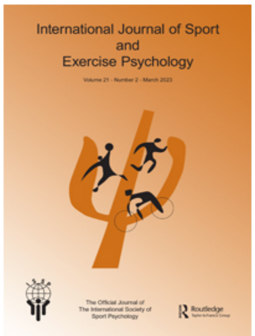

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Well-trained, trained and recreationally trained runners' cognition during a 5km tempo run: a think aloud study

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ABSTRACT

A think aloud (TA) protocol was used to explore whether thought processes and attentional focus differed between well-trained, trained, and recreationally-trained runners across a 5km tempo run. Eighteen runners completed a self-paced 5km tempo treadmill run. Participants were asked to TA and provided their ratings of perceived exertion alongside breathlessness, cognitive demands and lower-body effort, every 1 km. Verbalisations were coded using content analysis into categories and sub-categories and were compared across groups and over every kilometre of the run. Speed and Rate of Perceived Exertion scores increased over the 5km but there were no significant differences across groups. The nature of verbalisations for categories and sub-categories varied across groups with the majority of the well-trained runner's thoughts relating to *active self-regulation*, while *internal sensory monitoring* was used most frequently by the trained runners and *distraction* was most widely verbalised by the recreationally-trained group. There was a statistically significant difference between the use of *active self-regulation* across groups, with differences also seen for the sub-categories of *running form* and *motivational self-talk*. The number of verbalisations across categories changed over time, but there was no statistically significant interaction with group. Results highlight active self-regulatory differences between well-trained, trained and recreationally-trained runners in the study, suggesting that it is likely not just exposure to running that enables runners to develop effective psychological skills. Findings could be used by coaches to offer targeted support and opportunities for lower-level runners to develop effective cognitive skills to impact on performance and running adherence.

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Introduction

Running is a popular form of leisure-time activity and numbers of participants have been increasing worldwide in recent years (Hulteen et al., 2017). For instance, statistics showed that approximately 6.2 million people in England (just under 10% of the population) regularly took part in running (defined as twice within the last 28 days) in 2020–2021 (Sport England, 2022). Notably, running can serve as a rewarding and enjoyable form of physical activity, which in some cases may lead to a state of flow (an intrinsically rewarding psychological state including a state of control, whereby tasks can be completed effortlessly, even in challenging situations) (Jackman et al., 2021) and generate highly pleasurable feelings for participants (Jackman et al., 2022). Outside of these pleasant experiential qualities in running, running has numerous public health benefits such as lowering the risk of all-cause (27%), cardiovascular (30%) and cancer (23%) mortality (Pedisic et al., 2020). The mental and social benefits of participation in running have also been widely acknowledged, including as a means to prevent or treat mental illness, promote positive mental well-being, develop social identity and encourage healthy behaviours (Keating et al., 2020). Given such benefits, research has explored the cognitions, perceptions and strategies associated with engagement in endurance performance (Marcora, 2008). Such interest is warranted to better understand performance-related cognitions of runners. However, less attention has been paid to how performance-related cognitions manifest themselves within trained and recreationally-trained runners and particularly for running across the shorter 5 and 10km distances.

There is a long history of research exploring the psychological variables and thought processes associated with endurance activities, with particular emphasis being placed on elite performers over longer distances (e.g., Brick et al., 2015; Van Biesen et al., 2016). Work in this area has typically considered how elite athletes differ from lesser experienced and novice performers with the aim to better inform runners of effective strategies. The highly influential work of Morgan and Pollack (1977) initiated this area by highlighting that novice runners more often used association (monitoring bodily sensations) to support pace regulation and effort tolerance, as opposed to non-elite runners who used dissociative techniques (directing attention away from bodily sensations). However, 20 years later, Masters and Ogles (1998) concluded that despite findings indicating experience, type of run, and setting can influence cognitive strategy use, the field was hampered by methodological and conceptual difficulties such as the use of retrospective accounts, issues with recall/memory decay and reporting bias. Despite this, what is accepted is that endurance running is characterised by a dynamic process of attentional focus involving the monitoring of both internal (e.g., bodily states) and external (e.g., environmental) states and regulation of effort (Brick et al., 2015). Whilst accumulating fatigue may shift attention from external to internal (Brick et al., 2016), attention directed toward bodily sensations (e.g., breathing) may reduce movement efficiency (Schücker et al., 2014) and cognitive strategies characterised by task-relevant self-regulatory efforts may improve movement economy and pace (Hill et al., 2017).

Elaborating on the dimensions of association and dissociation, Brick et al. (2014) proposed a metacognitive framework of attentional focus for endurance activity that elaborated on previous categorisations. This framework proposed that cognitive processes can be better identified as internal sensory monitoring (breathing, muscle soreness, thirst, etc.), outward monitoring (strategy, split times, route, etc.), active distraction (attention-demanding tasks, attention-demanding environment, intentional distraction), involuntary distraction (unimportant scenery, spectators, irrelevant daydream, etc.), and active self-regulation (cadence, relaxing, pacing, etc.) Whilst findings indicate that the main challenge recreational endurance exercisers face is coping with exercise-related sensations of exertion, pain, or discomfort (McCormick et al., 2018), very little research has explored Brick et al.'s metacognitive framework within non-elite samples, particularly within the context of running. Whilst active self-regulatory efforts have been associated with clutch states (complete and deliberate focus, heightened awareness on situational demands, and intense effort; Swann et al., 2019) in recreational and trained runners (Jackman et al., 2021). Brick et al. (2020) found that relatively inexperienced runners (who had started running within the last year) possessed limited metacognitive skills and cognitive strategies that they used whilst running. When these cognitive strategies were employed, they appeared to have been developed as a result of undertaking high-intensity efforts and were generally labelled as unpleasant. Notably, these experiences were likely to occur during the early stages of the runners' careers, highlighting the key role that obtaining a variety of experiences (over time), coupled with appropriate reflection and awareness (either individually or with significant others), can have upon the development of such cognitive strategies.

Other research has drawn upon alternative methodology in the form of real-time or on-the-spot data recordings known as a think aloud (TA) protocol to gather data (Ericsson & Simon, 1980), which may be particularly useful to capture changes in thought processes across the course of an activity. This approach has been used in a variety of sport-based settings including endurance sports such as triathlon (Baker et al., 2005), cycling (Massey et al., 2020; Whitehead et al., 2018; Whitehead et al., 2019) and distance running (Samson et al., 2017), where it can be argued that significant psychological demands are placed on athletes for sustained periods of effort. Using a video-simulation approach, Baker et al. (2005) found that expert ultra-endurance triathletes reported proactive performance focused thoughts related to their current event situation, whilst mid- and back-pack triathletes reported thoughts that were more often unrelated to their performance and passive regarding their current event situation.

Samson et al. (2017) examined the real-time thought processes of runners completing a treadmill-based run lasting 30 minutes alongside a self-paced outdoor run of at least seven miles. Thematic analysis of the transcribed data found three main themes that described runners thought processes during their runs including: pace and distance, pain and discomfort, and the environment (typically as distraction). This research did not consider differences between thought processes for level of performer; however, this has begun to be explored within other endurance sports settings. This research has consistently found differences between the cognitive strategies adopted by well-trained athletes compared to their recreationally-trained counterparts. For instance, Whitehead et al. (2018) found that trained cyclists reported more self-regulatory and distance-related thoughts during a lab-based 16.1km time trial, whereas untrained cyclists' thoughts were typically focused on distraction and pain. Similarly, Massey et al. (2020) conducted a lab-based study highlighting that the thought processes of expert cyclists were more performance-relevant (e.g., internal sensory monitoring and power output), while recreationally-trained performers focused more heavily on task completion (e.g., distance) and irrelevant information (e.g., scenery). Common to both groups was that they used more motivational thought strategies in the latter stages of the trial.

Despite these recent developments, it can be argued that a greater understanding of the thought processes and cognitive strategies in the more common shorter 5km run distance is needed, particularly due to the distance commonly being utilised by beginner runners as a critical distance target (e.g., couch to 5km and parkrun). Additionally, an exploration of differences in the thought processes of different levels of running performers (well-trained, trained and recreationally-trained), and how these thoughts may change across different stages of a challenging tempo run (e.g., continuous running at a relatively high-intensity pace), is required. Training for running requires the undertaking of various types of activities (easy runs, tempo runs, long-interval training, short-interval training and race/time trials, (e.g., Casado & Ruiz-Pérez, 2017), with tempo runs reflecting a challenging but important feature of effective training. Tempo runs appear to be important for the development and maintenance of consistent pace and require deliberate concentration to perform effectively (Casado et al., 2020), as well as playing a central role in physiological and performance developments, namely through improvements in lactate threshold (Casado et al., 2021). Furthermore, tempo runs facilitate race preparation through replicating the challenges of long-distance running. Tempo running can be classed as relatively high intensity with minimal opportunity for rest and low effort periods (Casado et al., 2021). Subsequently, this type of run provides an ideal task to explore self-regulatory cognition differences between runners of different levels of experience, whilst also being a challenging, yet practical form of running to undertake while using TA. Furthermore, externally controlled pace/intensity has been shown to influence attentional focus during fast treadmill running such that it is cognitively easier, whereas self-paced effort presents as a more difficult cognitive challenge (Brick et al., 2016). The aim of the current study was to explore the thought processes and attentional focus of runners during a 5km tempo run through the following research questions: (1) Do thought processes and attentional focus within a 5km tempo run differ depending on the level of performer and experience? (2) Do thought processes and attentional focus change over the course of a 5km tempo run?

Method

Participants

Using values from previous research (Massey et al., 2020), an *a priori* power analysis was performed in G*Power3 (Faul et al., 2007), revealing a required $n = 15$ ($1-\beta = .80$, $\alpha = .05$). Subsequently, eighteen runners (9 male and 9 female) volunteered to take part in the study. All runners were currently regularly training at least twice per week and were healthy and injury-free at the time of testing. All participants were White British and were from a variety of socioeconomic backgrounds in the North West of England (ranging from 10% least deprived to 20% most deprived according to the Multiple Deprivation Index). 44% were in full-time employment, while 33% were working part-time and the remaining were retired – 17%, in full-time education – 0.06% or unemployed – 11%. Based upon their 5km personal best (PB) time (achieved within the last 12 months), weekly training distance, trial (5km tempo) and finish time, these runners were split into recreationally-trained (L2), trained (L3) and well-trained (L4) runners, based on guidelines to classify subject groups in Sports Science research (De Pauw et al., 2013). Further descriptive details about the three classifications including age, reported 5km PB time, running experience and current level of training can be found in Table 1.

Task

Runners completed a self-paced 5km run on a motorised treadmill (H/P/Cosmos Pulsar 4.0; H/P/Cosmos Sports and Medical GmbH, Nussdorf-Traunstein, Germany). Participants were instructed to run at a "tempo" or "comfortably hard" pace throughout the trial, which would allow them to cover the 5km distance in as fast a time as possible without reaching maximal exertion (85–90% effort). The task began from a standing start with a "go" signal from the researcher, and participants were free to choose their running speed using the + and − button on the treadmill controls from the outset. Participants were provided with live feedback on the treadmill's LCD screen (distance, speed, time) throughout the run and reminded that they could adjust or maintain their targeted speed at any time. The self-paced protocol was intended to provide a level of ecological validity despite the treadmill setting, so as to explore freely occurring and self-regulatory cognitions. Self-paced running strategies result in larger pace variations representing an intentional strategy to minimise the strain and fatigue, and maintain goal-based efforts (Billat et al., 2006).

Procedure

Ethical approval for the study was granted by the university's Research Ethics Committee. Several local running clubs and groups (including 5km improver groups, who had recently completed a group-led couch to 5km) were approached prior to commencement of the study and the primary researcher attended a number of club/group sessions to provide information about the study. Social Media posts were also shared on Facebook and Twitter to assist with recruitment. To be eligible for participation in the study, participants had to be comfortable with running 5km on a treadmill, be an active runner and be able to travel to the University Campus where the study was conducted.

TA and 5km run protocol. Participants attended the Sports Science laboratory at the researcher's institution where they were provided with in-depth information about the study prior to providing written and verbal consent. Participants were asked to wear light athletic clothing, not to participate in strenuous physical activity or consume alcohol in the preceding 24 h, to have not consumed food or caffeine within 1 h of testing, and to arrive for their run well hydrated. Adherence to such requests was

Table 1. Descriptive data for recreationally-trained, trained and well-trained runners.

	Sample size (*n*) & gender (F-female & M-male)	Age (years)	Reported 5km PB (min)	Running exp (years)	Weekly distance (km/week)
Recreationally-trained	6 (F:4 & M:2)	60.2 ± 13.3	30.8 ± 6.6	5 ± 2.3	19.3 ± 4.5
Trained	6 (F:3 & M:3)	45.5 ± 13.3	22.2 ± 1.7	18.8 ± 19.1	32.5 ± 17.4
Well-trained	6 (F:3 & M:3)	37.8 ± 13.6	19.3 ± 1.3	8 ± 6.3	41.3 ± 21.8

confirmed via health screening. For the first part of the research process, participants completed a survey that included demographic questions alongside information about their habitual physical activity and running times/personal bests to allow for categorisation of participants. Two tasks were then used to familiarise participants with the TA technique in line with Ericsson and Simon's (1980) established recommendations:(1) An anagram/word unscrambling task (2) A math-based (multiplication) task. If the researchers deemed that participants were struggling to think aloud or with the difficulty of the tasks, additional tasks were made available for further practice. Specifically, participants were asked to verbalise their thought processes at Level 2. Level 1 involves just the verbalisation of thoughts relevant to the task that is being completed. Level 2 includes a greater level of depth and involves the verbalisation of additional stimuli (i.e., sight, sound and smell), which are generally not automatically verbalised during the completion of a task. After participants were comfortable with TA, they were fitted with a Dictaphone (Olympus, WS-853) (held within a running belt or pocket) and small microphone that clipped onto their collar. They were then provided with instructions for the treadmill tempo run task, instructions and definitions regarding the within-run measures of perceived exertion and perceptions of breathlessness, cognitive demands and lower-body effort (scales and the anchors for each scale), and guidance on thinking aloud during the run. First, participants completed a self-paced comfortable warm-up of 1 kilometre (km) to familiarise themselves with the treadmill and speed settings. They were also encouraged to start to use the TA protocol during this warm-up. Upon completion of the warm-up, participants were given a short break before the Dictaphone was set to record and the 5km run began.

Participants were instructed to verbalise their thought processes in real time during the 5km run, without censorship or attempt to justify or explain their thoughts, according to the TA protocol. Visual prompts in the form of signs with "think aloud" written on them were placed in front of the treadmill in participant's line of sight. The researchers remained out of sight behind a screen to the rear of the treadmill for the majority of the trial and provided no encouragement but reminded participants to "remember to think aloud" at predetermined data collection points at every km and if participants remained silent for a prolonged period of over 30s at any point. These procedures were aligned with the best practice guidelines for utilising TA for endurance-based tasks (Crutcher, 1994; Ericsson & Simon, 1980, 1993; Wilson, 1994). All participants successfully verbalised their thoughts throughout the run at a sufficient level. Once the 5km distance was achieved, participants stopped running immediately and placed their feet to the sides of the treadmill belt while time elapsed and final perceptual measures were recorded, and the researcher slowed the treadmill speed down. Participants then warmed down for 2 minutes at a self-selected speed, and at the end of the session they were debriefed.

During run measures. Throughout the 5km trial, participants provided their ratings of perceived exertion (RPE) every 1km alongside perceptions of breathlessness, cognitive demands and lower-body effort (Borg, 1998). Using the same scale ranging from 0 (nothing at all) to 10 (very, very severe), limb discomfort/lower-body effort (how do your legs feel currently?), breathlessness (how does your breathing currently feel?), cognitive demands (please rate your perceived mental effort) and perceived exertion (how do you currently feel overall in terms of your whole-body exertion) were assessed. It can be suggested that perceptions of effort may be an important indicator of level of exertion given the interaction between this type of subjective measure and cognitive processes

(Tenenbaum & Connolly, 2008). Pace (time and distance covered) was also monitored via the treadmill throughout the run.

Analysis

A post-positivist approach was adopted for the current study (relativist ontological position and subjectivist/transactional epistemological position). The TA data were transcribed verbatim by a member of the research team (16,510 words, 521 min), timestamped to allow analysis by km and then subjected to line-by-line content analysis, including both deductive and inductive analysis techniques. After familiarisation with the transcripts, data were first coded inductively by the first author who has significant experience with generating and analysing qualitative data (including within different disciplinary areas) and both research and personal experience within running. This process included the generation of sub-categories (e.g., motivational self-talk, pain and discomfort, and distance). Once this was completed, Brick et al.'s (2014) framework was used, and the sub-categories were then reviewed and allocated to four overarching categories: *active self-regulation, distraction, internal sensory monitoring, and outward monitoring*. Once complete, the number of verbalisations within each category and sub-category was totalled and scored as both frequency data and a percentage of all verbalisations for each participant, and for each km across the 5km trial. To maximise reliability and as recommended in previous research of this kind (Whitehead et al., 2018), 10% of all data were also analysed by two independent researchers with experience with qualitative analysis, who were also committed runners and had published research on cognitions in endurance sport using TA. These researchers independently analysed the data sample using the categories identified by the lead researcher (see Table 2), which were scored as either 0 – no discrepancy/agreement or 1 – discrepancy. There was very good agreement between all researchers (Cohen's Kappa = 0.85 and 0.88), however, when there were discrepancies between coding, these were discussed between the researchers and amended accordingly. Any changes were also actioned across the whole data set for consistency.

SPSS Version 25 (IBM Corporation, 2017) was used for all statistical analysis and data were checked for normality using a Shapiro–Wilk test. To explore overall differences between groups on finish time, speed, total verbalisations and the number of verbalisations for categories and sub-categories, a series of One-Way ANOVA's were conducted including post hoc analysis where differences were found. Differences within and between groups (well-trained, trained and recreationally-trained) over time (i.e., after each km) were also assessed through a series of Repeated Measures ANOVA's including speed, RPE, perceptions of breathlessness, cognitive demands and lower-body effort, total verbalisations and the number of verbalisations for categories and post hoc analysis was also conducted where differences were found. Effect sizes for all results were also reported as eta-squared (η^2).

Results

Overall differences between groups

There was a statistically significant difference between groups for finish time ($F(2, 15) = 21.83$, $p > .001$, $\eta^2 = .74$), with post hoc analysis highlighting significant differences

Table 2. All categories and sub-categories identified from the Think Aloud data.

Categories	Sub-categories	Description	Example quotations
Active self-regulation	Controlling emotions and focus	Reference to controlling emotions or self-prompt to focus	"Just trying to stay focused" (P13 recreationally-trained) "Got to keep my concentration there" (P14 trained) "Suppose it's just a distraction though, concentrate" (P17 well-trained)
	Pace	Reference to purposeful strategy or action-based changes to pace	"Think I'll just keep to this pace for a bit" (P8 recreationally-trained) "Have to slow down. I can't keep that up" (P11 trained) "Might as well take it up for the last bit" (P17 well-trained)
	Form	Reference to running form including foot placement, posture or arm movements	"I'm remembering to relax my shoulders when I run" (P9 recreationally-trained) "Keep those arms swinging, keep the cadence going. Look up" (P20 well-trained) "Thinking about my foot fall. Am I overstepping it?" (P14 trained)
	Motivational self-talk	Motivational or self-encouraging verbalisations	"Nearly there. Come on, come on, come on, come on, come on, come on keep going" (P11 trained) "Make the second half count. Last K smash it out. Keep going" (P15 well-trained) "Good run this, good effort" (P20 well-trained)
	Conversions or calculations	Verbalisations involving pace or distance conversions or calculations (e.g., km/hour to minutes per mile)	"900m that's nothing. What 4, 2 min twice" (P17 well-trained) "About 7.35. 37 and a half" (P10 recreationally-trained) "13 what is that. What's that pace? Seven and a half, seven fifteen?" (P2 trained)
	Imagery	Use of imagery	"I've got to try and picture myself running outside at this speed" (P16 well-trained) "Just trying to visualise doing laps of the track" (P6 well-trained) "If I've got a certain distance to go, I'm picturing twice round the oval track" (P10 recreationally-trained)
Distraction	Generic running thoughts	Verbalisations not relevant to the current 5 km trial but related to running or training	"Got to run this weekend. 10 miler at St Anne's" (P17 well-trained) "So no, won't be a PB tomorrow but never mind, that's not what it's all about" (P8 recreationally-trained) "Maybe post-marathon I'll see if I can improve. I'd like to get sub-50 10km" (P19 trained)
	Non-running	Verbalisations not relevant to the current 5 km trial or running in general	"Miserable day outside today" (P13 recreationally-trained) "That will be me soon. I've applied for Lancaster and Leeds" (P6 well-trained) "I wonder if it's Tom's turn to make tea tonight or mine" (P18 trained)
Internal sensory monitoring	Body image/self-efficacy	Reference to body image or capabilities	"My fitness is rubbish at the moment" (P11 trained) "The thing I always hate about running is my boobs bouncing up and down." (P10 recreationally-trained) "I wish my bum didn't ripple." (P19 trained)
	Breathing	Reference to breathing or respiratory regulation	"Little bit more breathless" (P14 trained) "Put your shoulders back, breathe in and out" (P17 well-trained) "Starting to breathe a little heavier but not too bad" (P5 recreationally-trained)

(*Continued*)

Table 2. Continued.

Categories	Sub-categories	Description	Example quotations
	Fatigue	Reference to fatigue or tiredness	"My legs are so tired" (P11 trained) "Exertion" (P2 trained) "Yep. Getting a bit tired now" (P15 well-trained)
	HR or technology	Reference to heart rate or use of external feedback from treadmill or watch	"Just looked at my watch and saw the HR" (P13 recreationally-trained) "HR is up from before. It's at 164 from 146" (P14 trained) "My HR is getting quite high" (P6 well-trained)
	Monitor effort or overall feel	Reference to the amount of effort being put in or how the run was feeling	"I'm still feeling reasonable" (P10 recreationally-trained) "My legs are great – they're just sending messages back to my head going why am I not going faster" (P16 well-trained) "This feels okay now" (P3 trained)
	Pain and discomfort	Reference to physical injury, pain or general discomfort during the trial	"Just starting to feel a bit of pain around my ankle" (P4 trained) "Feeling one or two slight twinges in my lower right leg" (P5 recreationally-trained) "Balls of my feet are starting to hurt" (P17 well-trained)
	Temperature	Reference to the temperature of the room or body temperature	"I need that fan on, it's boiling" (P16 well-trained) "Getting warmer now. Face feels hot" (P18 trained) "Definitely warm" (P5 recreationally-trained)
	Thirst	Reference to thirst	"I'm thirsty, really need water" (P11 trained) "Feel quite thirsty now" (P13 recreationally-trained) "Thinking about having a drink. Water that is" (P7 recreationally-trained)
Outward monitoring	Distance	Reference to distance covered or distance left	"500 blasted out" (P15 well-trained) "One and a bit km to go" (P2 trained) "Yeah .2 to go" (P8 recreationally-trained)
	Time or trial aims	Reference to time, trial aims or expected finish time	"Trying to finish as close to 22 as we can" (P20 well-trained) "I'll be done at 27 hopefully" (P19 trained) "But not long so I just know my time won't be as good" (P8 recreationally-trained)
	Trial elements	Reference to trial-specific elements e.g., use of treadmill or discomfort with research	"That's a bit irritating. Treadmill slows down ever so slightly" (P16 well-trained) "Think this is going to feel like a long time running on this treadmill". (P18 trained) "I'm hoping this is one way glass in those windows so those men can't see me running on the treadmill" (P9 recreationally-trained)

between recreationally-trained runners (35.90 ± 6.8 min) and the well-trained (20.93 ± 1.29 min, $p > .001$) and trained (24.98 ± .91 min, $p > .001$) runners groups. However, the difference between well-trained and trained runners for finish time was not statistically significant ($p = .23$). There was also a statistically significant difference between groups for running speed ($F(2, 15) = 32.09$, $p > .001$, $\eta^2 = .81$), with post hoc analysis demonstrating the well-trained runners were performing at a significantly faster speed (14.20 ± 1.06 km/hour) than the trained runners (12.27 ± 1.03 km/hour, $p = .04$) and the recreationally-trained runners (8.70 ± 1.48 km/hour, $p > .001$). There was also a significant difference between the trained and recreationally-trained runners ($p > .001$). There were no significant differences between groups on the total number of verbalisations across the 5km trial ($F(2, 15) = .58$, $p = .57$). well-trained = 69.33 ± 21.93, trained = 59.33 ± 27.01, recreationally-trained = 54.84 ± 22.45. However, there was a statistically significant difference between groups on the number of verbalisations per minute, ($F(2, 15) = 5.78$, $p = .01$, $\eta^2 = .44$), therefore percentage data was used for all category-related statistical analysis. Post hoc analysis on the number of verbalisations per minute highlighted a difference between the well-trained (3.27 ± .95 verbalisations per minute) and recreationally-trained runners (1.52 ± .59 verbalisations per minute, $p = .01$). There were no differences between the well-trained and the trained (2.35 ± 1.06 verbalisations per minute, $p = .21$), or the trained and recreationally-trained ($p = .27$).

Categories. The majority of thoughts from the well-trained runners related to *active self-regulation* (53%), while *internal sensory monitoring* (29%) was used most frequently by the trained runners and *distraction* (30%) was the most widely verbalised by the recreationally-trained group (see Table 3). Analysis of the percentages of verbalisations related to the categories found there was a statistically significant difference between the use of *active self-regulation* across groups ($F(2, 15) = 6.99$, $p = .01$, $\eta^2 = .41$). Additional post hoc analysis demonstrated that the well-trained runners verbalised significantly more thoughts related to *active self-regulation* (53.14 ± 26.12%,) compared to the trained (24.14 ± 5.31%, $p = .02$) and the recreationally-trained runners (28.81 ± 11.74%, $p = .02$), yet there were no differences between the trained and recreationally-trained groups. There were also no statistically significant differences between groups for the other categories of *distraction* ($F(2, 15) = 1.59$, $p = .24$), *internal sensory monitoring* ($F(2, 15) = .45$, $p = .65$), and *outward monitoring* ($F(2, 15) = 1.53$, $p = .29$).

Sub-categories. There was a statistically significant difference between groups for thoughts related to *running form* ($F(2, 15) = 3.98$, $p = .04$, $\eta^2 = .35$). Post hoc analysis demonstrated that the well-trained runners verbalised significantly more thoughts related to *running form* (7.33 ± 4.4%), compared to the recreationally-trained (2, 2.43%, $p = .01$). Nonetheless, the differences between well-trained and trained (3.22 ± 3.15%) and trained and recreationally-trained were non-significant. There was also a statistically significant difference between groups for thoughts related to *motivational self-talk* ($F(2, 15) = 4.58$, $p = .03$, $\eta^2 = .38$). Well-trained runners verbalised significantly more thoughts related to *motivational self-talk* (24.69 ± 23.57%), compared to the recreationally-trained runners (2.91 ± 3.80%, $p = .04$), however the differences between well-trained and trained (4.35 ± 3.61%) and trained and recreationally-trained were non-significant. No other significant differences were found between groups for the sub-categories.

Differences between groups per km

Speed increased over the 5km trial (Figure 1), however there was no difference between groups ($F(4.49, 33.67) = 1.20$, $p = .33$, $\eta^2 = .30$). This was also the case for RPE ($F(8, 60) = .12$, $p = 1.00$, $\eta^2 = .57$), breathlessness ($F(8, 60) = .25$, $p = .98$, $\eta^2 = 0.35$), cognitive demand ($F(4.78, 35.87) = 1.11$, $p = .37$, $\eta^2 = .42$) and lower-body effort ($F(4, 26.21) = 1.35$, $p = .28$, $\eta^2 = .85$), which also all saw increases across the 5km trial that were not significantly different between groups (Table 4).

Differences over time (i.e., per km) for overall verbalisations

The number of verbalisations related to all categories did change over time, but there was no statistically significant interaction with group: *active self-regulation* ($F(8, 60) = .63$, p

Table 3. Frequencies and percentages of categories across the 5 km trial for well-trained, trained and recreationally-trained runners (*$p < .05$).

			Active self-regulation*		Distraction		Internal sensory monitoring		Outward monitoring	
	Total verbalisations	Verbalisations per min*	*N*	%	*n*	%	*n*	%	*n*	%
Well-trained	67.8 ± 21.9	3.26 ± 0.95*	36.2 ± 18.6	53.1 ± 26.1*	11.7 ± 10.8	15.2 ± 9.8	16.5 ± 8.9	25.1 ± 12.8	16.2 ± 8.4	23.2 ± 7.6
Trained	61.9 ± 27.0	2.34 ± 1.05	14.3 ± 7.3	24.1 ± 5.6	20.5 ± 20.9	19.7 ± 23.4	16.8 ± 6.1	29.3 ± 27.4	17.0 ± 8.7	26.0 ± 8.6
Recreationally-trained	54.8 ± 22.5	1.52 ± 0.59	14.2 ± 3.3	28.8 ± 11.7	16.5 ± 13.5	29.6 ± 16.9	14.0 ± 9.9	27.4 ± 18.3	16.5 ± 9.7	23.6 ± 7.9

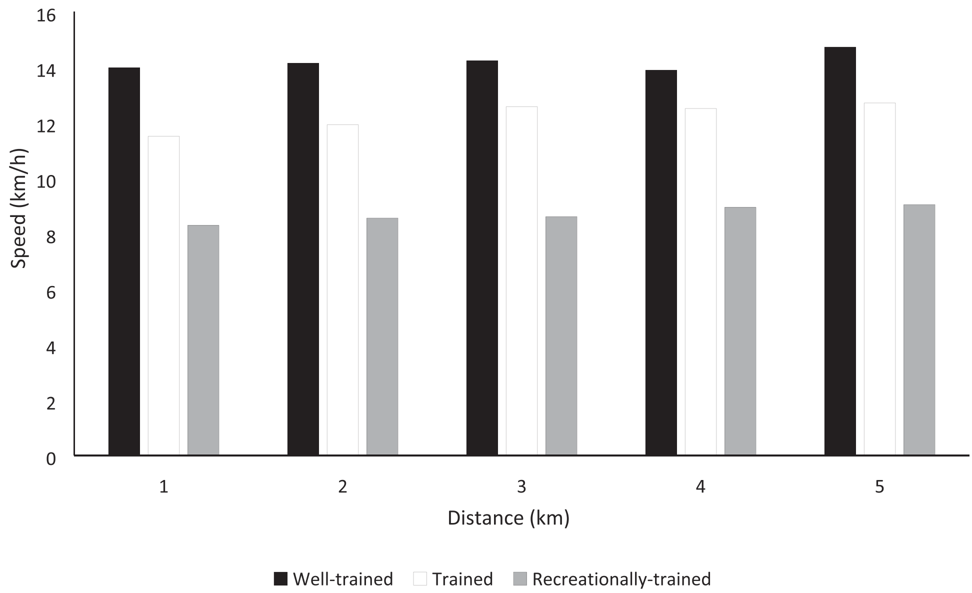

Figure 1. Speed (km/hour) for all groups across the 5km trial

= .75, $\eta^2 = .08$), *distraction* ($F(8, 60) = .70$, $p = .12$, $\eta^2 = .02$), *internal sensory monitoring* ($F(8, 60) = .63$, $p = .75$, partial $\eta^2 = .07$) and *outward monitoring* ($F(8, 60) = 1.01$, $p = .44$, $\eta^2 = .11$) (See Table 5). For the well-trained runners, the categories of *active self-regulation, distraction* and *internal sensory monitoring* did not change significantly over time, but the use of *outward monitoring* did differ statistically over time ($F(4, 20) = 3.20$, $p = .04$). However, post hoc analysis did not find any significant differences between each kilometre. For the trained runners, the frequency of verbalisations relating to *distraction* was significant over time ($F(4, 20) = 2.92$, $p = .04$), but further post hoc analysis did not find any significant differences between each kilometre. The categories *of active self-regulation, internal sensory monitoring and outward monitoring* did not change significantly over time. For the recreationally-trained runners, there was no significant effect of time for *active self-*

Table 4. Speed, breathlessness, cognitive demand, lower-body effort and RPE for well-trained, trained and recreationally-trained runners by km.

		1 km	2 km	3 km	4 km	5 km
Speed (km/h)	Well-trained	14.0 ± 1.1	14.2 ± 1.0	14.2 ± 1.1	13.9 ± 1.4	14.7 ± 1.5
	Trained	11.5 ± 0.5	11.9 ± 1.0	12.6 ± 1.3	12.5 ± 1.3	12.7 ± 1.2
	Recreationally-trained	8.3 ± 1.4	8.6 ± 1.4	8.6 ± 1.5	9.0 ± 1.7	9.1 ± 1.7
Breathlessness	Well-trained	4.3 ± 1.6	5.3 ± 2.0	6.5 ± 1.9	6.8 ± 1.5	7.3 ± 2.1
	Trained	4.3 ± 2.2	5.0 ± 2.1	6.0 ± 1.7	6.3 ± 2.9	7.5 ± 1.9
	Recreationally-trained	3.3 ± 0.8	4.0 ± 1.5	5.2 ± 1.5	5.2 ± 1.3	6.0 ± 1.4
Cognitive demand	Well-trained	4.0 ± 1.7	4.5 ± 1.6	5.2 ± 1.3	5.5 ± 1.5	6.7 ± 1.6
	Trained	3.2 ± 1.5	4.7 ± 1.2	4.5 ± 1.9	5.3 ± 2.1	6.3 ± 2.3
	Recreationally-trained	2.8 ± 1.3	3.3 ± 1.2	5.2 ± 1.5	5.8 ± 1.0	5.8 ± 1.5
Lower-body effort	Well-trained	3.5 ± 1.9	5.2 ± 2.2	5.0 ± 2.0	5.5 ± 2.3	6.2 ± 1.9
	Trained	2.8 ± 1.2	2.8 ± 1.5	4.0 ± 1.3	5.3 ± 2.2	6.0 ± 2.1
	Recreationally-trained	2.5 ± 1.0	3.8 ± 1.0	4.5 ± 1.5	5.2 ± 1.3	5.8 ± 1.6
RPE	Well-trained	4.2 ± 2.1	5.3 ± 2.5	5.8 ± 2.1	6.5 ± 2.1	7.2 ± 2.6
	Trained	3.8 ± 1.9	4.7 ± 1.6	5.3 ± 2.1	6.2 ± 1.9	6.3 ± 2.8
	Recreationally-trained	3.2 ± 1.3	4.0 ± 1.4	5.0 ± 1.4	5.3 ± 1.0	6.0 ± 1.5

Table 5. Frequencies and percentages of verbalisations on the four categories between groups across each km (*$p < .05$).

		1 km		2 km		3 km		4 km		5 km	
		N	%	*N*	%	*n*	%	*n*	%	*n*	%
Active self-regulation	Well-trained	6.0 ± 3.6	8.8 ± 4.8	6.2 ± 4.8	9.2 ± 7.6	6.0 ± 4.0	9.1 ± 6.2	7.3 ± 3.1	11.2 ± 4.6	8.5 ± 5.7	11.4 ± 6.5
	Trained	1.7 ± 1.2	2.8 ± 1.8	2.0 ± 1.4	3.2 ± 1.8	3.3 ± 2.6	5.8 ± 3.2	2.2 ± 1.2	4.2 ± 2.0	4.3 ± 3.4	6.5 ± 3.1
	Recreationally-trained	2.5 ± 1.0	5.8 ± 4.6	1.5 ± 1.0	3.3 ± 3.7	3.0 ± 1.9	6.3 ± 5.6	3.5 ± 2.1	6.2 ± 2.3	3.3 ± 0.8	6.7 ± 2.3
Distraction	Well-trained	2.3 ± 1.5	3.3 ± 1.6	3.0 ± 3.8	3.6 ± 4.1	1.7 ± 3.1	2.0 ± 3.2	2.0 ± 1.8	2.7 ± 1.8	1.5 ± 1.4	2.2 ± 2.1
	Trained*	2.2 ± 7.1	9.2 ± 8.6	3.8 ± 4.2	10.4 ± 8.8	1.7 ± 2.3	2.9 ± 2.9	2.0 ± 4.5	6.9 ± 7.3	1.5 ± 1.6	1.1 ± 2.1
	Recreationally-trained	4.7 ± 4.5	4.5 ± 5.9	5.0 ± 5.0	7.4 ± 6.7	2.7 ± 2.5	6.5 ± 4.7	3.7 ± 1.9	4.0 ± 2.9	2.2 ± 1.9	4.7 ± 2.2
Internal sensory monitoring	Well-trained	3.2 ± 2.3	4.6 ± 3.5*	3.0 ± 0.9	4.8 ± 2.2	3.2 ± 2.6	4.8 ± 3.9	3.3 ± 2.3	5.5 ± 4.6*	3.2 ± 2.4	4.6 ± 2.9
	Trained	3.2 ± 2.4	7.8 ± 7.6	3.0 ± 2.8	7.2 ± 3.5	3.2 ± 1.1	5.5 ± 2.1	3.7 ± 1.0	5.5 ± 4.8	2.5 ± 1.9	4.6 ± 3.6
	Recreationally-trained*	3.0 ± 2.1	7.5 ± 3.2	3.2 ± 1.7	6.7 ± 4.2	2.7 ± 2.8	3.4 ± 4.9	3.3 ± 1.9	3.5 ± 3.2	2.7 ± 1.9	3.8 ± 3.4
Outward monitoring	Well-trained*	2.5 ± 2.7	3.3 ± 2.5	1.7 ± 1.2	2.5 ± 1.7	2.8 ± 2.5	4.0 ± 2.8	4.2 ± 1.6	5.9 ± 2.0	4.3 ± 2.3	6.5 ± 3.1
	Trained	2.5 ± 2.0	6.3 ± 2.4	1.7 ± 1.7	5.1 ± 2.2	2.2 ± 3.0	4.8 ± 4.4	4.0 ± 1.9	5.4 ± 5.4	4.3 ± 2.5	7.7 ± 2.2
	Recreationally-trained	3.2 ± 2.1	6.8 ± 3.0	1.8 ± 1.7	3.5 ± 2.5	1.8 ± 2.8	6.1 ± 3.0	3.3 ± 1.9	4.0 ± 2.5	4.0 ± 3.5	5.7 ± 4.3

regulation, distraction and outward monitoring, yet statistical significance was found for *internal sensory monitoring* ($F(4, 20) = 4.34$, $p = .01$), within which, post hoc analysis showed a significant increase between kilometre 1 and kilometre 4 (.40 (95% CI, .01 to .07), $p = .04$).

Discussion

The current study used TA to explore the thought processes and attentional focus of runners during a 5 km tempo run. The findings highlight differences in the thought processes and attentional focus of well-trained runners compared to their trained and recreationally-trained counterparts. Moreover, the trained runners possessed some, but not all, of the self-regulatory cognitive processes compared to the well-trained runners. In contrast, recreationally-trained runners reported a limited number of psychological skills to draw upon while running.

The findings demonstrate that active self-regulatory cognitions are the characterising feature of the well-trained group in comparison to the other running groups. A substantial percentage (53%) of the well-trained runners exhibited thoughts concerning controlling cognition during running, predominantly via active self-regulatory strategies. Previous research has shown that highly skilled athletes are effective at controlling their thought processes (Nietfeld, 2003) and they use mental strategies to manage the demands of their sport (Samson et al., 2017) and make decisions to improve performance (Brick et al., 2020). While there was no statistical significance between the finish times of the well-trained and trained athletes, these groups differed in the content of their cognition with the trained athletes making much less frequent use of active self-regulatory strategies (24% compared to 53%). As such, despite similarities in performance, these two groups employ very different strategies to complete a somewhat challenging tempo run. Trained runners made more frequent use of internal sensory monitoring (29%) (e.g., pain and discomfort, monitoring effort), compared to well-trained runners. Like active self-regulation, this demonstrates some ability of these runners to focus on monitoring their bodily processes in an attempt to achieve optimal performance. However, whilst the well-trained runners supplemented internal monitoring with active self-regulatory efforts, the trained group was less likely to do so.

An internal focus on body sensations during running does not necessarily disrupt movement efficiency (Schücker et al., 2014), however, these trained runners seemed to lack the ability to make effective use of tangible strategies to get the most out of their running performance (i.e., the use of active self-regulation). As the trained runners had a greater number of years running experience, there could be other factors which also contribute to the development of such skills, such as more focused or high-intensity training, coaching strategies or exposure to more regular race/competition environments (i.e., targeted training). Indeed, Brick et al. (2015) found elite runners' monitored pain and discomfort to guide cognitive strategy use. In our sample, this ability to use this monitoring to guide self-regulatory efforts is a differentiating feature of running expertise. This supports suggestions from Brick et al. (2016) that optimal performance is derived from the ability of endurance athletes to monitor both internal and external stimuli and make use of appropriate cognitive strategies to cope with the demands of the task, however this area requires further exploration.

Reflecting these differences in active-self-regulation, well-trained runners employed greater motivational self-talk and focused more on running form during the run. Motivational self-talk is an advocated technique in sport psychology to improve endurance performance (Barwood et al., 2015; Blanchfield et al., 2014), and is commonly adopted by runners facing more challenging situations (Nedergaard et al., 2021). In the current study, motivational self-talk by the trained (3%) and recreationally-trained (4%) was negligible; however, well-trained runners made use of this strategy throughout the tempo run, with 25% of all verbalisations fitting into this category. Therefore, whilst less experienced runners focused on internal sensations associated with the effort of the tempo-run, the well-trained runners were able to selectively employ motivational and form-based cognitive control to impact performance. Indeed, self-talk can reduce perceptions of effort in endurance performance (Basset et al., 2022) and therefore is a strategy that should be encouraged by coaches and run leaders working with lower-level runners.

This further supports research (Brick et al., 2016) highlighting how task-relevant monitoring of body sensations or form can help optimise pace via improved running economy. According to Brick et al. (2016), these cognitions are likely developed through relevant experience, which may provide insight into why recreationally-trained and trained runners used these strategies less than the well-trained group. Consistent with previous research, elite (Brick et al., 2015) and recreational (Brick et al., 2020) endurance runners will frequently focus on their form or technique as an active self-regulatory strategy to impact efficiency. Other research has highlighted that such a focus increases when running is challenging (e.g., uphill) and when fatigue is impacting technique (Samson et al., 2017; Whitehead et al., 2018). As has been previously suggested (Brick et al., 2020), these self-regulatory thoughts can also help runners to increase workload and pace, without necessarily increasing perceptions of effort. Such strategies are key when engaging in a tempo-type run under training (non-race) conditions. Indeed, in line with proposals from researchers (Jackman et al., 2021), frequent use of these strategies could yield performance gains for lower-level runners such as the trained and recreationally-trained runners in this study. García et al. (2015) categorised these movement related task-relevant thoughts as "command and instruction", with a focus on self-regulatory efforts to guide bodily movements during running and suggested training alternative thoughts can be ineffective, cognitively effortful and ergogenically limited. Interestingly, Brick et al. (2020) note that recreational runners learn such strategies from coaches during beginner running programmes. Exposure to more individualised coaching (which is more likely to occur with higher level runners), may have been an important development phase of these cognitive strategies for the well-trained group.

Distraction (30%) was most widely verbalised by the recreationally-trained group. This supports earlier research within recreational-level runners (Samson et al., 2017) and untrained cyclists (Whitehead et al., 2018), in that these individuals are more likely to be distracted during exercise. This may reflect their limited experience, particularly with more challenging forms of training. Indeed, previous evidence suggests that dissociative thoughts, particularly those used as a form of active distraction during moderate-vigorous physical activity, support more pleasurable experiences (Bourke et al., 2021). However, given that the recreationally-trained runners in the study took longer to complete the 5 km run, this, coupled with their limited self-regulatory strategies, may have led them to rely on task-irrelevant distraction. According to the dual-mode theory (Ekkekakis et al. 2005), these dissociative cognitive processes and strategies can regulate affective responses and perceived exertion at moderate exercise intensities. However, as exercise intensity and salience of interoceptive cues (e.g., elevated heart rate) increases, attention shifts to internal associative processes. Consequently, the utility of dissociation, distraction or other cognitive strategies is diminished when exercise becomes increasingly challenging (Tenenbaum & Connolly, 2008). Counterintuitively, these distractive efforts during discomfort have been proposed to lead to "hitting the wall" and negative affective appraisals post-exercise (Lind et al., 2009) due to the transition towards association with increasing physical demands. Furthermore, as the aim of the tempo run was to maintain a relatively challenging level of exertion, these distractive thoughts may have therefore interfered with the recreational runners' task goal and pace monitoring as effort sensations increased in salience (García et al., 2015).

The second aim of the study was to assess thought processes and attentional focus changes over the course of the run. While there was no statistical significance between groups, analysis revealed interesting changes over the course of the run and the patterns of these changes also differed according to level of performer. In particular, the well-trained runners use of outward monitoring changed over the course of the 5 km run. Runners made minimal outward monitoring references within the first part of the tempo run, but this increased within the last 2 km, where a focus on distance covered/remaining and time increased. In previous studies, trained athletes verbalise distance-related thoughts (e.g., Whitehead et al., 2018) to inform self-regulatory efforts to maintain goal attainment (Brick et al., 2016). In contrast, recreationally-trained runners' outward monitoring fluctuated across the 5 km run, with these runners being focused on how far they had run, expected finish time and elements related to the trial itself (e.g., using the treadmill).

The RPE scores and perceptions of breathlessness, cognitive demands and lower-body effort of recreationally-trained runners were also marginally lower at all stages of the run, which is likely indicative of the (relative) intensity they were performing at. Previous research by Brick et al. (2020) has highlighted how recreational runners may use chunking techniques (distance or time) to allow them to complete a run. These techniques help to provide an insight as to why recreational runners appear to draw on these strategies more consistently, compared to the well-trained runners who may use such outward monitoring thoughts as a motivational tool towards the end of a run. This is in line with findings within a cycling context (Massey et al., 2020). The RPE, body demands and associated speeds of the well-trained runners also reflects this, as these runners decreased their speed in the 4th kilometre before increasing speed despite their RPE scores continuing to rise. This final km end-spurt, alongside greater outward monitoring by the well-trained group, reflects increases in pace to achieve goal attainment and is similarly supported by their motivational self-talk.

Analysis of distraction thoughts revealed differences between well-trained and recreationally-trained groups, although the differences between each km were shown to be non-significant. Trained runners initially provided more irrelevant (non-task focused) thoughts at the beginning of the run; however, distraction verbalisations decreased as the run progressed. Although non-significant, this pattern was seen for the well-trained runners who had less non-task specific thoughts in the latter stages of the run. These well-trained runners allowed their minds to wander in the less intensive stages of the run (RPE and demand scores lower) but then became more focused and strategic during the later stages of the 5km. Echoing findings from Samson et al. (2017), during which other, performance-related techniques such as focusing on breathing or form and decisions around pace take precedent. Comparatively, recreationally-trained runners have more consistent distractive thoughts throughout the 5km run, suggesting that distraction is less used as a deliberate method compared to trained and well-trained runners. Samson et al. (2017) suggest that recreational runners may benefit from distraction as this prevents focusing on negative thoughts, pain and fatigue. However, this may only be applicable when the accumulation of fatigue or increases in intensity do not make such distraction difficult due to increasingly salient physiological sensations of exertion (Aitchison et al., 2013).

Recreationally-trained runners internal sensory monitoring frequency decreased as the run progressed, supporting Brick et al.'s (2020) retrospective study of recreational runners showing a predominant focus on internal sensory stimuli (breathing and effort-related sensations) in the initial stages of a run. The implications for these less experienced runners may be unpleasant affective responses during a run, which may decrease motivation and, lead to drop out (Johnson et al., 2020). Providing less experienced runners opportunities to develop alternative cognitive skills/strategies, may positively impact their exercise adherence (Jackman et al., 2021). Promising evidence suggests that runners can be trained to employ individually tailored, effective self-talk that can impact on their physiological responses and perceptions of effort during running (Basset et al., 2022).

Limitations and future research

While TA can give insights into cognition, the verbalisations from all runners were generally of limited depth. The real-time nature of TA during a relatively short physically demanding endurance task, coupled with runners' lack of experience in using TA (Whitehead et al., 2018) may have led to a relatively surface-level analysis of thoughts. Conducting follow-up post-task interviews may allow for greater in-depth exploration of participants' thought processes. Specifically, how the active self-regulatory strategies used by the well-trained runners are developed and employed. In addition, although attempts were made to preserve the self-paced nature of the running task, the research was conducted in a controlled lab-based setting. Some of the lower-level runners (especially in the recreationally-trained group) had less experience with treadmill running, which could have impacted thought processes. Where possible, future research should be conducted in more naturalistic environments, potentially investigating different types of training runs (e.g., easy, tempo, interval).

Age differences of participants across the three groups are also a consideration. The recreationally-trained runners were the oldest runners, followed by trained runners and the youngest participants were in the well-trained group. Furthermore, despite a relatively evenly number of males and females across groups, the current study did not explore gender differences which have been highlighted for further research attention (e.g., Brick et al., 2016). While runners were from a range of socio-economic backgrounds, all participants in the study were White British, so further research with runners from a range of ethnic backgrounds is also recommended.

Conclusion

This study enhances current knowledge on the thought processes and strategies adopted by endurance and recreational athletes undertaking endurance-based activities for training purposes. In particular, the results highlight the self-regulatory cognition differences between well-trained, trained and recreationally-trained runners. Differences indicate that it is not just exposure to running that develops effective psychological skills, but type of training background appears critical. Coaches and run-leaders (couch to 5k) can offer targeted support and opportunities for lower-level runners to develop effective cognitive strategies, such as exposure to intensities and distances. This could have a positive impact upon both performance and continued adherence to beginner running initiatives.

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Data availability statement

The data that support the findings of this study are available from the corresponding author, [Dr Laura Johnson], upon reasonable request.

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