived effort intensities. Resting values for self-efficacy did differ significantly between fixed perceived effort intensities ($t_{17} = 3.78, p = .002, d = .89$). Resting values for $[La^-]_b$ ($Z = 10.00, p = .155, r = .56$), affective valence ($t_{17} = 1.75, p = .099, d = .41$), and self-efficacy ($t_{17} = 0.68, p = .504, d = .16$) demonstrated no significant difference between training status.

Cadence was not significantly different between intensities ($t_{195} = 1.43, p = .153, \beta = 0.26$ [− 0.10, 0.61]), or training status ($t_{196} = -0.38, p = .709, \beta = -0.67$ [− 4.11, 2.77]). There were no significant condition × time interactions for exercise intensity ($t_{195} = 0.60, p = .550, \beta = 0.06$ [−0.14, 0.27]) or training status ($t_{196} = 1.02, p = .310, \beta = 0.11$ [− 0.10, 0.32]). Cadence was observed to significantly increase over the course of the exercise ($t_{195} = 2.55, p = .012, \beta = 0.14$ [0.03, 0.24]) but observation of the raw values (mean at TZ1 = 86.5 revolutions.min^{-1} versus mean at TZ6 = 87.2 revolutions.min^{-1}) show this change was trivial and in keeping with the instructions delivered by the researcher (± two revolutions.min^{-1}).

3.2. Part A

3.2.1. Power output and physiological markers

Power output demonstrated a significant condition effect as it was found to be significantly higher in the $RPE_{+15\%GET}$ than the RPE_{GET} condition ($t_{195} = 13.14, p = .001, \beta = 22.19$ [18.88, 25.50]). Power output also decreased over time in both conditions with main time effects ($t_{195} = -9.66, p = .001, \beta = -4.77$ [− 5.74, − 3.81]). There was also a condition × time interaction for power output changes ($t_{195} = -2.21, p = .028, \beta = -2.18$ [−4.12, −0.25]) suggesting trajectories in power output changes differed significantly (Figure 2αi).

Heart rate demonstrated a significant condition ($t_{195} = 18.06, p = .001, \beta = 14.65$ [13.06, 16.24]) and time main effect ($t_{195} = 7.08, p = .001, \beta = 1.68$ [1.22, 2.15]). However, there was not a significant condition × time interaction observed ($t_{195} = 0.77, p = .443, \beta = 0.37$ [−0.57, 1.30]) suggesting heart rate was higher in the $RPE_{+15\%GET}$ compared to RPE_{GET} condition but both conditions elicited a similar increase in heart rate (Figure 2βi).

Blood lactate demonstrated a significant condition ($t_{231} = 12.02, p = .001, \beta = 2.83$ [2.37, 3.30]) and time ($t_{231} = 4.63, p = .001, \beta = 0.19$ [0.11, 0.28]) main effect. A significant condition × time interaction was also observed ($t_{231} = 3.27, p = .001, \beta = 0.27$ [0.11, 0.44]) suggesting that blood lactate was significantly higher in the $RPE_{+15\%GET}$ condition, increased over time across both conditions, but increased at a greater rate in the $RPE_{+15\%GET}$ versus RPE_{GET} condition (Figure 2γi).

3.2.2. Think aloud data

Instances of internal sensory monitoring were significantly higher in the $RPE_{+15\%GET}$ compared to RPE_{GET} conditions with significant main effects observed ($t_{195} = 2.57, p = .011, \beta = 0.95$ [0.23, 1.68]). A significant time main effect was not observed across the entire cohort ($t_{195} = -1.82, p = .070, \beta = -0.20$ [−0.41, 0.02]) and there was not a significant condition × time interaction ($t_{195} = 0.14, p = .890, \beta = -0.03$ [−0.40, 0.46]) (Figure 3αi).

Instances of outward monitoring were not significantly different between exercise intensities with no main condition effect ($t_{195} = -0.40, p = .690, \beta = -0.10$ [− 0.60, 0.40]). There was a significant increase in outward monitoring over the course of the fixed perceived effort cycling ($t_{195} = 5.30, p = .001, \beta = 0.40$ [0.25, 0.54]). However, there was no significant differences in the changes in outward monitoring instances between conditions ($t_{195} = 1.31, p = .193, \beta = 0.20$ [−0.10, 0.49]) (Figure 3βi).

Instances of self-regulation were significantly higher in the $RPE_{+15\%GET}$ versus RPE_{GET} condition with main condition effects observed ($t_{195} = 4.14, p = .001, \beta = 1.69$ [0.89, 2.49]). Instances of self-regulation from the think aloud protocol did not demonstrate a main time effect ($t_{195} = 1.50, p = .134, \beta = 0.18$ [−0.05, 0.41]) but there was a significant condition × time interaction ($t_{195} = 2.99, p = .003, \beta = 0.71$ [0.25, 1.18]) indicating a greater increase in verbalisations relating to self-regulation as the exercise progressed in the $RPE_{+15\%GET}$ versus RPE_{GET} condition (Figure 3γi).

Instances of distraction from the think aloud protocol showed no significant condition ($t_{195} = -0.34, p = .736, \beta = -0.07$ [−0.50, 0.36]) or time ($t_{195} = 0.15, p = .882, \beta = 0.01$ [−0.11, 0.14]) main effects. Likewise, there was no significant condition × time interaction observed ($t_{195} = 0.22, p = .824, \beta = 0.03$ [−0.22, 0.28]) (Figure 3δi).

The total number of verbalisations was significantly higher in the $RPE_{+15\%GET}$ versus RPE_{GET} condition with significant main condition effects observed ($t_{195} = 3.89, p = .001, \beta = 2.46$ [1.22, 3.71]). A significant time effect was also observed with more verbalisations towards the

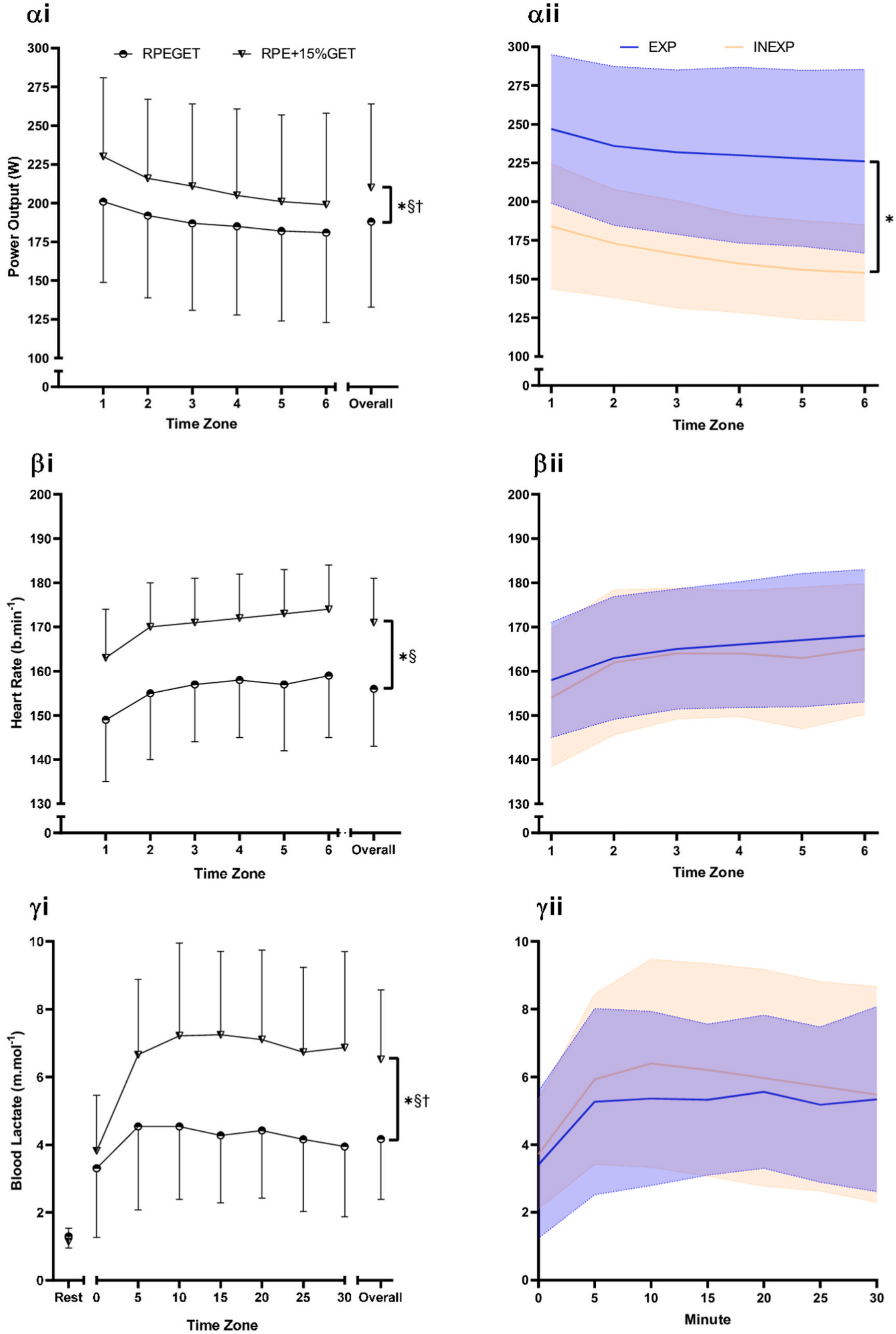

Figure 2. (i) Mean group (α) power output, (β) heart rate, and (γ) blood lactate responses during fixed perceived effort cycling. (ii) Mean (solid line) experienced (blue) and inexperienced (orange) power output, heart rate, and blood lactate responses during fixed perceived effort trials. Error bars represent SD and shaded areas represent 95% confidence intervals. Significant condition (✱), time (§), and condition × time (†) effects illustrated.

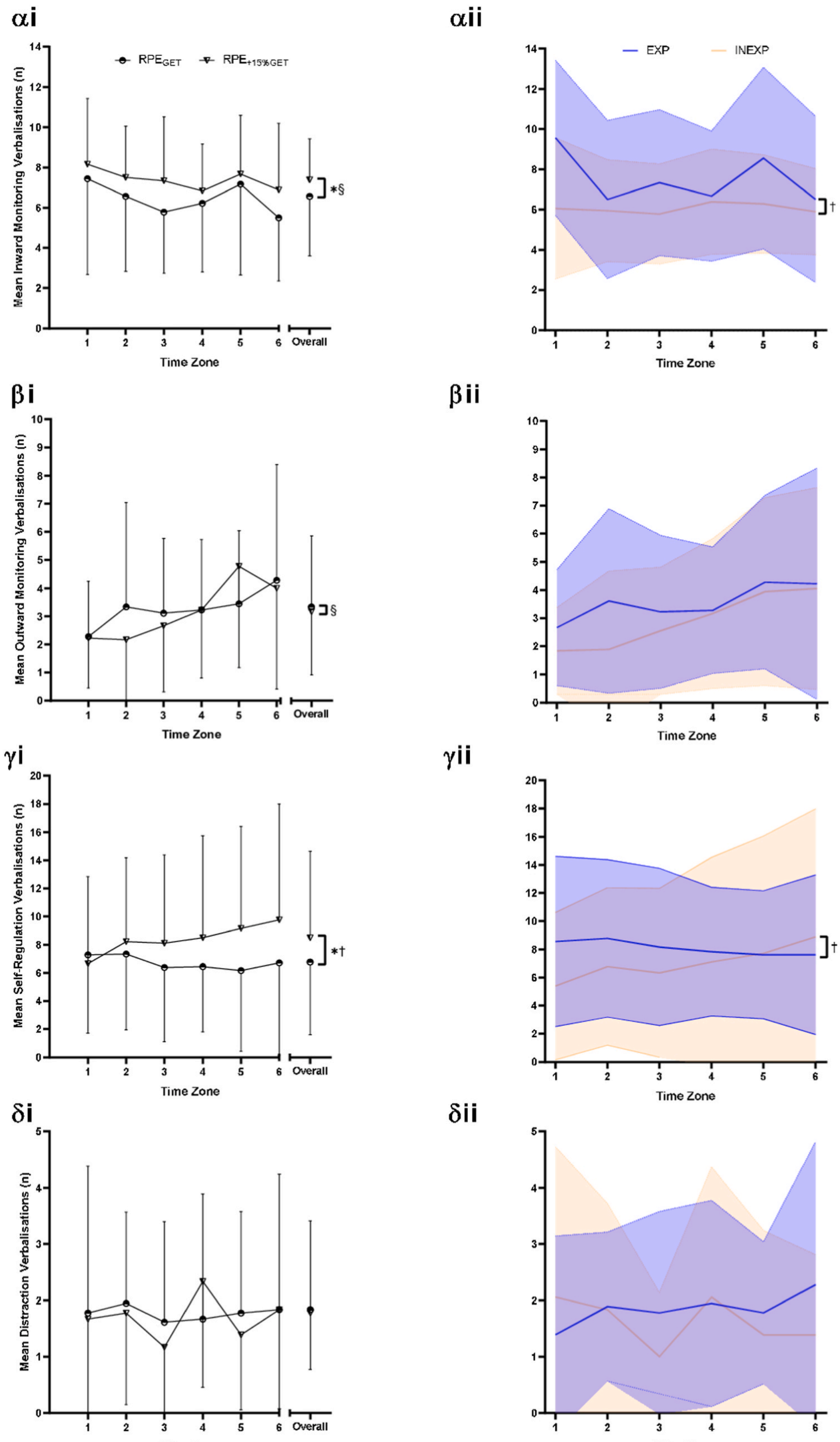

Figure 3. (i) Mean group (α) internal monitoring, (β) external monitoring, (γ) self-regulation, and (δ) distraction responses during fixed perceived effort cycling. (ii) Mean (solid line) experienced (blue) and inexperienced (orange) think aloud responses during fixed perceived effort trials. Error bars represent SD and shaded areas represent 95% confidence intervals. Significant condition (✱), time (§), and condition × time (†) effects illustrated.

end of the exercise compared to the start ($t_{195} = 2.09, p = .038, \beta = 0.39$ [0.02, 0.75]). Finally, there was also a significant condition × time interaction ($t_{195} = 2.61, p = .010, \beta = 0.97$ [0.24, 1.70]) inferring that there is a difference in how the number of verbalisations changed based on the intensity of the fixed perceived effort exercise.

When analysing the primary themes of internal monitoring think aloud data, LMM showed a significant condition main effect on the number of verbalisations relating to breathing ($t_{195} = 2.39, p = .018, \beta = 0.30$ [0.05, 0.54]) and heart rate ($t_{195} = 2.51, p = .013, \beta = 0.10$ [0.02, 0.18]) whereby individuals focused more on their breathing and heart rate during the $RPE_{+15\%GET}$ versus RPE_{GET} condition. In contrast, LMM showed a significant condition main effect on the number of verbalisations relating to physiological state (miscellaneous) ($t_{195} = -3.48, p = .001, \beta = -0.25$ [−0.39, −0.11]) whereby individuals focused more on their other physiological sensations in the RPE_{GET} versus $RPE_{+15\%GET}$ condition.

A significant time main effect was observed on the number of verbalisations relating to temperature ($t_{195} = -2.32, p = .022, \beta = -0.09$ [−0.16, −0.01]), RPE ($t_{195} = -2.80, p = .006, \beta = -0.17$ [−0.28, −0.05]), and physiological state (miscellaneous) ($t_{195} = -2.23, p = .027, \beta = -0.05$ [−0.09, −0.01]) whereby the number of verbalisations relating to these themes decreased over the course of the 30-min exercise.

When investigating the primary themes of outward monitoring think aloud data, LMM showed a significant condition main effect on the number of verbalisations relating to time ($t_{195} = 2.70, p = .008, \beta = 0.48$ [0.13, 0.83]) which was consistently higher in the $RPE_{+15\%GET}$ versus RPE_{GET} condition. Alternatively, verbalisations relating to the researcher's behaviour was higher in the RPE_{GET} versus $RPE_{+15\%GET}$ condition ($t_{195} = -3.13, p = .002, \beta = -0.44$ [−0.72, −0.17]).

A significant time main effect was observed on the number of verbalisations relating to time ($t_{195} = 6.17, p = .001, \beta = 0.32$ [0.22, 0.43]) and researcher's behaviour ($t_{195} = 2.06, p = .040, \beta = 0.09$ [0.00, 0.17]) which both increased over the course of the exercise.

When analysing the primary themes of self-regulation think aloud data, LMM showed a significant condition main effect on the number of verbalisations relating to emotional control/appraisal ($t_{195} = 2.43, p = .016, \beta = 0.40$ [0.08, 0.72]), self-talk ($t_{195} = 3{,}57, p = .001, \beta = 0.98$ [0.44, 1.52]), technique/form ($t_{195} = 3.28, p = .001, \beta = 0.50$ [0.20, 0.80]), and power (remain constant) ($t_{195} = 2.42, p = .017, \beta = 0.13$ [0.02, 0.23]) which were all higher in the $RPE_{+15\%GET}$ versus RPE_{GET} condition.

A significant time main effect was observed on the number of verbalisations relating to power output (no direction) ($t_{195} = -2.08, p = .039, \beta = -0.05$ [−0.09, 0.00]) and power output (decrease) ($t_{195} = -3.53, p = .001, \beta = -0.10$ [−0.15, −0.04]) and power output (total) ($t_{195} = 2.85, p = .005, \beta = -0.12$ [−0.20, −0.04]) which all reduced throughout the exercise. Whereas self-talk significantly increased over the course of the exercise ($t_{195} = 3.65, p = .001, \beta = 0.29$ [0.14, 0.45]).

Finally, a significant condition × time interaction was observed for verbalisations concerning cadence ($t_{195} = 2.50, p = .013, \beta = 0.21$ [0.04, 0.37]) which increased in the $RPE_{+15\%GET}$ but decreased in the RPE_{GET} condition. A significant condition × time was observed for verbalisations concerning self-talk ($t_{195} = 3.33, p = .001, \beta = 0.54$ [0.22, 0.85]) which increased in the $RPE_{+15\%GET}$ condition whereas it remained constant in the RPE_{GET} condition.

3.2.3. Perceptual markers

A significant condition main effect demonstrated that affective valence was significantly lower in the $RPE_{+15\%GET}$ compared to RPE_{GET} condition ($t_{231} = -14.44, p = .001, \beta = -2.15$ [−2.44, −1.86]). There was also a significant time main effect with affective valence decreasing significantly over the course of the exercise ($t_{231} = -13.38, p = .001, \beta = -0.35$ [−0.40, −0.30]). In addition, there was a significant condition × time interaction ($t_{231} = -9.74, p = .001, \beta = -0.51$ [−0.62, −0.41]) indicating that affective valence became more negative at an earlier stage of the 30-min exercise during the $RPE_{+15\%GET}$ versus RPE_{GET} condition (Figure 4αi).

Finally, a significant condition main effect demonstrated that self-efficacy responses were significantly lower in the $RPE_{+15\%GET}$ compared to RPE_{GET} condition ($t_{231} = -9.44, p = .001, \beta = -12.20$ [−14.74, −9.67]). No significant time main effects were observed for self-efficacy responses ($t_{231} = -1.45, p = .150, \beta = -0.33$ [−0.78, 0.12]). In addition, there was not a significant condition × time interaction for self-efficacy responses observed ($t_{231} = 0.16, p = .873, \beta = 0.07$ [−0.82, 0.97]) (Figure 4βi).

3.3. Part B

3.3.1. Power output and physiological markers

A significant condition main effect displayed that power output was significantly lower amongst inexperienced versus experienced cyclists ($t_{196} = -3.28, p = .005, \beta = -67.57$ [−107.93, −27.22]). However, there was not a condition × time interaction ($t_{196} = -1.65, p = .100, \beta = -2.24$ [−4.89, 0.42]) suggesting power output changes over the course of the fixed perceived effort exercise did not vary between experienced and inexperienced cyclists (Figure 2αii).

No significant condition main effects ($t_{196} = -0.49, p = .633, \beta = -2.70$ [−13.59, 8.18]) or condition × time interactions ($t_{196} = 0.04, p = .967, \beta = 0.03$ [−1.49, 1.55]) were observed for heart rate (Figure 2βii). Likewise, no significant condition main effects ($t_{232} = 0.64, p = .529, \beta = 0.57$ [−1.16, 2.29]) or condition × time interactions ($t_{232} = -0.38, p = .705, \beta = -0.05$ [−0.31, 0.21]) were observed for blood lactate (Figure 2γii).

3.3.2. Think aloud data

Instances of internal sensory monitoring did not significantly differ between inexperienced and experienced cyclists ($t_{196} = -1.78, p = .095, \beta = -1.73$ [−3.64, 0.18]) but there was a significant condition × time interaction ($t_{196} = 2.02, p = .045, \beta = 0.44$ [0.01, 0.87]) as it appears experienced cyclists monitored internal sensations more at the start of the exercise compared to inexperienced counterparts but gradually shifted their focus away from internal sensations as the exercise continued (Figure 3αii). Instances of outward monitoring did not exhibit any significant condition ($t_{196} = -0.59, p = .567, \beta = -0.64$ [−2.78, 1.50]) or condition × time interactions ($t_{196} = 1.55, p = .124, \beta = 0.23$ [−0.06, 0.52]) (Figure 3βii).

Instances of self-regulatory thoughts did not differ between groups with no main condition effect observed ($t_{196} = -0.39, p = .699, \beta = -1.06$ [−6.32, 4.21]). However, there was a significant condition × time interaction ($t_{196} = 3.45, p = .001, \beta = 0.85$ [0.37, 1.33]) as experienced cyclists disclosed more self-regulatory thoughts at the earlier stages of the exercise with a gradual decrease as the exercise continued. In contrast inexperienced cyclists disclosed less self-regulatory thoughts at the start of the exercise but gradually disclosed more self-regulatory thoughts as the exercise continued (Figure 3γii). Instances of distraction showed no significant condition main effect ($t_{196} = -0.43, p = .676, \beta = -0.22$ [−1.24, 0.80]) or condition × time interactions ($t_{196} = -1.77, p = .078, \beta = -0.23$ [−0.48, 0.02]). However, an inverse relationship to the self-regulatory thoughts were observed across different training status groups (i.e., experienced = increase in distractions versus inexperienced = decrease in distractions as exercise progressed) (Figure 3δii).

Finally, the total number of verbalisations did not differ between training status groups ($t_{196} = -0.83, p = .418, \beta = -3.65$ [−12.25, 4.96]) suggesting a similar understanding of the think aloud protocol between groups. However, there was a significant condition × time interaction ($t_{196} = 3.41, p = .001, \beta = 1.29$ [0.55, 2.04]) whereby experienced cyclists maintained a consistent number of verbalisations throughout the exercise whereas inexperienced cyclists progressively increased the number of verbalisations as the exercise continued.

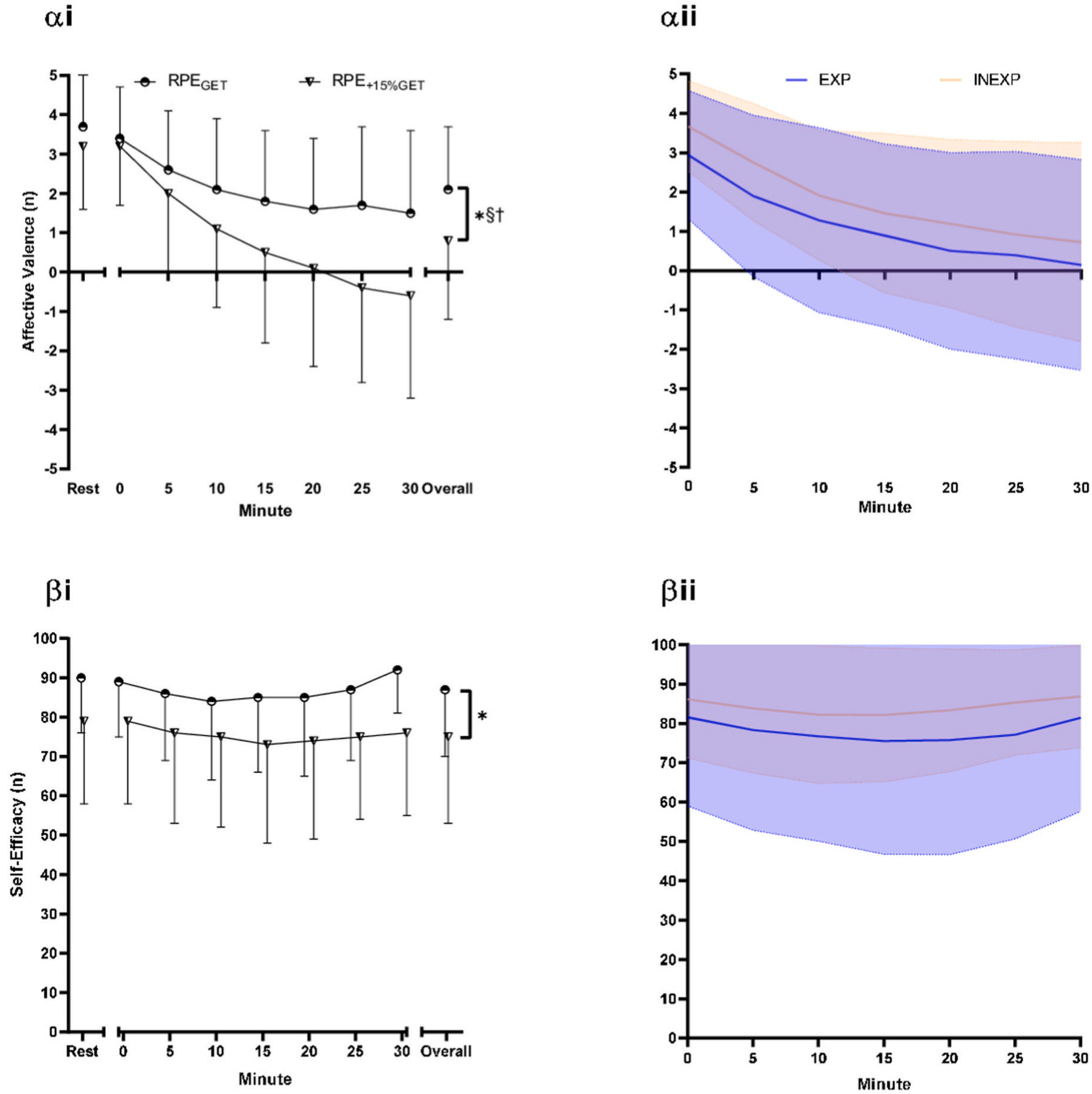

Figure 4. (i) Mean group (α) affective valence, and (β) self-efficacy during fixed perceived effort cycling. (ii) Mean (solid line) experienced (blue) and inexperienced (orange) perceptual responses during fixed perceived effort trials. Error bars represent SD and shaded areas represent 95% confidence intervals. Significant condition (**✱**), time (§), and condition × time (†) effects illustrated.

After analysis of the primary themes of think aloud data, no condition main effects were observed for any theme except for verbalisations concerning power output (no direction) ($t_{195} = -3.57, p = .003, \beta = -0.33$ [$-0.52, -0.15$]) which was more prevalent amongst experienced versus inexperienced cyclists.

Significant condition × time interactions were observed for internal monitoring verbalisations concerning pain ($t_{195} = 2.22, p = .028, \beta = 0.23$ [0.03, 0.42]) and fatigue ($t_{195} = 2.09, p = .038, \beta = 0.16$ [0.01, 0.30]) which increased amongst inexperienced cyclists whilst they decreased amongst experienced cyclists over the course of the exercise. Significant condition × time interactions were observed for outward monitoring verbalisations concerning time elapsed/remaining ($t_{195} = 2.17, p = .031, \beta = 0.23$ [0.02, 0.44]) which increased more sharply amongst inexperienced versus experienced individuals across the exercise. Finally, a significant condition × time interaction was observed for self-regulation verbalisations concerning self-talk ($t_{195} = 3.46, p = .001, \beta = 0.57$ [0.25, 0.90]) which increased amongst inexperienced cyclists whilst they remained constant amongst experienced cyclists through the exercise.

3.3.3. *Perceptual measures*

No significant condition main effects ($t_{232} = 0.75, p = .463, \beta = 0.66$ [$-1.06, 2.37$]) or condition × time interactions ($t_{232} = -0.46, p = .647, \beta = -0.04$ [$-0.19, 0.12$]) were observed for affective valence responses (Figure 4αii). Similarly, no significant condition main effects ($t_{232} = 0.68, p = .506, \beta = 6.19$ [$-11.63, 24.01$]) or condition × time interactions ($t_{232} = 0.51, p = .609, \beta = 0.36$ [$-1.00, 1.71$]) were observed for self-efficacy responses (Figure 4βii).

4. Discussion

The main aims of this study were: *Part A* - to investigate the attentional focus and self-regulation of perceived effort at different fixed perceived effort intensities; and *Part B* – to investigate the differences in attentional focus and self-regulation of perceived effort between experienced and inexperienced cyclists during fixed perceived effort cycling tasks.

For *Part A*, the main findings were that power output was significantly higher in the $RPE_{+15\%GET}$ versus RPE_{GET} condition with a sharper decrease in the $RPE_{+15\%GET}$ versus RPE_{GET} condition also observed. Physiologically, this difference in power output was paired with significantly higher heart rate and blood lactate levels in the $RPE_{+15\%GET}$ condition. Perceptually, participants also demonstrated significantly lower/worse affective responses (which also worsened at a faster rate) and ratings of perceived self-efficacy in the $RPE_{+15\%GET}$ versus RPE_{GET} condition. Finally, participants disclosed significantly more verbalisations concerning internal sensory monitoring and engagement in self-regulatory strategies to cope with perceived effort during the $RPE_{+15\%GET}$ versus RPE_{GET} condition.

Findings relating to the physiological and perceptual responses to exercise at two separate fixed perceived effort exercises were expected based on previous studies which have demonstrated similar changes to power output, heart rate, blood lactate, affective valence, and self-efficacy (Cochrane et al., 2015; O'Malley et al., 2023; Robinson et al., 2021). In respect to think aloud data, findings of the present study were also consistent with previous studies which have found that individuals' main cognitions concern active self-regulation and internal sensory monitoring (Whitehead et al., 2018) during self-regulated exercise.

Specifically, internal sensory monitoring appeared more prominent at the start of the exercise than in the latter stages whilst self-regulation remains relatively stable throughout. Findings of this nature are expected as engagement in a higher intensity exercise (e.g., $RPE_{+15\%GET}$) involves individuals exercising mostly within the heavy domain (Cochrane et al., 2015; O'Malley et al., 2023), causing a natural accumulation of metabolic by-products that were more prominent than when exercising at a lower intensity of exercise (RPE_{GET}) (Burnley & Jones, 2018). Consequently, the increase in physiological afferent signals to the central nervous system are processed into perceptions that are then evoked in the think aloud data (Brick, Campbell, et al., 2016; Brick et al., 2014; Ekkekakis et al., 2011; Hutchinson & Tenenbaum, 2007). Results from this study which noted a greater focus on pain (Mauger, 2013), breathing (Laviolette & Laveneziana, 2014; Nicolò, Marcora, & Sacchetti, 2016) and temperature (Brotherhood, 2008), particularly at the earlier stages of the exercise where power output was higher, are consonant with this notion (see supplementary materials).

Although understanding *what* individuals are focusing on during a fixed perceived effort trial is useful, understanding *how* they are coping with perceived effort is of real interest for application to the real world (Lazarus, 2000). Findings of this study indicate two main things. First, participants seem to opt for behavioural self-regulatory strategies (i.e., lowering their power output) more during higher than lower fixed perceived effort intensities. Naturally, lowering power output requires less central drive which consequently results in less production and processing of neuronal corollaries that elicit perceptions of effort (de Morree et al., 2012; Pageaux, 2016). Second, whilst changing power output may be the dominant response to self-regulating perceived effort (Evans et al., 2016), neuro-economical and aberrant models of decision making (Chong et al., 2017, 2018; Westbrook & Braver, 2015) suggest that individuals will also resolve towards using cognitive effort to activate cognitive strategies so that a task feels less aversive (Berridge, 2019) and suffices for the exercise task without overexerting themselves (Inzlicht, Shenhav, & Olivola, 2018).

Relatedly, individuals in this study utilised associative attentional focus which may be associated with more cognitive strategies like emotional control/reappraisal and self-talk to cope with the perceived effort for the task. Meanwhile, less attention was dissociative towards external cues as well as less implementation of distraction strategies to cope. Reappraisal has been identified as a highly functional cognitive strategy to alter the perception of aversive sensations (Lazarus, 1991, 2000; Smith & Lazarus, 1983). First, Giles et al. (2018) exhibited that when runners utilised cognitive reappraisal strategies during a prolonged activity, they reported lower perceived effort than when no cognitive appraisal was used. Moreover, other studies have also seen that cognitive reappraisal mitigates the decreases in affective valence during prolonged exercise (Berman, O'Brien, Zenko, & Ariely, 2019; Grandjean da Costa et al., 2022). Finally, Sammy et al. (2017) demonstrated that reappraisal elicited more functional cardiovascular responses with less peripheral resistance than without reappraisal. Jointly, increases in self-efficacy were also observed in this study when appraisal was used. Therefore, reappraisal appears to be a functional cognitive self-regulatory strategy that participants of this study identified with to bring their own psychophysiological state/self into accord with the required perceived effort (Carver & Scheier, 2000).

In relation to self-talk, Blanchfield et al. (2014) discerned that individuals who could effectively motivate themselves with positive self-talk could forestall their attainment of time-to-task failure and improve endurance performance. Seemingly, individuals in this study engaged more in self-talk during higher intensity exercise (e.g., $RPE_{+15\%GET}$) to maintain a higher motivational intensity (Barwood et al., 2008, 2015) and alter their perceptions of negative sensations when they were more intense (Blanchfield et al., 2014). This is consonant with previous studies which indicate self-talk strategies are particularly useful in athletic populations for coping with high levels of effort and pain (McCormick et al., 2019). Resultantly, evidence from this study is one of the first to suggests that reappraisal and self-talk have the scope to potentially reduce the effect that disturbances in physiological state have (Arthur, Wilson, Moore, Wylie, & Vine, 2019; Hase, O'Brien, Moore, & Freeman, 2019; Sammy et al., 2017) as well as improving psychological state (Barwood et al., 2008, 2015; Berman et al., 2019; Blanchfield et al., 2014; Giles et al., 2018; Grandjean da Costa et al., 2022; McCormick et al., 2015; Sammy et al., 2017) so that less change in behaviour (i.e., lowering power output) is required at a set perceived effort (Carver & Scheier, 1982; Evans et al., 2016).

For *Part B*, the main findings were that experienced athletes exerted significantly higher power output than inexperienced athletes despite no difference in physiological (heart rate, blood lactate) or psychological (affective valence, self-efficacy) state. Although, there were no significant differences in the frequency of verbalisations to specific subthemes between experienced and inexperienced participants, there were some significant condition × time interactions. Notably, experienced athletes verbalised more absolute and a higher percentage of total thoughts pertaining to internal sensory state and instances of self-regulation at the start of the exercise (Table 3), whereas inexperienced athletes showed a gradual increase in thoughts pertaining to internal sensory states and self-regulation towards the end of the fixed perceived effort exercise.

Although the lack of condition main effects concerning subthemes between experienced and inexperienced was unexpected (Samson et al., 2017; Whitehead et al., 2018), the raw absolute counts and percentage calculations (Table 3) of when experienced individuals focused on internal states is indicative of a greater associative attentional focus compared to inexperienced individuals (Brick et al., 2014; Hutchinson & Tenenbaum, 2007). As noted, an associative focus during endurance-based exercise is linked to superior athletic performance as the participant is more metacognitively attuned to their internal state (Brick, MacIntrye, et al., 2016) and understanding of their potential control over it (Lind et al., 2009; Masters & Ogles, 1998; Morgan & Pollock, 1977). Beyond athletic performance, Evans et al. (2016) infer that other goal-directed pursuits without performance demands would benefit from an associative focus as it is closely related to more targeted and functional self-regulation of the self in relation to task goals.

Another crucial difference noted by the condition × time interactions is *when* participants primarily focused on their internal sensory states and *when* strategies like reappraisal or self-talk were employed to self-regulate their psychophysiological state. Specifically, experienced cyclists appear to acknowledge their internal states (e.g., pain, dyspnea, temperature) and subsequently self-regulate those states via reappraisal at an earlier stage of exercise. Alternately, inexperienced cyclists appear to focus less on internal states until the end of the exercise and use self-

Table 3
Mean absolute counts and (percentages [%]) of verbalisations across between intensities, training status, and time zones.

RPE_{GET}

	Experienced							Inexperienced						
Time Zone	1	2	3	4	5	6	Overall	1	2	3	4	5	6	Overall
Internal Sensory Monitoring	84 (42)	69 (36)	53 (32)	55 (35)	76 (42)	44 (26)	381 (36)	50 (36)	49 (32)	51 (37)	57 (36)	53 (34)	55 (34)	315 (35)
Outward Monitoring	24 (12)	37 (19)	33 (20)	31 (20)	33 (18)	39 (23)	197 (19)	17 (12)	23 (15)	23 (17)	27 (17)	29 (19)	38 (24)	157 (17)
Self-Regulation	82 (41)	69 (36)	62 (37)	60 (38)	56 (31)	65 (38)	394 (37)	49 (35)	63 (42)	53 (38)	56 (35)	55 (35)	56 (35)	332 (37)
Distraction	8 (4)	19 (10)	18 (11)	11 (7)	14 (8)	22 (13)	92 (9)	24 (17)	16 (11)	11 (8)	19 (12)	18 (12)	11 (7)	99 (11)

$RPE_{+15\%GET}$

	Experienced							Inexperienced						
Time Zone	1	2	3	4	5	6	Overall	1	2	3	4	5	6	Overall
Internal Sensory Monitoring	88 (44)	77 (37)	79 (39)	65 (33)	78 (35)	73 (36)	460 (37)	59 (43)	58 (40)	53 (37)	58 (33)	60 (31)	51 (25)	339 (34)
Outward Monitoring	24 (12)	28 (13)	25 (12)	28 (14)	44 (20)	37 (18)	186 (15)	16 (12)	11 (8)	23 (16)	30 (17)	42 (22)	35 (17)	157 (16)
Self-Regulation	72 (36)	89 (43)	85 (42)	81 (41)	81 (37)	72 (36)	480 (39)	48 (35)	59 (41)	61 (42)	72 (40)	84 (44)	104 (51)	428 (43)
Distraction	17 (8)	15 (7)	14 (7)	24 (12)	18 (8)	19 (9)	107 (9)	13 (10)	17 (12)	7 (5)	18 (10)	7 (4)	14 (7)	76 (8)

talk consistently throughout the exercise (see supplementary materials). Based on previous research, the pattern of focus and self-regulation indexed by experienced athletes may be more functional on a neuro-psychophysiological level (Chong et al., 2018; Lind et al., 2009).

To explain, reappraisal is a resource-demanding cognitive strategy (Gross, 2015; Jones, Meijen, McCarthy, & Sheffield, 2009), meaning a higher supply of cerebral oxygenation/resources as well as perceived efficacy to implement is required for reappraisal to be executed effectively (Gross, 2013; Meijen, Turner, Jones, Sheffield, & McCarthy, 2020). However, self-talk is a relatively easy cognitive strategy that does not require a high supply of cerebral resources (Gross, 2013). Robinson et al. (2021) identified that cerebral oxygenation in the prefrontal cortex (largely associated with executive function) progressively decreases as perceived effort increases. Unfortunately, authors in that study did not report if there were significant differences between experienced and inexperienced cyclists in cerebral haemodynamics over time (Robinson et al., 2021) but others have discerned that individuals who are well-trained have a unique adaptation to maintain cerebral oxygenation during intense physical exercise that untrained exercisers cannot (Santos-Concejero et al., 2015). Thus, in relation to this study, experienced athletes may have evidenced a functional use of reappraisal at earlier stages of the exercise before they accrued mental and physical fatigue which would hinder their perceived ability to implement reappraisal strategies (Englert, Pageaux, & Wolff, 2021). Then, approaching the latter stages of the exercise trial, experienced shifted towards less resource-dependent strategies like self-talk (Gross, 2013; McCormick et al., 2015). Alternatively, inexperienced cyclists seemed to demonstrate a consistently low use of reappraisal strategies but a high use of self-talk throughout which could be posed as a less functional awareness and use of resources.

However, this argument is theoretical and solely based on previous findings, as no cerebral haemodynamics markers were obtained in the current study. Robinson et al. (2021) provide an excellent entry into this area, and future studies would benefit greatly from utilising think aloud protocols alongside methods like functional near infrared spectroscopy to ascertain a link between cognitions, self-regulatory strategies, and the required neurological resources during endurance-based activities.

A potential limitation of this study and possible reason for the lack of differences between experienced and inexperienced cohorts was the strategy for recruitment and allocation to experienced/inexperienced groups. Principally, all participants were currently active cyclists with the only differing factors being the number of years that they had been active (experienced = ≥ 3 years) and their physiological capacity ($\dot{V}O_2$ max). Consequently, despite there being a difference in performance level according to previous research (de Pauw et al., 2013), the participants completed submaximal exercise (maximum RPE 15) which may not be intense enough to accentuate differences in most behaviours between participants that only differ in number of years cycling experience and $\dot{V}O_2$ max. Therefore, future studies may wish to identify other means of classifying participant groups.

A final area for future research is that there is a remaining ambiguity surrounding the cost-benefit of utilising cognitive strategies like reappraisal and self-talk. As noted, effort refers to the application of physical *and* mental resources towards a task (Preston & Wegner, 2009). Accordingly, the employment of cognitive strategies is effortful and would therefore impact perceived effort (Pageaux, 2016). However, in this context, there appears to be a use of cognitive strategies particularly by experienced athletes to avoid reducing power output for a set RPE. In short, cognitive strategies seem to be used to allow the individual to get more 'bang for their buck' at a given RPE. If that is the case, this could mean that experience may lead to cognitive strategies becoming more autonomous and mentally effortless (Cos, 2017; Siddle, 1991). Certainly, an exploration into this potential adaptation is eagerly anticipated.

In summary, this study observed that participants exerted a higher power output paired with significantly higher heart rate and blood lactate, and significantly lower ratings of affective valence and self-efficacy during the $RPE_{+15\%GET}$ versus RPE_{GET} condition. This is the first study to clearly demonstrate that during higher intensity perceived effort exercise ($RPE_{+15\%GET}$), participants opted to regulate their perceived effort through behavioural strategies like lowering their power output more than at lower intensities of perceived effort (RPE_{GET}). In addition, think aloud data indicated that participants focused more on internal sensory states such as pain, heavy breathing, and temperature during higher intensities of perceived effort exercise. To add, this study is also the first to show that, participants activated more cognitive self-regulatory strategies like reappraisal and self-talk during the $RPE_{+15\%GET}$ condition to counter the negative perception of these sensations and to likely maintain higher motivational intensity. When investigating if the training status of athletes (experienced versus inexperienced) impacted the types of foci and self-regulatory strategies used, this study found that there were no significant differences in attentional focus between subgroups as the number of verbalisations relating to internal sensory states were not significantly different. However, this study did observe that experienced participants acknowledged their negative internal sensations earlier in the exercise with subsequently earlier self-regulation compared to inexperienced counterparts. This may be a more functional adaptation to implement resource-dependent strategies due to the underlying neuro-psychophysiological changes (e.g., cerebral oxygenation, perceived control) that exist at different stages of endurance exercise. As such, this is the first study that utilises a novel fixed perceived effort task paradigm to help understand how perceived effort is self-regulated via behavioural and cognitive self-regulatory strategies at different intensities or time-points of an exercise. In addition, the study provides a novel insight into the differences in aberrant decision-making between individuals of different experience levels and how this impacts when someone chooses to use behavioural or cognitive self-regulatory strategies during a prolonged exercise activity.

Author contribution

CAO, CLF and ARM were responsible for the design and planning of the study. CAO was responsible for the data collection, analysis, and write-up of the manuscript. CAO, CLF and ARM were responsible for the proof-reading and editing of the manuscript. All persons designated as authors qualify for authorship, and all those who qualify for authorship are listed. All authors have read and approved of the final manuscript submitted for publication. Authors are accountable for the work and will ensure that all questions pertaining to the accuracy and authenticity of the work are appropriately investigated and resolved.

Declaration of competing interest

There are no conflicts of interest in the development, production, and dissemination of this study, its data, and the final manuscript. No third parties or grant providers were involved in the production of this study. The lead author was in receipt of the University of Kent VC Scholarship as part of their doctoral programme which this study is a part of.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.psychsport.2023.102544.

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