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The Effect of Secret Clock Manipulation on 10km Cycle Time Trial Performance

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Abstract: The anticipatory RPE feedback model (Tucker 2009) proposes that during self paced exercise tasks, muscular work is continually regulated through comparison of a subconscious 'template' Rating of Perceived Exertion (RPE) that serves to protect against the development of catastrophic physiological failure, and a 'conscious' RPE that is generated through afferent feedback with regards to peripheral physiological status and through psychological inputs. The aim of this study was to investigate the effect of altering psychological inputs via incorrect time feedback on both RPE and performance during a series of maximal effort 10km cycle time trials. After task familiarisation, eight participants performed three separate time trials using their own cycle mounted onto the Kingcycle ergometer rig. Distance covered was available via large visual display along with elapsed time. On one occasion the display clock ran at the correct speed, but on two other occasions the clock manipulation was altered so that it ran either 10% too fast or 10% too slow. The order of the interventions was randomised. Although no significant differences were observed in total performance time, the magnitude of the endspurt participants were able to generate in the final 10% of the trial was significantly ($P<0.01$) greater during the slow clock trials than during the fast clock trials. Despite differences in pace distribution under each clock condition, a similar generally linear increase in RPE was observed throughout trials in all conditions. It is proposed that these findings lend support to the anticipatory RPE feedback model, and that altered psychological inputs probably act by influencing the fraction of metabolic reserve capacity that can be accessed during such trials.

Keywords: cycle, trial performance, clock, exercise

Introduction

During sporting competition athletes have been demonstrated to display a variety of different pacing strategies. Most can be classified as either 'all out' (where the participant starts rapidly and progressively decelerates), 'slow start' (where there is an acceleration throughout), even pace (where the pace is uniform throughout), or variable pace (where there are fluctuations in pace throughout the event). Whatever strategy is employed, the brain must continually monitor a vast array of feedback from the peripheral physiological systems and the environment in order to make fine adjustments to muscular work so as to avoid catastrophic failure in any physiological system (St. Clair Gibson et al 2006). The environmental and physiological feedback is proposed to be incorporated into a mathematical algorithm that uses knowledge of the endpoint of exercise as an anchor to determine whether the current power output is appropriate in light of the athletes existing physiological resources, a process that has been termed 'telioanticipation' (Ulmer 1996).

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Tucker (2009) suggests that the conscious regulation of self-paced exercise may use the Rating of Perceived Exertion (RPE) as a mediator of pacing strategy. A 'template RPE' is set in advance of an exercise task that ensures the maximal tolerable RPE is reached at the point when the exercise task is completed and not before. The 'conscious RPE' is generated as a result of afferent physiological signals in the context of the expected duration of the exercise bout. In effect, the athlete regulates muscular power output through alterations in skeletal muscle recruitment during a trial in order to ensure that the conscious perception of effort is acceptable. Therefore, the conscious RPE may be considered to be reflective of the athletes 'strategy' during a self paced trial, whereas continual fluctuations in muscular power output reflect 'tactical' responses to changes in the nature of the afferent feedback received. Tucker at al (2004) provide evidence that exercise behaviour is indeed regulated in order to prevent physiological failure under conditions of increased environmental stress. When performing 20km cycle time trials in hot (35^{o}C) and cool (15^{o}C) conditions, participants achieved better performances when the temperature was lower. Power output and iEMG was lower in the hot trials, although core temperature and RPE was similar in both conditions, thereby suggesting that the muscle mass recruited was 'tactically' reduced in order to prevent achievement of a dangerously high core temperature. This finding that the perception of effort is similar despite varying levels of muscular power output in different environmental conditions supports the notion that fatigue can be viewed as a conscious sensation resulting from the interpretation of subconscious regulatory processes (Noakes et al 2005).

In contrast to these ideas, Macora (2008) argues that the proposed model of regulation of exercise behaviour through RPE is unnecessarily complex and that it is not clear why subconsciously generated high levels of perceived exertion are needed in order to deter the conscious brain. It is argued that subconscious regulation of muscle recruitment could theoretically result in the achievement of maximal exercise performance regardless of psychological factors such as motivation, and that the incorporation of RPE into the model of exercise regulation is therefore unnecessary. Rather, changes in motivational intensity can more simply explain exercise behaviour in different conditions. The observed increase in RPE throughout an exercise trial can be explained by the increases in central motor command to the skeletal muscle required to compensate for progressive reductions in neuromuscular responsiveness and increases in ventilation as exercise progresses.

Using a time to task failure protocol, DeVrijer & Bishop (2009) demonstrated that it may be possible to enhance athletic performance through use of an intervention likely to influence motivation. Following an initial familiarisation trial, participants performed three cycle trials to volitional exhaustion at 120% of the power at VO_2 max. Elapsed time was shown to subjects, but secret clock manipulation was used so that during one of the trials the clock ran 10% too fast and during another it ran 10% too slow. Time to failure was significantly longer under the fast clock compared to the slow clock condition. The authors proposed that incorrect time feedback may have increased motivation during the fast clock trials due to false perception of a high level of performance.

The aim of the present study is to determine the affect of a similar intervention (secret clock manipulation) on performance, pacing and perceived exertion during a self paced cycle time trial.

Methods

Participants
Eight well trained males (33 ± 13 years) who were currently regularly engaged in endurance cycling events participated in this study. All provided full written informed consent and completed a pre-exercise health questionnaire prior to participation in the procedures which had approval from an Institutional Ethics Committee.

Design
A repeated measures experimental laboratory based study was conducted. The participants reported to the laboratory on four separate occasions and performed a self paced 10km cycle time trial on each visit. The first of these acted as a familiarisation trial, while the next three served as the experimental trials.

Measures
Rating of Perceived Exertion (RPE)
The Borg Category 20 Scale (Borg, 1970) was used to record the participants' current rating of perceived exertion at each 0.5km throughout the time trial. Participants were required to provide a whole number corresponding with their rating of perceived exertion where 6 corresponds to a qualitative anchor of *"light"* to 20 *"very very hard"*.

Performance Expectations
Performance expectations were assessed by asking participants to articulate the goal they set themselves prior to each time-trial.

Procedure
On initial arrival at the laboratory participants provided information regarding their goals. Following an individualised warm up, participants performed three self paced 10km time trials using their own bicycles mounted onto the Kingcycle ergometry system (Kingcycle Ltd, High Wycombe UK). The front wheel was removed and the cycle attached to the Kingcycle by the front forks and a pillar under the bottom bracket. The rear wheel was positioned on the air-braked flywheel and the velocity of its revolution monitored by a photo-optic sensor. The Kingcycle rig was interfaced to a PC equipped with the Kingcycle v6.7 software package which calculated the power output (Watts) that the cyclist would have generated at that cadence on level ground. The system was calibrated by asking participants to reach a power output of approximately 250W while seated in the same position as they would be during the subsequent trial. They then stopped pedalling and the height of the pillar supporting the bottom bracket was adjusted so that the deceleration of the flywheel was equal to a reference power decay curve. The only instructions given to participants were to complete each trial as quickly as possible. Distance covered and elapsed time was

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provided via a large visual display immediately in front of the participant throughout each trial. However, during one of the experimental conditions the clock calibration was altered so that it ran 10% too fast, and during another it ran 10% too slow. In the third condition the clock ran at the correct speed. The order of the experimental conditions was randomised. At 0.5km intervals throughout the time trial, participants were asked to report their current RPE. A period of not less than 2 days, and not more than 7 was allowed between successive trials for each subject.

Data analysis
Descriptive statistics (mean and standard deviation) were calculated for both speed ($m.s.^{-1}$) and RPE over each 0.5km increment under each experimental condition. Two way analysis of variance (ANOVA) was used to assess differences between variables throughout trials in each condition. One way ANOVA was used to assess differences in performance time between conditions, and also to assess differences in the magnitude of the acceleration or 'endspurt' that is frequently observed in the final 10% of self paced activities (Catalano 1974).

Results

No significant differences were observed in 'real time' performances achieved under each clock condition. However, there was a trend towards the fastest times being achieved with the slow clock (896.28 ± 53.19s), and the slowest times with the fast clock (913.42 ± 80.90s).

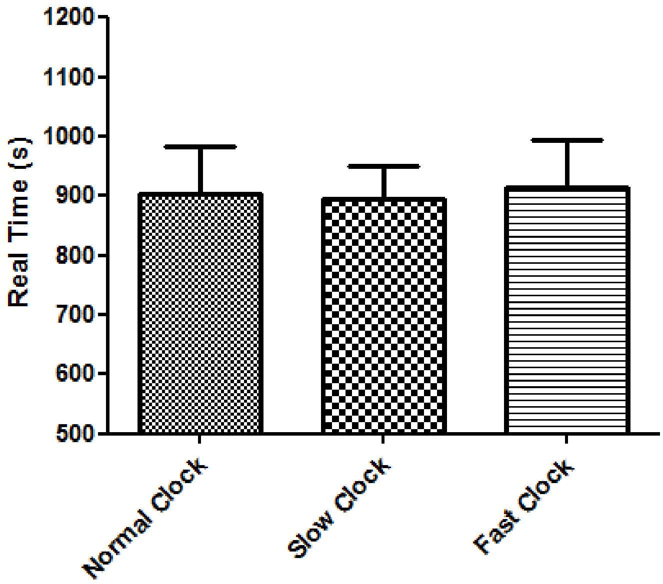

Figure 1. Performance times in each clock condition.

Despite the similar overall performance times, the nature of the pacing strategy used differed under the different clock conditions. Mean speed over each 0.5km interval was similar in all conditions for the first 5km, but following this there was a visually apparent divergence in speed with the highest speeds achieved with the slow clock and the lowest speeds with the fast clock.

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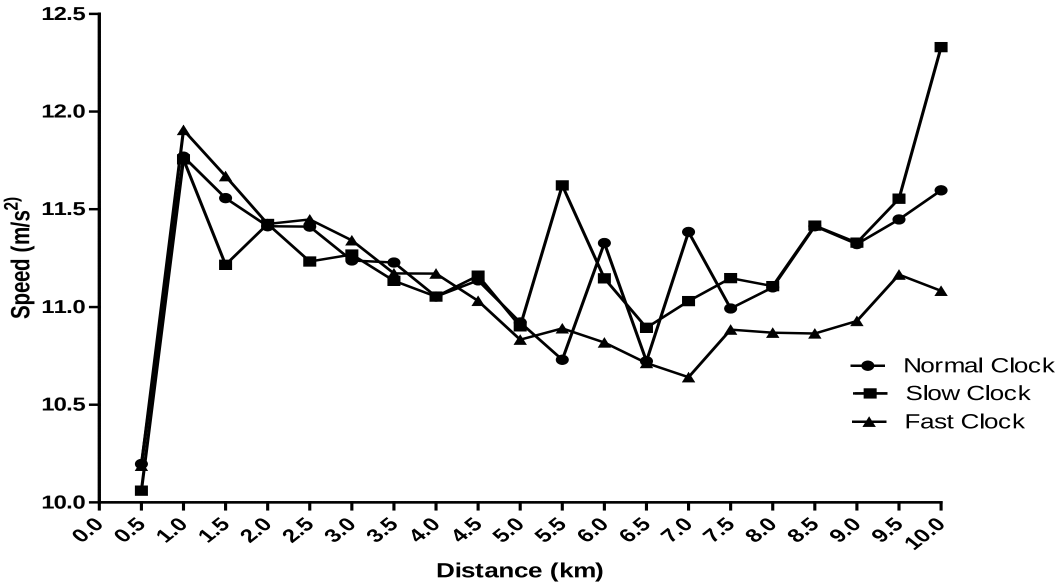

Figure 2. Mean speed for each 0.5km interval in each clock condition (error bars removed for clarity)

Secret clock manipulation clearly affected the ability to generate an endspurt in the final 10% of each trial. Although mean speed was similar in the first 90% of the trial under each clock condition (slow: 11.18m.s.$^{-1}$ normal: 11. 16m.s.$^{-1}$ fast: 11.04m.s.$^{-1}$), participants were able to generate a significantly greater ($P<0.01$) mean speed over the final 10% with the slow clock (11.94m.s.$^{-1}$) than with the fast clock (11.12m.s.$^{-1}$).

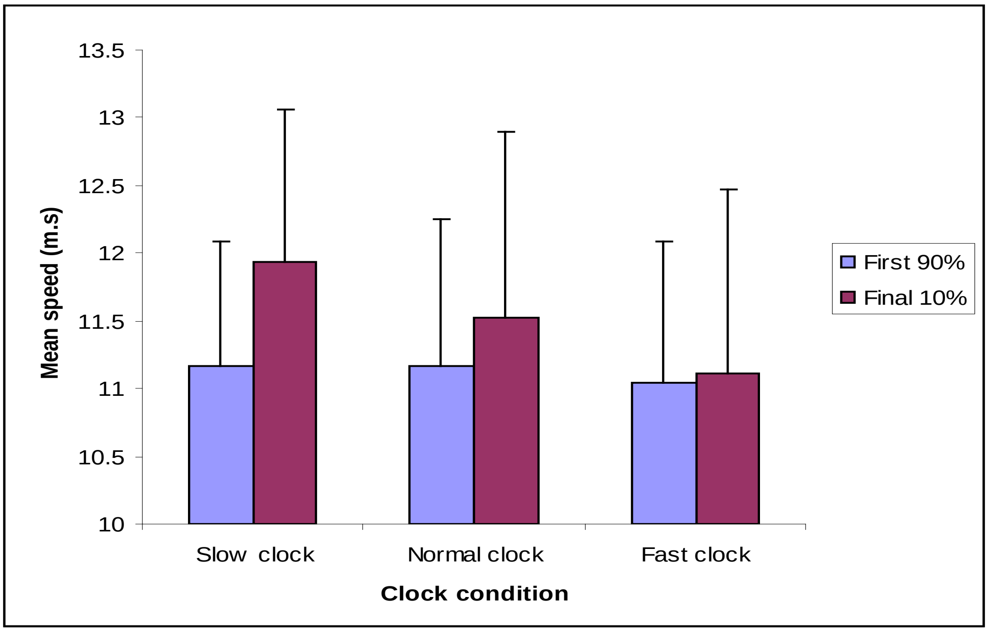

Figure 3. Mean speed for first 90% and final 10% of trial under each clock condition.

In terms of the magnitude of endspurt generated, the speed during the final 10% of the trial relative to the first 90% was significantly (*P<0.01*) greater with the slow clock (106.95%) than with the fast clock (100.53%).

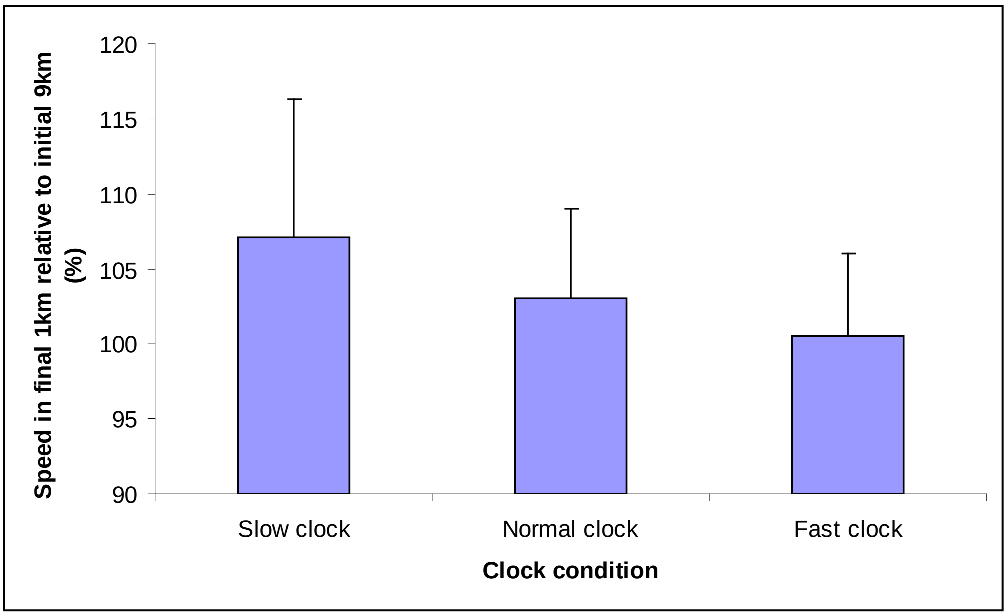

Figure 4. Speed during final 10% of each trial expressed as a percentage of mean speed during the initial 90%.

Participants displayed a generally similar linear increase in RPE under all clock conditions with no statistically significant differences found at any intermediate point.

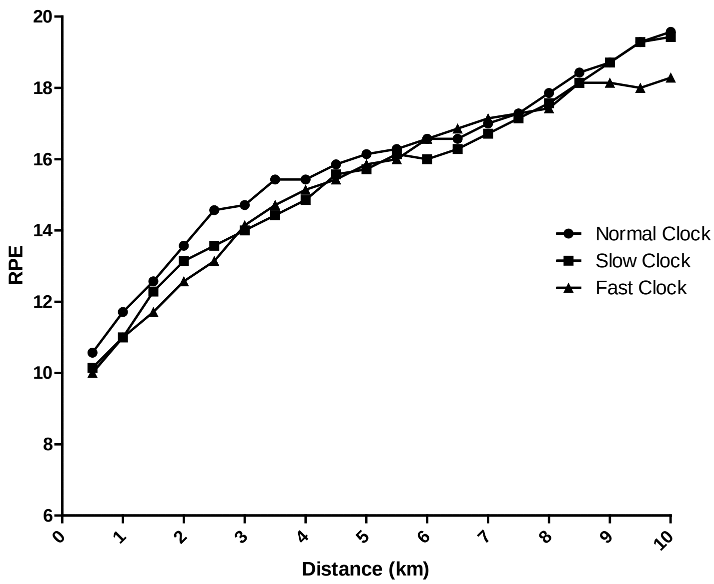

Figure 5. Mean RPE at each 0.5km interval in each clock condition (error bars removed for clarity).

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In terms of goal orientation, every participant reported the setting of a process orientated goal (e.g. "to maintain a good cadence" or "not to 'blow up' near the end") prior to the familiarisation trial. However, of the total of twenty remaining experimental trials that constituted the study, participants stated that their goal was to better their own (believed to be) previous best time on all but two occasions. When display time was subsequently converted to real time, then on only four occasions did participants actually achieve their stated performance goal. One participant achieved their 'real' target time under both normal and fast clock conditions, another under the fast clock condition, and a third under the slow clock condition.

Discussion

The similar RPE profiles in each clock condition lend support to the anticipatory RPE feedback model (Tucker 2009). This model suggests that a 'template RPE' is set in anticipation of a self paced exercise bout in order to prevent achievement of the highest tolerable RPE prior to task completion. The template RPE is based on both knowledge of the forthcoming exercise bout and previous experience of similar activities. In order to regulate exercise behaviour it is proposed that this template RPE is continually compared to a 'conscious RPE' that is generated as a result of afferent feedback from the peripheral physiological systems and the integration of psychological inputs such as arousal, motivation, and the presence of competitors. The brain then varies skeletal muscle recruitment in order to ensure that the conscious RPE does not exceed the template RPE. The ability of secret clock manipulation to alter the muscular work rate despite similar RPE values confirms the importance of the role played by psychological inputs in generating the conscious RPE. Although the precise effect of clock manipulation on psychological factors in this study is unknown, both DeVrijer and Bishop (2009) and Morton (2009) suggest that it is a technique likely to influence participants levels of motivation.

The similar RPE profiles observed under different clock conditions despite differing muscular work rates would also suggest the assertion of Macora (2008) that increases in RPE throughout an exercise trial are simply the result of progressive reductions in neuromuscular responsiveness and increases in ventilation is incorrect. If this were the case, then it would be expected that greater muscular work rates would be accompanied by higher RPE values, as peripheral fatigue and ventilation would be greater. Therefore, it would appear that motivational intensity alone cannot explain the results of the present study.

It is possible that the effects of clock manipulation during a self paced trial may be similar to the effect of intermittent crowd support during athletic competition. During periods of crowd support, reported RPE is typically higher than during periods without support (Noakes 1992). If muscular work is indeed varied in order to match conscious RPE to a subconscious template, then it would seem likely that muscular work rate would be increased during these periods of crowd support if changes to psychological inputs (such as motivation) mean that RPE for any given fixed workload is reduced. St. Clair Gibson et al (2006) report anecdotal evidence that suggests this may indeed be the case. If a leading athlete moves decisively ahead of his competitors in the final stages of a race then their RPE is dramatically reduced despite an increase in muscular work. Conversely, RPE increases rapidly in competitors who are unable to match the leaders speed. In the present study, it may be that the effect of a 'slow' clock calibration is effectively the same as is moving ahead of competitors towards the end of a competition. The slow clock would mean that participants perceived themselves to be more likely to achieve or surpass their goals (which were nearly all outcome related). If the effect of this was to reduce RPE at any given workload, then in order to continue to match conscious RPE to the template RPE muscular work would need to be increased, thereby explaining the greater magnitude of endspurt observed in the slow clock condition. The converse would be the case in the 'fast' clock condition. Participants would have perceived themselves to be less likely to achieve their goal thereby leading to reduced motivation and an increased RPE at the same workload. Muscular work rate would then need to be reduced in order to ensure that the conscious RPE did not exceed the template RPE.

It is interesting that the effect of secret clock manipulation was not apparent early in the trials but developed as each exercise bout progressed. In particular, it appears that 50% and 90% of total distance represented important points at which the effects were magnified. It is possible that the increasing impact of clock manipulation after the exercise bouts commenced is simply be due to the fact that the absolute discrepancy between 'real' and 'display' time will continually increase. For example, after two minutes of exercise in the fast clock condition, display time will be twelve seconds slower than real time elapsed. However, after ten minutes display time will now be sixty seconds slower than real time. The changes in performance in each of the different clock conditions that began to occur at 50% of total distance may be due to this being an obvious marker by which participants were able to assess their current performance. This idea is supported by qualitative information provided by a number of participants after completion of the trials. For example, different participants reported that "when I saw the clock at halfway I worked out that I would have to go even faster in the second half to beat fifteen minutes", or "I knew I was in trouble when I saw the 5km time". Subjective observation of participants indicated that they began to look at the display clock more frequently as they reached 50% distance, presumably because knowledge of performance at this point allowed simple calculation of likelihood of achieving their outcome goal. As participants looked at the display less frequently prior to this point then the effect of clock manipulation on RPE or muscular work would be minimal.

The acceleration or 'endspurt' in the final 10% of the trial is a commonly observed phenomenon in self paced exercise bouts, and has been suggested to represent an 'endspurt of certainty' (St. Clair Gibson et al 2006) whereby the brain calculates that it can safely allow an increase in muscular work rate without the risk of disrupting physiological homeostasis. However, in the present study, and despite the ability to produce a substantial endspurt during the last 10% of the slow clock trials (106.95% of the speed during the initial 90%), participants were barely able to increase work rate at all in the final 10% during the fast clock trials (100.53% of speed during the initial 90%). Again, this can be explained through reference to the anticipatory RPE feedback model. An increase in the conscious RPE for any given muscular work rate as a result of reduced motivation induced by incorrect time feedback would mean that muscular work rate would need to be reduced in order to prevent the conscious RPE exceeding the template RPE. As conscious RPE is approaching maximal values during the final 10% of the trial as a result of changes in the nature of the afferent feedback the brain is receiving from the peripheral physiological systems, then any further increases in RPE as a result of psychological inputs may preclude further increases in muscular work. Conversely, incorrect feedback that enhances motivation would reduce conscious RPE thereby allowing muscular work to be increased without the template RPE being exceeded. In effect then, it may be that enhanced motivation as a result of incorrect (i.e. slow) time feedback allowed participants to access a greater proportion of their available ‘metabolic reserve’ during the final 10% of trials. Noakes et al (2005) suggest that the maintenance of a metabolic reserve capacity acts to ensure that physiological homeostasis is maintained, thereby preventing catastrophic physiological failure. If this is the case then the findings of this study would indicate that the ability to access a high fraction of an individuals metabolic reserve capacity (and thereby achieve high levels of athletic performance) is dependent on optimal psychological status.

In conclusion, secret clock manipulation during a self paced exercise task influences muscular work rates during the second 50% and in particular the ability to generate an endspurt in the final 10%. It is suggested that this data lends support to the anticipatory RPE feedback model of exercise regulation which proposes that both afferent physiological feedback and psychological inputs are integrated to generate a conscious RPE which is continually compared to a subconscious template RPE. Further work should investigate the impact on exercise performance of interventions (both physiological and psychological) specifically designed to reduce RPE at any given exercise intensity.

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