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**Pacing strategy in trail running: a cognitive subtractive model of the affective balance
between effort and pleasure?**

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Abstract

The objective of the present study was to uncover the cognitive rules developed by athletes in pacing strategy during a trail running competition. Fifty participants completed a questionnaire on how decisions were made around pacing. Each questionnaire consisted of 12 scenarios that featured the two components of affective balance (effort and pleasure) as information cues. We applied repeated-measures analyses of variance and Tukey's post hoc tests to the data. The results showed that pleasure and effort had a significant effect on deciding to reduce the pace and deciding to maintain the pace. The type of cognitive rule depended on the pacing outcome, with a subtractive integration rule when deciding to maintain the pace and a conjunction integration rule when deciding to reduce the pace. The presence of two different cognitive rules emphasized the importance of information integration in pacing strategy.

Keywords: pacing strategy; affective balance; cognitive rules; information integration; trail running

Introduction

The popularity of endurance sports (e.g. trail running) has grown considerably over recent years. Accordingly, the numbers of competitors and races have also increased, and the races are becoming more demanding (Rochat et al., 2017). Trail runners of all levels generally want to improve their performance, and push their limits during the race. They must be able to cope with different types of constraints: environmental (e.g. meteorological changes), psychological (e.g., negative thoughts), and physical (e.g., fatigue) (Rochat et al., 2018). To overcome these potential constraints, an athlete (such as a trail runner) may apply different pacing strategies (Skorski & Abbiss, 2017). The objective of the study was to understand the manner in which pleasure and effort are integrated cognitively into the pacing decision process.

Pacing strategy and affective balance (AB)

Pacing is considered as a complex system in which athletes regulate the exercise intensity at each moment in the race by taking account of their physiological and psychological status and by seeking to avoid catastrophic physiological failure (Sakalidis et al., 2021). As a result, the athlete may either maintain or reduce the exercise intensity (i.e. the pace). This process is internal and may be unconscious or conscious (Edwards & Polman, 2013). As with the central governor model, the athletes can integrate various information cues while regulating their running (e.g., Noakes, 2004). Information processing is essential for a pacing strategy (St Clair Gibson et al., 2006). In the global model of the pacing process (GMPP), Baron et al. (2018) emphasized the influence of the athlete's perceptions of pleasure and effort in the decision to maintain or reduce the pace.

According to the GMPP, the athlete monitors the difference between the perceived effort and the level of pleasure when regulating the pace (Baron et al., 2018). This difference is referred to as the AB and is defined by a subtractive model: $AB = \text{effort} - \text{pleasure}$. This

model has been applied to trail running, in order to understand the influence of psychological components on the regulation of intensity during a race (Gros Lambert et al., 2021; Gros Lambert et al., 2020).

However, no indication was given in these studies concerning the cognitive decisional process involved in pacing during individual sports events (Konings & Hettinga, 2018). How are information cues on effort and pleasure integrated mentally into the pacing decision process? Which decision rules do athletes use to regulate their pace? Are the two information cues integrated cognitively in the same way when the athlete decides to maintain or reduce the pace?

Information integration theory (IIT) and cognitive algebra

IIT (Anderson, 2008) is a theoretical cognitive framework that has been used in the sports domain to understand how people combine various information cues when making a decision or a judgement about an act or a situation. The IIT approach leads on to the concept of cognitive algebra because it allows the identification of different cognitive rules such as subtractive, conjunctive, or disjunctive rules. These three types of cognitive rule are illustrated below. Let us hypothesize that (i) an individual is confronted with a set of 12 situations characterized by three levels of the Pleasure factor (little, moderate, a lot) and four levels of the Effort factor (minimal, moderate, significant, maximal) during a trail running and (ii) that these 12 situations influence the decision to maintain or decrease the pace. The levels of decision-making can be analyzed graphically (Figure 1). When the curves are parallel and decrease, the individual gives the same importance to effort and pleasure: the cognitive rule is subtractive, and the Effort x Pleasure interaction is not statistically significant (the left panel in Figure 1). When the curves form a fan open to the right, the cognitive rule is conjunctive, and the Effort x Pleasure interaction is statistically significant (the middle panel in Figure 1). When the curves form a fan open to the left, the cognitive rule is disjunctive, and the Effort x

Pleasure interaction is statistically significant (the middle panel in Figure 1). In the two latter interaction rules, effort is respectively more important or less important than pleasure.

Anderson's cognitive rules for IIT (Anderson, 2008) allow one to test a well-defined mathematical model (Fruchart et al., 2018) and have already been implemented with regard to decision-making in sport (Fruchart et al., 2010; Zarrouk & Fruchart, 2021). Research based on IIT has shown that cognitive rules are sometimes context-sensitive: individuals develop a conjunctive rule for a difficult task and an additive or disjunctive rule for a less difficult task (Zarrouk & Fruchart, 2021). In trail running, IIT has already been used to differentiate between various cognitive rules, i.e. the mental processes by which athletes combined five information cues (relatedness, autonomy, competence, mental vitality, and physical vitality) when judging happiness (Fruchart, 2021). The latter study found that within the overall global concept of happiness, individuals can develop different cognitive rules for each component sub-dimension (pleasure, engagement, and meaning).

The objective of the present study was to determine the cognitive rules developed by trail runners in their decision to maintain or reduce the pace during a race when they mentally combine the two components of AB (effort and pleasure).

According to the sports psychology literature on the AB and pacing strategy (Baron et al., 2018; Gros Lambert et al., 2021), we drew up two hypotheses. Firstly, we hypothesized that both pleasure and effort would have a significant impact on the athletes' decision-making (i.e. reducing or maintaining the pace). Secondly, we hypothesized that athletes would use a subtractive cognitive rule to integrate effort and pleasure in their decision-making.

Method

Participants

The sample size was determined by an a-priori power analysis using G*Power (Faul et al., 2007) for a 4 (Effort: minimal, moderate, significant, maximal) \times 3 (Pleasure: little,

moderate, a lot) repeated-measures ANOVA. To detect an effect size of Cohen's $f=0.25$, with $\alpha=.001$ and power $=.80$, a minimum sample of 46 participants was required. We chose a small effect size ($f=0.25$) because the combined effect of Effort and Pleasure on pacing decision process could not be compared to findings in previous literature (Lakens, 2013).

Fifty adult amateur trail runners were included in the study (29 men ($M_{age} = 30.86$; $SD = 13.20$) and 21 women ($M_{age} = 32.90$; $SD = 11.48$)). The runners gave their written, informed consent prior to inclusion in the study, and none of the study participants received any remuneration. Each participant had already competed in the type of the trail run described in the study questionnaire, i.e. a 15 km run with 700 meters of climbing.

Material

The material consisted of two questionnaires: one on making decisions about reducing the pace, and the other on making decisions about maintaining the pace. Each questionnaire comprised a set of cards presenting a scenario, a question, and a rating scale. Each scenario was designed to have two within-subject factors: Effort (minimal, moderate, significant, maximal), and Pleasure (little, moderate, a lot). The 4 x 3 factorial design yielded 12 scenarios in each questionnaire.

An example (here, maximal effort/a lot effort) of a typical scenario was: "You are doing the Saintville mountain trail run. The race is 15 km long and there are 700 metres of climbing. The course is technically challenging: some of the slopes are steep and rocky, and the paths are narrow. For the moment, everything is going well. At one point in the race, you are making an intense physical effort, and you are feeling a lot of pleasure". The location changed in each scenario.

In the first questionnaire (reducing the pace), the question below each scenario was: "At that moment, to what extent would you reduce your pace?" Beneath each question was an 11-point response scale, ranging from "Not at all" on the far left to "Very much" on the far

right.

In the second questionnaire (maintaining the pace), the question below each scenario was: “At that moment, to what extent would you maintain your pace?”. Beneath each question was an 11-point response scale, ranging from “Not at all” on the far left to “Very much” on the right.

Procedure

The study’s procedure and design were conducted in accordance with the ethical tenets of the Declaration of Helsinki and the university’s ethical standards. The participants were recruited from various sports centres and clubs. After the participants had been given information about the study’s objectives and procedures and had agreed to participate, a study appointment was made. All participants were tested individually in a room at a sports centre.

Anderson’s procedure (Anderson, 2008) involves a familiarization phase and then an experimental phase. In the familiarization phase, the experimenter explained the participant’s task, i.e. reading descriptions of various trail-running situations in which he/she had to decide to reduce the race pace (questionnaire 1) or maintain the race pace (questionnaire 2). The participants were given four scenarios, so that they were exposed to the full range of stimuli. During the familiarization phase, the participants were allowed to ask questions if they did not understand an aspect of the experiment and was allowed to alter their replies. In the experimental phase, the participant was presented with 12 scenarios for each questionnaire. The participants were not allowed to ask questions or alter their replies. The experimenter divided each category of participant (men and women) in two groups. Half of the participants completed questionnaire 1 (reducing the pace) first and questionnaire 2 (maintaining the pace) second. The other half completed the questionnaires in the opposite order.

Data analysis

All the participants’ ratings from the experimental phase were converted to numerical

values corresponding to the number of graduations between the left anchor (i.e. the origin) and the point on the response scale. We then performed graphical and statistical analyses of these numerical values. For each questionnaire, normality was verified by the Shapiro-Wilk test and parametric tests were conducted. A repeated-measures analysis of variance was performed according to the Effort x Pleasure factorial design, and Tukey's post hoc tests were performed on each factor (Effort and Pleasure). Statistical analyses were performed with Statistica software (version 8).

Results

The results of the two ANOVAs are shown in Table 1. Figure 2 shows the combined effects of effort and pleasure on decision-making for maintaining the pace (top panel) or reducing the pace (bottom panel). The mean ratings for decision-making are given on the y-axis. Each line corresponds to one level of the Pleasure factor. The four levels of the Effort factor are shown on the x-axis.

In the top panel of Figure 2, the fact that the curves are separate indicates an effect of the Effort factor on decision-making for reducing the pace. The curves rise from left to right, indicating an effect of the Pleasure factor on decision-making for reducing the pace. The curves form a fan open to the right, which indicates that the athletes used a conjunctive rule. The Effort x Pleasure interaction was statistically significant, $F(6,294) = 22.51, p < .001, \eta^2_p = .31$. The Tukey's post hoc tests revealed significant differences between all levels of the Effort factor and between all levels of the Pleasure factor ($p < .001$).

In the bottom panel of Figure 2, the curves are also separate; this indicates an effect of the Effort factor on decision-making for maintaining the pace. The curves descend from left to right, which indicates an effect of the Pleasure factor on decision-making for maintaining the pace. The curves are parallel and descend from left to right, indicating that the athletes used a subtractive integration rule. The Effort x Pleasure interaction was not statistically significant,

$F(6,94) = 1.47, p = .187, \eta^2_p = .03$. The Tukey's post hoc tests revealed significant differences between all levels of the Effort factor and between all levels of the Pleasure factor ($p < .001$).

Discussion

The objective of the present study was to determine the cognitive rules developed by trail runners in their decision to maintain or reduce the pace during a race when they mentally combine the two components of AB (effort and pleasure).

Our first hypothesis was that pleasure and effort have a significant effect on decisions about reducing the pace or maintaining the pace (Baron et al., 2018; Gros Lambert et al., 2021). This hypothesis was confirmed. Pleasure and effort were both determinants of the AB in the present study and, in the literature, are also known to be psychological determinants of pacing strategy (Baron et al., 2018): the more effort the athletes produce, the more likely they are to reduce the pace and the less likely they are to maintain the pace, and the more pleasure the athletes feel, the less likely they are to reduce the pace and the more likely they are to maintain the pace.

The second hypothesis was that the runners use a subtractive cognitive rule when integrating effort and pleasure in the decision to reduce or maintain the pace (Baron et al., 2018; Gros Lambert et al., 2021). This hypothesis was confirmed for maintaining the pace but not for reducing the pace. Indeed, when deciding to maintain the pace, effort and pleasure were integrated through a subtractive rule: Decision to maintain the pace = Effort – Pleasure, i.e. the same as for the AB (Baron et al., 2018). When the trail runners decided to maintain the pace, they gave the same levels of importance to effort and to pleasure. However, when trail runners decided to reduce the pace, they used a conjunctive integration rule: Decision to reduce the pace = Effort x Pleasure. This finding showed that the effect of pleasure varies as a function of the effort: when the level of effort is low, the effect of pleasure is reduced; when

the level of effort is high, more importance is given to pleasure.

The observation of various types of cognitive rule is in line with the literature data on the IIT in sport (Fruchart, 2021; Zarrouk & Fruchart, 2021). Within the overall concept of pacing strategy, we observed two different types of cognitive integration rule: a subtractive rule when deciding to maintain the pace and a conjunctive rule when deciding to reduce the pace (Fruchart, 2021). Our results also confirmed the context-sensitive nature of cognitive rules and the athletes' ability to apply a conjunctive rule when they were going through a bad patch during a race and an additive rule when they are at ease during a race (Zarrouk & Fruchart, 2021). In the present study, the runners used a conjunctive rule to reduce the pace when they were going through a bad patch but used an additive rule to maintain the pace they were at ease.

Our innovative approach to understanding cognitive decision-making rules on AB and the pacing strategy nevertheless had some limitations, although these limitations might open up opportunities for further research. Firstly, we studied the pacing strategy under laboratory conditions and so the ecological validity of our results can be questioned. However, Anderson's methodology (as used in the present study) was found to have a good level of external validity in the sporting domain (Fruchart et al., 2007). Secondly, we did not take account of the participants' levels of experience. Experienced athletes are able to pace themselves better than inexperienced athletes (Eston & Williams, 1988). Thirdly, we did not determine the impact of other variables (such a motivation and the human-environment interaction) on decisions about pacing (Gros Lambert et al., 2021; Konings & Hettinga, 2018). For example, Zarrouk and Fruchart (2021) showed that motivation influences cognitive integration rules. Gros Lambert et al. (2021) found that AB in trail runners had three types of motivation. By considerably increasing the number of participants and by applying a cluster analysis, one might be able to map the various pacing strategies (as performed in a different

field in sports psychology (e.g., Fruchart et al., 2020).

The difference between the cognitive rules applied as a function of the pacing strategy (maintaining the pace or reducing the pace) emphasizes the complexity of the cognitive processes involved in pacing and AB (Baron et al., 2018). Our results suggest the necessity to take into consideration the combination of athletes' feelings of effort and pleasure in pacing strategies and show that the impact of the pleasure varies as a function of the effort in the decision to reduce the pace. Coaches and psychologists could assist athletes in their pacing strategies. After each training, the coach might conduct debriefing with athletes about the impact of combining pleasure and effort on their decision of maintaining and reducing the pace (Hogg, 2002). To fight the reduction of intensity in race, psychologists might develop personalized interventions to identify different determinants of pleasure for each athlete and elaborate intervention programs, such as mental imagery (Renner et al., 2019), that might facilitate the fulfillment of pleasure when the feeling of effort is important.

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Table 1

Main results of the ANOVAs performed on each factor in decision making (reducing the pace and maintaining the pace).

Factor	Effect		Error		<i>F</i>	<i>p</i>	η^2_p
	<i>df</i>	<i>MS</i>	<i>df</i>	<i>MS</i>			
REDUCING THE PACE							
Effort	3	341.63	147	8.42	40.55	<.001	.45
Pleasure	2	569.95	98	6.94	82.09	<.001	.63
Effort x Pleasure	6	37.19	294	1.65	22.51	<.001	.31
MAINTAINING THE PACE							
Effort	3	562.55	147	6.52	86.33	<.001	.64
Pleasure	2	493.21	98	6.20	79.53	<.001	.62
Effort x Pleasure	6	2.33	294	1.58	1.47	.187	.03

p <.001 is statistically significant

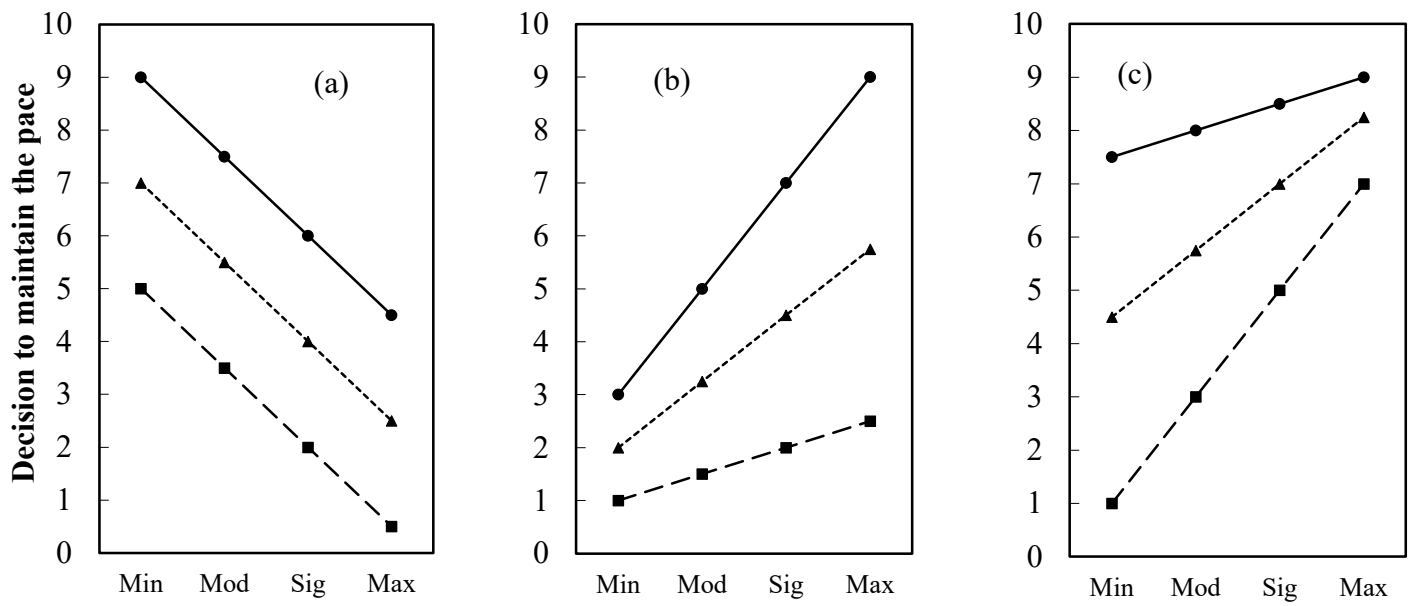


Figure 1. Typical patterns of data obtained with (a) a subtractive rule, (b) a conjunctive integration rule, and (c) a disjunctive integration rule.
 Legend: The decision to maintain the pace is shown on the y-axis. The four levels of effort are shown on the x-axis (Min = Minimum ; Mod = Moderate ; Sig = Significant ; Max = Maximum). Each line corresponds to a level of pleasure: a lot of pleasure (the solid line), moderate pleasure (the dotted line), and little pleasure (the dashed line).

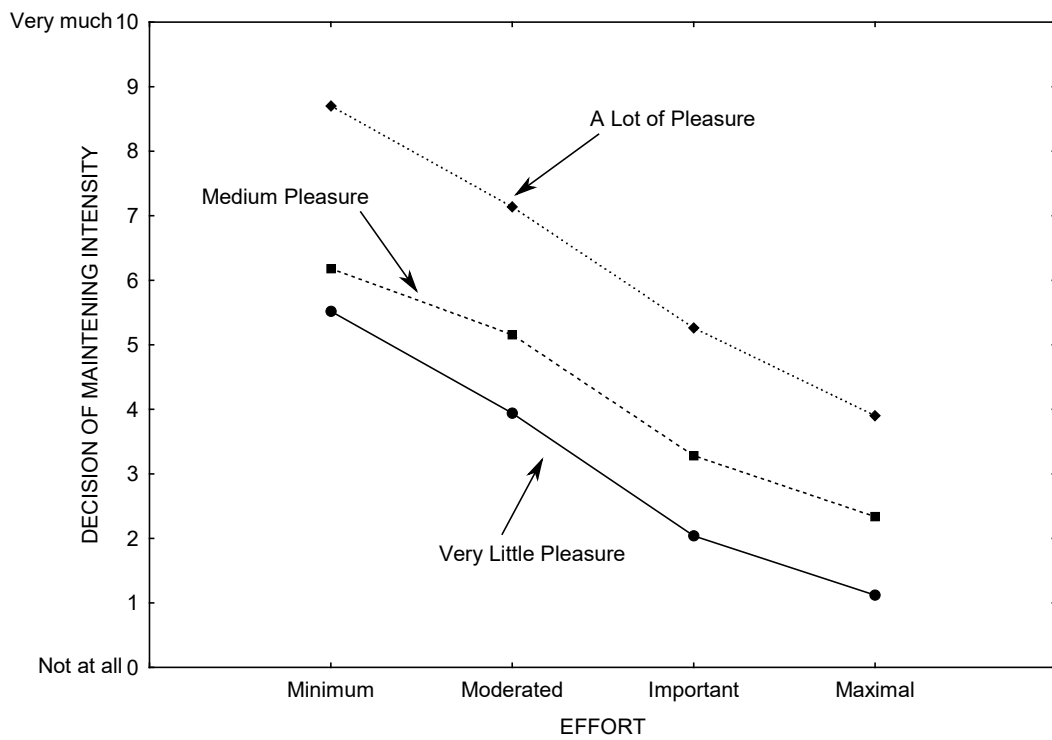
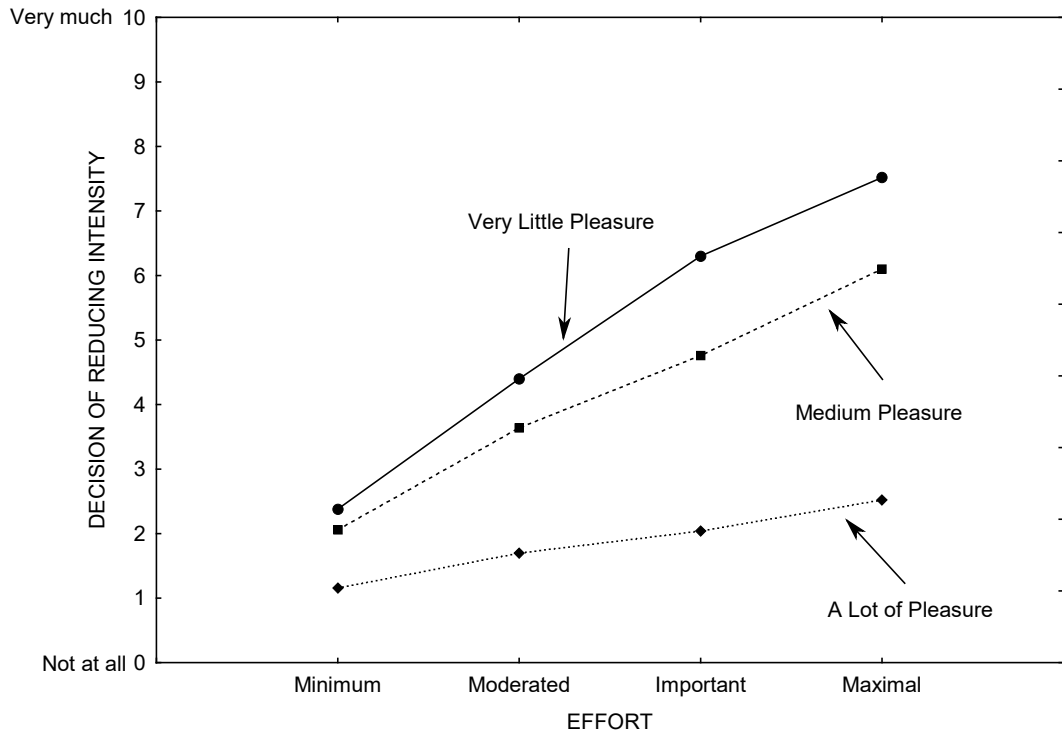


Figure 2. Effect of effort and pleasure in reducing of intensity decision making (high pattern showing a conjunctive rule) and in maintaining of intensity decision making (low pattern showing a subtractive rule).