Running head: Peer presence and perceived exertion

Title: Peer presence increases session ratings of perceived exertion

Authors: Geoffrey M Minett[1], Valentin Fels-Camilleri[2], Joshua J Bon[3,4], Franco M Impellizzeri[5], David N Borg[1,6,7]

Affiliations

[1]Queensland University of Technology, School of Exercise and Nutrition Sciences, Brisbane, Australia.

[2]University of Strasbourg, Faculty of Sports Sciences, Strasbourg, France

[3]Queensland University of Technology, School of Mathematical Sciences, Brisbane, Australia.

[4]Australian Research Council Centre of Excellence for Mathematical and Statistical Frontiers, Brisbane, Australia.

[5]University of Technology Sydney, School of Sport, Exercise and Rehabilitation, Sydney, Australia.

[6]Griffith University, Menzies Health Institute Queensland, The Hopkins Centre, Brisbane, Australia.

[7]Griffith University, School of Allied Health Sciences, Brisbane, Australia.

Corresponding author:

Geoffrey M Minett

Email: geoffrey.minett@qut.edu.au

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Abstract

Purpose: This study aimed to examine the effect of peer presence on the session rating of perceived exertion (RPE) responses. **Method:** Fourteen males, with mean (standard deviation) age 22.4 (3.9) years, peak oxygen uptake 48.0 (6.6) $mL \cdot kg^{-1} \cdot min^{-1}$ and peak power output 330 (44) W, completed an incremental cycling test and three identical experimental sessions, in groups of four or five. Experimental sessions involved 24 min of cycling, whereby the work rate alternated between 40% and 70% peak power output every 3 min. During cycling, heart rate was collected every 3 min, and session-RPE was recorded 10 min after cycling, in three communication contexts: in written form unaccompanied (intrapersonal communication); verbally by the researcher only (interpersonal communication); and in the presence of the training group. Session-RPE was analysed using ordinal regression and heart rate using a linear mixed-effects model, with models fit in a Bayesian framework. **Results:** Session-RPE was voted higher when collected in the group's presence compared to when written (odds ratio = 4.26, 95% credible interval = 1.27 to 14.73). On average, the posterior probability that session-RPE was higher in the group setting than when written was 0.53. Session-RPE was not different between the group and verbal, or verbal and written collection contexts. **Conclusions:** This study suggests contextual psychosocial inputs influence session-RPE, and highlights the importance of session-RPE users controlling the measurement environment when collecting votes.

Keywords: Effort, exercise, load, monitoring, training load, bias

Introduction

Quantifying training load using the session rating of perceived exertion (RPE) method[1] has been widely adopted as a simple approach to understanding the effects of training load on athlete fitness, performance and fatigue.[2–4] Many internal (e.g., heart rate, HR), external (e.g., Global Positioning System and accelerometers) and indices (e.g., training impulse) of training load exist.[5] However, the ease (i.e., Training load = RPE x time (min)), low cost and capacity of the session-RPE based approach to accommodate differing exercise modes has seen widespread uptake of the instrument.[6]

Although session-RPE has been correlated with objective physiological measures of training load, including variables of HR, oxygen uptake and lactate,[7] other influencing factors might explain measurement variation. It has long been evidenced that momentary RPE should be interpreted as the integration of physiological, psychological and experiential influences.[8] For example, anxiety, somatic perception, depression and neuroticism directly correlate with momentary RPE, while interestingly, inversely correlated with extroversion.[8] Further evidencing psychological contribution, the dissociative attentional effects of music and video can reduce momentary RPE scores during high-intensity exercise.[9] Understanding of the collective psychophysiological construct represented in the momentary RPE, and likely session-RPE training load measurement, are important considerations when reviewing the response to a given training impulse. Appreciation for the influences on the measure outside of the prescribed training also highlights the need for vigilance in standardising session-RPE collection to ensure data quality and targeted constructs.

Despite the popularity of the session-RPE approach to training load measurement, methodological reports relating to best practice collection are lacking. The timing used to recall session-RPE appears to have little effect.[10,11] However, to the authors' knowledge, the influence of the administration mode is relatively unknown. Methods of session-RPE measurement standardisation (e.g., questioner, face-to-face, electronic, anchoring, and privacy) are sporadically reported, and rarely, in full. Such variables can introduce bias that greatly affects data quality.[12] Risk of these biases may be highest in team sports like rugby union, where 89% of coaches surveyed collected session-RPE scores verbally,[13] risking introducing effects of peer influence.

Peer presence is known to have ranging effects on health and social decision making.[14] Further, socio-environmental cues may affect exercise and sports performance,[15,16] potentially by altering self-confidence[17] and physical discomfort associated with fatigue.[18] Accordingly, it could be reasoned that the company of others in a competitive team environment would adjust session-RPE scores in a socially desirable way.[13] This study aimed to examine the effect of peer presence on session-RPE responses. It was hypothesised that participants would rate session-RPE higher in the presence of an audience than when collected by a researcher, or via intra-personal communication, in written form.

Methods

Participants

A convenience sample of 14 adult males volunteered for the study. Participants were considered recreationally trained,[19] consistently partaking in team and/or individual sport training and competition three or more times each week in the prior six months. Their mean (standard deviation, SD) demographic and fitness characteristics were: age 22.4 (3.9) years; height 180 (5) cm; nude body mass 79.7 (9.4) kg; peak oxygen uptake ($\dot{V}O_{2peak}$) 48.0 (6.6) $mL \cdot kg^{-1} \cdot min^{-1}$; peak power output 330 (44) W; maximal HR 183 (9) $b \cdot min^{-1}$. Participants were undergraduate exercise science students and completed cycling activity as a part of their training/cross-training activities. They were nonsmokers and free of any injury and illness (Exercise and Sports Science Australia adult pre-exercise screening tool). Ethical approval was granted by the University Human Research Ethics Committee (#51165). After the experimental procedures and associated risks were explained, all participants provided written informed consent.

Procedures

Participants visited the laboratory on four separate days. The first visit involved familiarisation to the study procedures, including perceptual scales, and an incremental cycling test. The session-RPE scale was discussed with participants, and recall anchoring was performed.[20] The session-RPE scale ranges from 0 'Rest' to 10 'Maximal', increments of 1, with descriptors assigned to most ratings: 1 'Very, Very, Easy', 2 'Easy', 3 'Moderate', 4 'Somewhat Hard', 5 'Hard' and 7 'Very Hard'.[1] As recommended,[1] participants were asked '*how was your workout?*'. This wording (verbal and written formats) was standardised across all conditions. Visits 2–4 comprised of three identical experimental cycling trials. Ten min after cycling,[10] session-RPE votes were collected, in three communication contexts, with session-RPE recorded: via intrapersonal communication, unaccompanied in written form (written); via interpersonal communication, verbally to the researcher only (verbal); and via verbal interpersonal communication in the presence of the training group (group). These conditions were completed in a random, cross-over manner. The block randomisation sequence was computer-generated (Microsoft Excel, Redmond, USA). Each experimental session was conducted in groups of at least three, but no more than five participants.

Participants were blinded from the research question to minimise the potential for bias in session-RPE responses. Instead, participants were informed that the study aimed to examine the effects of a new line of sports drinks on responses to the cycling task. The true study aim was disclosed after all data collection. Fluid consumption and fan cooling were restricted during exercise. Participants were asked to avoid caffeine, alcohol and strenuous activity in the 24 hours before testing. Adherence to these requests was visually assessed via the inspection of diet and physical activity diaries. Experimental cycling trials were separated by four or five days.

During the initial visit, participants completed an incremental cycling test to determine their $\dot{V}O_{2peak}$, PPO and maximal HR. The test commenced at 50 W, increasing by 25 $W \cdot min^{-1}$ until voluntary exhaustion (Excalibur Sport; Lode, Groningen, Netherlands). Expired gas and flow volumes were collected during the test and were analysed by a calibrated metabolic cart (TrueOne 2400, ParvoMedics, Salt Lake City, USA). Values were taken as the average of the two highest consecutive 15-second epochs. Peak power output was considered the value achieved during the final minute before volitional exhaustion. The peak power output value used to calculate the exercise intensity of intervals (i.e., 40% and 70% peak power output) during the cycling trials.

Cycling trials were completed in groups of four or five participants, at a matched time of day (±2 hours), in laboratory conditions [24.2 (0.5) °C, 62 (7) % relative humidity]. In line with the deceptive study aim, 20 min before cycling, each individual consumed 400 mL of an unidentified sports drink solution (Gatorade, Chicago, USA) from an opaque, brand-free drink bottle. The exercise protocol involved 24 min of cycling intervals, whereby the work rate alternated between 40% and 70% peak power output every 3 min. During trials, the cycle ergometer (Keiser M3, Keiser Corporation, Fresno, USA), including settings, remained consistent within a participant, with self-selected gearing identified during the familiarisation session.

The Daily Analyses of Life-Demands for Athletes (DALDA) questionnaire was completed on arrival for testing days.[21] Responses for the 'Symptoms of stress' section were summed (i.e., a = 1, b = 2, c = 3).[21] Higher scores indicate fewer symptoms. A mid-stream urine sample was collected on arrival to assess hydration via specific gravity (PAL-10S, Atago Co. Ltd., Tokyo, Japan).[22] Nude body mass (WB-110AZ; Tanita Corp., Tokyo, Japan) was recorded before cycling. Standard athletic clothing was worn during trials (i.e., t-shirt, shorts, and running shoes). A HR monitor chest strap and wrist-watch receiver (F1, Polar, Electro-oy, Kempele, Finland) were fitted before cycling, with HR recorded at baseline (i.e., 0 min) and every 3 min throughout cycling. Capillary blood lactate samples were drawn from the finger before and within 1 min after cycling (Lactate Scout; SensLab GmbH, Leipzig, Germany). Finally, 10 min after cycling,[10] a session-RPE was collected in the prescribed communication format.

Statistical analysis

All analyses were performed in R (version 3.4.0). Models were fit in a Bayesian framework, using Stan[23] with the *brms* interface.[24] Missing data were visually inspected, with data assumed missing at random (Supplement 1).[25]

Session-RPE was analysed using ordinal regression. The model included *Condition* and *Trial Order* as a fixed factors, and *DALDA Symptoms of Stress* scores and the absolute *Change in Lactate* (i.e., $\Delta_i = \text{post}_i - \text{pre}_i$) as standardised covariates (mean = 0, SD = 1). The mean (SD) *DALDA Symptoms of Stress* scores for each condition were: written 49 (2), verbal 50 (3) and group 49 (2); and the mean (SD) *Change in Lactate* was: written 5.3 (3.8) mmol·L, verbal 4.6 (3.4) mmol·L and group 4.8 (3.6) mmol·L. The session-RPE model also included a random intercept for each participant in the study to account for the correlation between repeated observations on an individual. A

Normal (mean = 0, SD = 1) prior distribution was used for the regression coefficients and half *t*-distribution (df = 3, mean = 0, scale = 2.5) prior for the SD of the random effects.

Urine specific gravity (logged), nude body mass, blood lactate (Gamma response distribution), and HR were analysed using linear mixed-effects models. Urine specific gravity and nude mass were modelled with *Condition* as a fixed factor. Blood lactate was fit with *Time* (i.e., pre- and post-cycling), *Condition*, and *Time* by *Condition*, as fixed factors. Urine specific gravity, nude body mass, and blood lactate models included a random intercept term for *Participant ID*. The HR model included *Condition* and *Time* (cubic smoothing spline, with 5 knots) as fixed effects; and *Interval* and *Participant ID* as random effects (intercept only). Weakly informative prior distributions were used for the regression coefficients and variance parameters in these models.

Posterior estimates were generated using Markov chain Monte Carlo methods, and are reported as the mean, mean difference (MD) or odds ratio (OR) and 95% credible interval (CrI) unless otherwise stated. Pairwise posterior probabilities were computed to compare that on average, session-RPE votes in condition '*k*' were: greater than, and equal to, session-RPE votes in condition '*l*'. Posterior predictive checks were performed to assess the suitability of all models.

Results

Session-RPE was four times more likely to be rated in a higher category when collected in the group setting compared to the written setting (OR = 4.26, 95% CrI = 1.27, 14.73). On average, the posterior probability that participants would rate a higher session-RPE category in the group compared to the written setting was 0.53, and the posterior probability of equal ratings between these two conditions was 0.29. Session-RPE votes collected in the verbal setting were not different to the written setting (OR = 1.90, 95% CrI = 0.61, 5.99). On average, the posterior probability that participants would rate a higher session-RPE category in the verbal than the written setting was 0.41, and the posterior probability of equal ratings between these two conditions was 0.34. There was no evidence for a difference in Session-RPE votes collected in the group setting compared with votes collected in the verbal setting (OR = 2.48, 95% CrI = 0.76, 8.25). On average, the posterior probability that participants would rate a higher session-RPE category in the group setting compared to the verbal setting was 0.45, and the posterior probability of equal ratings between these two conditions was 0.30.

There was no evidence that nude body mass, urine specific gravity and pre-cycling lactate were different between conditions (Table 1). Lactate increased over the task (β = 4.7, 95% CrI = 3.2, 6.6; Table 1), but was not different between conditions. HR increased during cycling (β = 7.6, 95% CrI = 6.0, 9.4). There was evidence of a condition effect on HR (β = 2.02, 95% CrI = 0.04, 4.35), with HR responses higher in the verbal condition compared to both the written (MD = 2.02 $b{\cdot}min^{-1}$, 95% CrI = 0.04, 4.35) and group conditions (MD = 2.27 $b{\cdot}min^{-1}$, 95% CrI = 0.07, 4.42). The posterior probability that HR during cycling was at least 2 $b{\cdot}min^{-1}$ higher in the verbal condition compared to the written and group settings was 0.56 and 0.60, respectively.

Discussion

This study investigated the effect of peer presence on session-RPE responses. While others have proposed that the influence of peer presence on the rating of session-RPE is a limitation of subjective training load monitoring[26], to our knowledge, this is the first study to address this issue directly. As hypothesised, session-RPE was more likely to be rated higher when collected in the group setting compared to when collected in written form (Figure 1). Heart rate was 2 $b{\cdot}min^{-1}$ higher when cycling in the verbal collection condition; however, this did not appear to affect session-RPE responses. This study suggests that contextual psychosocial inputs could influence session-RPE, and may highlight the importance of controlling the measurement environment to reduce circumstantial variance in data that informs training-related decisions.

Participants were more likely to provide higher session-RPEs in the presence of an audience (Figure 1). This finding might be explained by participants wanting to communicate (to others) a high effort ethic.[27] Consciously or otherwise, social contagion could also factor owing to concern and subsequent influence on responses.[28] This notion goes towards the idea of self-concept, and a sense of identity, that individuals were giving an equal effort so to be valued by their peers.[29] Such a scenario seems possible in team sports where winning coaches value hard-working athletes[30], and these expectations could influence athletes' session-RPE responses. Concern regarding altered training schedules (i.e., more or less sessions) and indirect effects on team selection based on session-RPE responses also cannot be dismissed. This line of thinking could arguably be worse in emerging athletes where their age/maturity and career ambitions lead them towards appraisal seeking behaviours.[31]

The effect of peer presence on session-RPE has implications for training load monitoring, and in some instances could explain previous observations of a disconnect between session-RPE and training prescriptions.[32] Individuals working with athletes or persons who use session-RPE as a training load monitoring tool in team settings should be mindful of the contexts in which responses are collected. Users of session-RPE must have an awareness of the influence that peer presence may have on ratings for some athletes. This thinking further reinforces the need for coaches, managers and team selectors, to develop good, trustworthy relationships with athletes, so to better understand how a certain individual or personality may, or may not, be affected by responding to the presence of the wider team.

While it would be convenient to suggest that collection via a mobile application could be used to overcome the influence of peer presence, recent evidence suggests that face-to-face collections may be more valid.[33] Under the assumptions, and with the sample size, of the current study, session-RPE responses collected unaccompanied in written form were not different compared to those collected in the presence of only the researcher (Figure 1). The posterior probability that session-RPE was higher when collected by the researcher compared to written form was 0.41. Future work is required to investigate whether the presence of a single individual influence's session-RPE responses, as many of the discussions above hold for collection via face-to-face—particularly if collected by a coach—compared to collection when unaccompanied (e.g., mobile application or written form).

Despite the matched mechanical work, a higher HR was observed in the verbal condition. Although this may be affected by the measument sampling rate (i.e., every 3 min), the physiological meaningfulness of this difference (2 $b \cdot min^{-1}$) is most arguably negligible. The primary limitation of the study is the sample size. Although we used estimation methods in a Bayesian framework to quantify differences between conditions, the small sample size was reflected in large uncertainty of some of the estimates. For example, the large width of the 95% CrI of the OR between the intra-individual and group setting conditions. Future research should replicate this study with a larger sample size to confirm the generalisability of the findings; and investigate other potential sources of bias for session-RPE ratings, such as scale modifications (e.g., removing verbal anchors, adding scale colourings). Exploring the associations between witnessed session-RPE responses and sociopsychological profiling may also be insightful. Similarly, current perspectives may be advanced further by examining responses to varying exercise intensities.

Practical Applications

The presence of other athletes and coaches seemingly affects the session-RPE score. Standardising the session-RPE measurement processes and environment is recommended to minimise the risk of introducing error. Further, interpretation of session-RPE data should occur through the lens of the collection context.

Conclusion

Findings from this study provided evidence supporting the influence of contextual psychosocial inputs on session-RPE responses. These outcomes highlight the importance of controlling the measurement environment to reduce circumstantial variance in data that informs training-related decisions. Users of the session-RPE need to be consistent with the environment in which session-RPE is collected and be aware of the influence that peer presence may have on responses from some individuals.

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Figure captions

Figure 1. Mean and 66% (thick inner line) and 95% (thin outer line) credible interval posterior probability of rating each session-RPE category in the three experimental conditions.

Figure 2. Mean and 66% (thick inner line) and 95% (thin outer line) credible interval heart rate responses at minute zero and during cycling for the three experimental conditions. Asterisk indicates a higher heart rate in the verbal condition compared to both the written and group condition.

Table captions

Table 1. Markers of hydration and metabolism.

Figure 1.

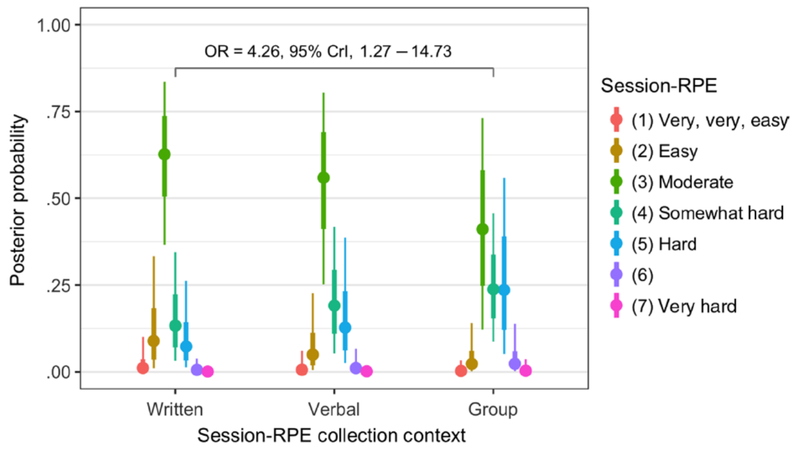

Figure 2.

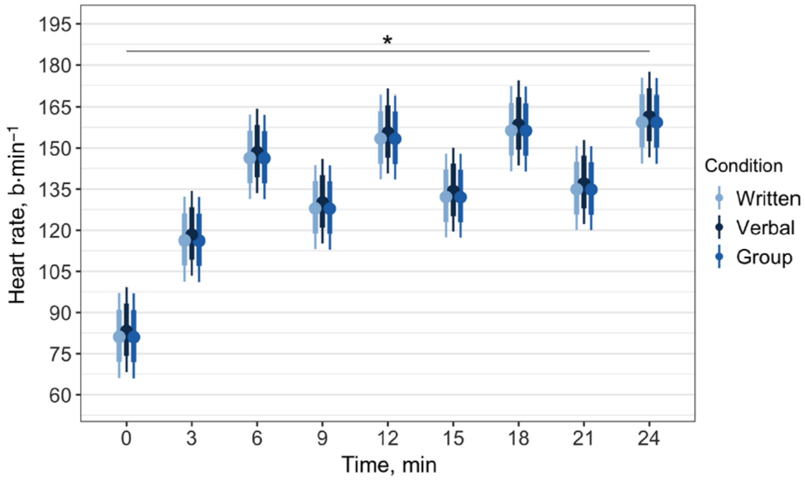

Table 1.

Variable	Communication context		
	Written (intrapersonal)	Verbal (interpersonal)	Group
Urine specific gravity	1.017 (1.012–1.022)	1.016 (1.011–1.020)	1.016 (1.011–1.021)
Nude body mass, kg	79.9 (74.6–85.4)	79.8 (74.5–85.3)	79.8 (74.5–85.2)
Lactate, mmol·L^{-1}			
Precycling	1.5 (1.2–1.9)	1.3 (1.0–1.7)	1.4 (1.0–1.8)
Postcycling	6.8 (5.2–8.8)*	5.9 (4.5–7.6)*	6.2 (4.8–8.0)*

*Effect of time (β = 4.7, 95% credible interval = 3.2–6.6).