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Title: Altered psychological responses to different magnitudes of deception during cycling

Running head: Magnitudes of deception in cycling time trials

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Altered psychological responses to different magnitudes of deception during cycling

CONFLICT OF INTEREST AND SOURCE OF FUNDING

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1 **Abstract**

2 **Purpose:** Deceptive manipulations of performance intensity have previously been investigated
3 in cycling time trials (TT), but used different magnitudes, methods and task durations. This
4 study examines previously employed magnitudes of deception, during 16.1 km TT and
5 explores as yet unexamined psychological responses. **Methods:** Fifteen trained cyclists
6 completed five TT, performing two alone (BLs), one against a simulated dynamic avatar
7 representing 102% of fastest BL (TT_{102%}), one against a 105% avatar (TT_{105%}), and one against
8 both avatars (TT_{102%,105%}). **Results:** Deceptive use of competitors to disguise intensity
9 manipulation enabled accomplishment of performance improvements greater than their
10 perceived maximal (1.3% - 1.7%). Despite a similar improvement in performance, during TT_{102%,105%}
11 there was a significantly lower affect and self-efficacy to continue pace than TT_{105%} ($p < 0.05$),
12 significantly lower self-efficacy to compete than TT_{102%} ($p = 0.004$), and a greater RPE than TT_{FBL} (p
13 < 0.001). **Conclusion:** Since the interpretation of performance information and perceptions are
14 dependent on the manner in which it is presented; ‘framing effect’, it could be suggested that the
15 summative impact of two opponents could have evoked negative perceptions despite eliciting a similar
16 performance. Magnitudes of deception produce similar performance enhancement, yet elicit
17 diverse psychological responses mediated by the external competitive environment performing
18 in.

19
20 **Key Words:** Pacing Strategy, Power Output, Perceived Exertion, Affect, Self-efficacy

21 **Introduction**

22 Teleoanticipatory setting of a pacing strategy for an athletic event is based upon expected task
23 demands (34). A confounding issue, however, is that the tactics, pacing strategies, and abilities
24 of opponents are relatively unknown, and somewhat surreptitious pre-competition.
25 Consequently, during a task, anticipatory pacing strategies require continual adjustment in an
26 attempt to match goal-driven targets and in reaction to competitors' performances (17,35,39).
27 Competition enforces decision making through the calculation of potential benefit and
28 perceptions of risk, relating to a change in pace during the event (29). The associated actions
29 and affective responses of these decisions then motivate behavioural choices and steer the
30 amount of effort one is willing to exert (35,42). Little is currently known about the decision
31 making processes that influence pacing, or the underlying psychological mechanisms involved.
32 This is despite evidence suggesting that the presence of competitors, who are striving to achieve
33 the same outcome, interferes with athletes' psychological dispositions (6,22,26,30). In
34 particular, affect and goal achievement are pertinent to the selection of a pacing strategy (31).
35 It is therefore important to gain further understanding of the effect of direct competition on
36 these constructs, the physiological and psychological influences, and the resultant changes in
37 behaviour and performance.

38

39 Visual simulated competitors have been employed in the laboratory setting to investigate the
40 influence of direct competitor presence on cycling performance (7,25,36,43,44). This
41 simulation of competitor behaviour improves the illusion of real-time feedback within a virtual
42 environment (42) and enables instantaneous exploration of direct competition influences
43 during performance (34). In addition, the provision of false information regarding an
44 opponent's ability has manipulated task expectancy further examining the influence of
45 competitor presence on performance outcomes (7,43). Participants were informed they were

46 competing against opponents of a similar ability to themselves, but in reality, were competing
47 against their previous best performance. In contrast, Stone and colleagues deceived participants
48 into believing that an on-screen avatar represented their fastest previous performance, but
49 actually represented a performance corresponding to 2% greater power output (36). These
50 manipulations of the expectant task demands and the use of simulated competitors resulted in
51 observed behavioural changes and performance improvements, associated with changes in
52 motivation (7,43), attentional focus (43), and pacing strategies (36). A false manipulation of
53 feedback of 5% greater speed than the previous best performance however has been shown to
54 modulate pacing strategy, but had negligible impact on performance (24). The magnitude of
55 the deception was seemingly too large to be maintained when attempted in a subsequent trial
56 performed with accurate feedback as this would have been the equivalent to 14.5% power (13).
57 In addition, Micklewright *et al.* did not include a competitor in their deception, where the
58 additional influences associated with the presence of competition (7,43) may have resulted in
59 improved performances. Moreover, studies have manipulated previous performances using
60 magnitudes of deception applied to a whole-trial average, i.e. 102% of average trial power
61 output (36). This provides an unrealistic performance to compete against, or be used as a
62 training tool, as a fixed pace for the task duration is both unrepresentative of the previous
63 performance being simulated and a true competitor's behaviour. If they are to capture the
64 temporal aspects of pacing decision making, researchers should consider using more sensitive
65 manipulations that better replicate the dynamic pacing profile of the previous trial. Avatars can
66 provide accurate visual representations of previously performed pacing variations, whilst
67 concealing any deceptive manipulation applied to subsequent trials.

68

69 Research into the magnitude of deception that elicits performance improvements is in its
70 infancy (36). Furthermore, deceptions of 102% (36) and 105% (24) manipulations of a

71 performance have been performed using different methods (with and without competitive
72 simulations), different performance variables (power output and speed), and different distances
73 (4 km and 20 km). This issue is notable since the effect of different magnitudes of deception
74 may be dependent on the duration of the task with respect to whether the deception remains
75 undetected, and whether successfully competing against the simulated competitor appears
76 achievable. Consequently, the different distances used by previous deception studies confound
77 the interpretation of findings with respect to the influence of magnitude of the deception on
78 performance outcomes. Further research into the influence of different magnitudes of deception
79 during the same distance events are therefore warranted, in which, adopting a distance that is
80 commonly performed during time trials would increase ecological validity.

81

82 The main aim of the present study was to investigate the effects of two magnitudes of deception
83 (102% and 105% speed manipulations), alone and simultaneously, on 16.1 km self-paced
84 cycling time trial (TT) performance. To address the limitations of existing research, this study
85 compares the two magnitudes across the same commonly performed distance and enhances
86 ecological validity employing a true competitor's pacing profile rather than an even pace
87 representation. Further inclusion of a novel condition allowed exploration into the influence of
88 the multiple competitor presence on performance. A secondary aim was to explore the
89 influence of psychological constructs, ~~such as~~ **of** affect and self-efficacy, on decision making
90 and performance outcomes.

91

92 **Method**

93 Participants

94 Twelve trained competitive male cyclists aged 35.2 ± 5.0 years; body mass 84.3 ± 11.0 kg;
95 height 179.4 ± 6.5 cm; and peak oxygen uptake ($\dot{V}O_{2\text{peak}}$) 58.7 ± 6.7 ml•kg•min⁻¹ participated

96 in this study. Each had over 8 yr competitive cycling experience, race experience in 16.1 km
97 TTs and typical training volumes equating to > 8 h.wk⁻¹. $\dot{V}O_{2peak}$ values obtained on the first
98 visit categorised the participant's performance level as 'trained cyclists' (9). The institutional
99 ethics committee approved the study and all participants gave informed consent and completed
100 health screening before participation. Prospective power analysis showed that a sample size of
101 12 participants achieves 86% power with a 5% significance level and a minimum worthwhile
102 effect of 2.2% between conditions, equating to a standardised effect size of 1.1 (16).

103

104 Experimental Design

105 A repeated measures, counter-balanced design was implemented and participants visited the
106 laboratory on six occasions performing a maximal oxygen uptake procedure and five 16.1 km
107 TT. The trials were performed at the same time of day (\pm 2-h) to minimise circadian variation
108 and were separated with 3-7 days to limit training adaptations. Participants were asked to
109 maintain normal activity and sleep pattern throughout the testing period, and to replicate the
110 same diet for the 24-h preceding each testing session. Participants refrained from any strenuous
111 exercise, excessive caffeine, or alcohol consumption in the prior 24-h. They consumed 500 ml
112 of water and refrained from food consumption in the two hours before each visit. Hydration
113 state was assessed prior to trial commencement using a portable refractometry device
114 (Osmocheck, Vitech Scientific, West Sussex, UK). Participants were informed that the study
115 was examining the influence of visual feedback during the TT, and were fully debriefed
116 regarding the true nature of the study upon completion of all trial (19). All participation in the
117 study was kept anonymous, and in addition participants were asked to refrain from any
118 potential discussion with other participants until study completion. To prevent any pre-
119 meditated influence on preparation or pre-exercise state, the specific feedback presented was
120 only revealed immediately before each trial. No verbal encouragement was given to the

121 participants during any trial to prevent inconsistencies in the provision of this feedback.
122 Participants were instructed to complete each TT in the fastest time possible and to prepare for
123 each session as if it were a genuine competitive event.

124

125 Peak oxygen uptake

126 During their initial visit participants performed an incremental maximal exercise test on a cycle
127 ergometer (Excalibur Sport Lode, Groningen, Netherlands), established as having co-efficient
128 of variation of agreement with the Computrainer for both $\dot{V}O_{2peak}$ and heart rate as 8% and
129 4.4% respectively (10). Following a 5-min warm-up at 100 W, participants began the protocol
130 at a prescribed resistance in accordance with accepted guidelines (British Cycling, 2003), and
131 20 W increments were applied until participants reached volitional exhaustion to determine
132 $\dot{V}O_{2peak}$. Continuous respiratory gas analysis (Oxycon Pro, Jaeger, GmbH Hoechburg,
133 Germany) and heart rate (Polar Electro OY, Kempele, Finland) were measured throughout.

134

135 Time trials

136 During five further visits, participants performed a 16.1 km cycling TT on their own bike,
137 mounted on a cycle ergometer (Computrainer Pro, Racermate ONE, Seattle, USA). This
138 ergometer has previously reported to provide a reliable measure of power output (8) and
139 produced a low coefficient of variation ($CV = 0.6\%$) for time, between two 16.1 km trials from
140 our laboratory. The ergometer was interfaced with the Computrainer's 3D visual software and
141 projected onto a 230 cm screen positioned 130 cm away from the cyclists front wheel and
142 calibrated according to manufacturer's instructions.

143

144 Prior to each TT participants completed a 10-min warm-up at 70% maximal heart rate
145 (HR_{max}), determined from the maximal test, followed by two minutes rest. The first TT

146 familiarised participants with the equipment and procedures, during which participants
147 performed with a virtual visual display of an outdoor environment and total distance covered
148 throughout, as if performing on a flat, road-based 16.1 km course. Participants were not
149 informed that the initial visit was a familiarisation session, but that it was one of the four
150 experimental trials, to avoid a change in performance. The second visit replicated the
151 familiarisation trial and paired t-tests were performed to analyse the presence of any systematic
152 bias between the two baseline trials (BL). The two baseline trials showed no significant
153 differences in power output ($p = 0.60$), heart rate ($p = 0.35$), RPE ($p = 0.88$), affect ($p = 0.15$)
154 or self-efficacy ($p = 0.58$). Only the faster of the two BL (TT_{FBL}) was included in the inferential
155 analysis. Six participants performed their fastest baseline in their first baseline trial and the six
156 in their second baseline illustrating no evidence of a learning effect.

157

158 During three further visits participants were informed they would be competing against
159 simulated avatars projected on to the screen, and that the avatar's represented performances
160 produced by cyclists of a similar ability. Each competitive TT had different simulated avatars
161 as opponents, the order of which was randomised and counterbalanced. One was performed
162 with an avatar actually representing a performance 2% greater in speed than their fastest
163 baseline ($TT_{102\%}$), one representing a 5% greater speed manipulation ($TT_{105\%}$) and one
164 performed with simultaneous 2% and 5% avatars ($TT_{102\%105\%}$). Distance covered and distance
165 of the lead avatar(s) were displayed throughout. Participants were blinded to all other data
166 (speed, power output, heart rate) during each experimental time trial.

167

168 Experimental measures

169 Power output, speed and elapsed time were blinded during all trials and stored at a rate of 34
170 Hz. Each were subsequently downloaded after performance for analysis. Percentage of mean

171 speed across each quartile was also expressed to demonstrate pacing profiles. Heart rate was
172 also blinded and recorded continuously using polar team system sampled at 5-s frequencies.
173 These were then averaged as quartile data points for analysis. During each TT, breath-by-breath
174 respiratory gases were measured for the duration of a kilometre at every 4 km, subsequently
175 averaged, and expressed in 5-s intervals. This intermittent collection of respiratory data was
176 adopted to allow for data collection whilst providing minimal interference on performance and
177 permit fluid intake (500 ± 20 ml) during the TT. Prior to each trial, willingness to invest
178 physical and mental effort were each assessed on a visual analogue scale ranging from 0 (not-
179 willing) to 10 (willing). Pre-task self-efficacy and affect were also recorded together with
180 measurements every 4 km during the trial. These pre-trial equivalence measures were
181 employed to determine consistency of pre-trial states across the conditions and identified no
182 significant differences between all trials across resting values of willingness to invest physical
183 effort ($p = 0.11$), willingness to invest mental effort ($p = 0.75$), hydration status ($p = 0.17$),
184 affect ($p = 0.78$) and self-efficacy ($p = 0.73$).

185

186 At each 4 km of the trial participants were asked to rate their perceived exertion (RPE) on a 6-
187 20 scale Borg scale (3), and their affective feeling states as to whether the exercise felt pleasant
188 or unpleasant, measured using an 11-point Likert scale ranging from -5 to +5 with verbal
189 anchors at all odd integers and zero (+5 = very good, +3 = good, +1 = fairly good, 0 = neutral,
190 -1 = fairly bad, -3 = bad, -5 = very bad). Additionally, at every 4 km self-efficacy to continue
191 at the current pace (SE_{pace}), and their self-efficacy to compete with the competitor(s) for the
192 remaining distance of the trial during the competitor trials (SE_{comp}), was recorded on a 0-100%
193 scale divided into 5% integer intervals. The self-efficacy scales were adopted from guidelines
194 previously developed and recently constructed (41). Post-trial interviews were completed and
195 qualitatively analysed using QSR NVivo 10 software (NVivo 10, QSR International Ltd,

196 Cheshire, UK). Information was collected using semi-structured interviews pertaining to how
197 participants felt, their thoughts towards their pace, their thoughts towards the competitor, and
198 what their strategy was during each 4 km of the trial. Data were collated into a thematic analysis
199 followed by a process of descriptive frequencies.

200

201 Statistical Analysis

202 The effect of condition (TT_{FBL} , $TT_{102\%}$, $TT_{105\%}$, $TT_{102\%,105\%}$) and distance quartile (0-4 km, 4-
203 8 km, 8-12 km and 12-16.1 km), were analysed for completion time, power output, heart rate,
204 RPE, affect and self-efficacy variables using the mixed procedure for repeated measures (28).
205 Various plausible covariance structures were assumed for each dependant variable and the one
206 that minimised the Hurvich and Tsai's criterion (AICC) value was chosen as the best fitting
207 and used for the final model. A quadratic term for distance quartile was entered into the model
208 where appropriate and removed where no significance value was observed. Post hoc pairwise
209 comparisons with Sidak-adjusted p values were conducted where a significant F ratio was
210 observed. In addition, bivariate relationships between pacing and psychological responses were
211 analysed using Pearson's product moment correlations. Statistical significance was accepted
212 as $p < 0.05$ (IBM Statistics 22.0; SPSS Inc., Chicago, IL). Smallest worthwhile change in
213 performance was calculated and expressed as a percentage change relative to TT_{FBL} in addition,
214 to increase applicability and practically to athletes and coaches (18).

215

216 Results

217 Performance

218 There was no significant main effect for condition ($F= 1.2$, $p = 0.34$) observed for time trial
219 time (Table 1). The competitive trials were however performed faster than TT_{FBL} ; $TT_{102\%105\%}$
220 (Mean difference, MD = -0.46 min, 95% CL = -1.33, 0.42; $p = 0.61$), $TT_{102\%}$ (MD = -0.39 min,

221 95% CL = -1.05, 0.27; $p = 0.43$) and $TT_{105\%}$ (MD = -0.36 min, 95% CL = -1.11, 0.38; $p =$
222 0.67). Each of the competitor conditions elicited time trial time improvements greater than the
223 previously reported smallest worthwhile improvement, 0.6% (28) and greater than the present
224 study's baseline trial coefficient of variation (CV = 0.6%). $TT_{102\%}$ improved by 1.4%, $TT_{105\%}$
225 improved by 1.3% and $TT_{102\%105\%}$ improved performance by 1.7%. There was no significant
226 main effect for condition observed for speed ($F = 0.7$, $p = 0.58$), however there was a significant
227 decrease in speed across distance quartile ($F = 7.6$, $p = 0.001$). There was no significant
228 condition x distance quartile interaction ($F = 0.054$, $p = 1.00$), however during $TT_{102\%,105\%}$
229 participants did performance a greater starting strategy (Figure 1), of which a greater mean
230 speed in the initial quarter of the trial was significantly correlated with a lower mean speed in
231 the third quarter ($r = -0.848$, $p < 0.001$),.

232

233 [Insert Table 1 near here]

234 [Insert Figure 1 near here]

235

236 Physiological measurements

237 No significant main effects for condition ($F = 2.3$, $p = 0.11$) or an interaction between condition
238 and distance quartile ($F = 0.1$, $p = 0.99$) were identified for heart rate. However, a main effect
239 for distance quartile was observed with heart rate significantly increasing over time ($F = 24.5$,
240 $p < 0.001$). There was no main effect for condition for VO_2 ($F = 1.1$, $p = 0.95$), but a significant
241 main effect was evident for distance quartile ($F = 6.2$, $p < 0.001$), with the final quartile
242 significantly higher than the second (MD = 1.7 ml.kg.min⁻¹, 95% CL = 0.1, 3.34; $p = 0.04$)
243 and third quartile (MD = 2.0 ml.kg.min⁻¹, 95% CL = 0.7, 3.2; $p < 0.001$). There was however,
244 no condition x distance quartile interaction ($F = 0.2$, $p = 0.99$). No significant condition effect
245 was observed for RER ($F = 1.3$, $p = 0.27$), but a main effect for distance quartile was seen (F

246 = 8.2, $p < 0.001$). The RER was significantly higher in the first quartile than in the second (MD
247 = 0.03, 95% CL = 0.01, 0.05; $p = 0.006$) and the third (MD = 0.04, 95% CL = 0.02, 0.06; $p <$
248 0.001). Additionally, the fourth quartile was significantly greater than the third (MD = 0.03,
249 95% CL = 0.004, 0.05; $p = 0.013$). There was no interaction ($F = 0.3$, $p = 0.97$).

250

251 Psychological variables

252 Ratings of perceived exertion had a significant main effect for condition ($F = 13.4$, $p < 0.001$),
253 in which RPE was significantly higher in TT_{102%} than FBL (MD = 0.8, 95% CL = 0.3, 1.4; p
254 < 0.001) and TT_{102%105%} significantly higher than in FBL (MD = 0.9, 95% CL = 0.4, 1.3; $p <$
255 0.001). The ratings of perceived exertion also significantly increased across distance quartiles
256 ($F = 25.0$, $p < 0.001$), but there was no condition x distance quartile interaction effect ($F = 0.4$,
257 $p = 0.92$) (Figure 5.2a). There was a significant main effect for condition observed for affect
258 ($F = 3.0$, $p = 0.03$) with significantly higher values reported during TT_{105%} than during
259 TT_{102%105%} (MD = -0.9, 95% CL = -1.8, -0.1; $p = 0.03$). Affect also significantly decreased
260 across distance quartiles ($F = 9.0$, $p < 0.001$). There was no condition x distance quartile
261 interaction ($F = 0.2$, $p = 0.99$) (Figure 5.2b). In addition during the first quartile of TT_{102%105%}
262 significant positive correlations were observed between the percentage of mean speed
263 performed and RPE ($r = 0.70$, $p = 0.02$) and a strong negative correlation with affect ($r = -0.6$,
264 $p = 0.052$).

265 There was a significant main effect for condition for SE_{pace} ($F = 3.6$, $p = 0.03$), but no
266 significant time effect ($F = 0.9$, $p = 0.45$) or interaction ($F = 0.5$, $p = 0.87$). Significantly greater
267 SE_{pace} (Figure 5.2c) was found during TT_{105%} than during TT_{102%,105%} (MD = 11.6%, 95% CL
268 = -0.02, 23.1; $p = 0.05$). There was a significant main effect across the three competitor trials
269 for SE_{comp} ($F = 4.6$, $p = 0.02$), however no significant main effect for distance quartile ($F = 2.7$,
270 $p = 0.07$) and no interaction ($F = 0.4$, $p = 0.91$). Post hoc analysis found significantly higher

271 SE_{comp} (Figure 5.2d) during TT_{102%} when compared with TT_{105%} (MD = 15.8%, 95% CL = 5.3,
272 26.3; p = 0.001), and TT_{102%,105%} (MD = 14.3%. 95% CL = 3.7, 24.8; p = 0.004).

273

274 [Insert Figure 2 near here]

275

276 Qualitative responses

277 Frequency data recorded from the post-trial questions found that the most common strategy
278 participants adopted during TT_{102%} was to ‘stay ahead’ of the competitor (41.7%). During
279 TT_{105%} they adopted to ‘go at own pace’ (58.3%), and during TT_{102%,105%} they chose to ‘ignore
280 the fastest competitor’ (33.3%). Participants’ thoughts towards the competitor during TT_{102%}
281 was to ‘ignore’ (25%), as were the thoughts during TT_{105%} (50%), as well as perceiving the
282 competitor to be ‘too fast’ (50%). Whereas during TT_{102%,105%} thoughts were to ‘concentrate on
283 the closer competitor’ (41.7%). The most frequent thoughts towards pace during TT_{102%} were
284 that it was ‘manageable’ (41.7%), and during TT_{105%} and TT_{102%,105%} that participant ‘could
285 not sustain’ (50% each).

286

287 Discussion

288 The primary aim of this study was to examine the influence of different magnitudes of
289 deception (102%, 105%) elicited through dynamic pacing avatars, on 16.1 km self-paced
290 cycling TT performance. This study is the first to investigate both of these magnitudes of
291 deception under the same task duration and further investigated such influences within a novel
292 competitive environment performing in the presence of two competitors. The main findings
293 demonstrate that each method of deception, irrespective of its magnitude, elicited comparable
294 improvements in 16.1 km TT performance (1.3% - 1.7%) compared to performing alone. This
295 equates to a ‘real-world’ competitive advantage in the region of 21.6 – 27.0 s and highlights

296 the ergogenic potential of increasing perceived maximal performances by deceptively altering
297 performance feedback or stimulating a competitive environment. A secondary aim of our study
298 was to explore the influence of different magnitudes of deception on psychological constructs
299 during such performances. We demonstrate for the first time that although each magnitude of
300 deception and competitive environment produced comparable performance improvements,
301 they produced disparate psychological responses.

302

303 Performing against a single competitor, comparing different magnitudes of deceptively hidden
304 performance intensity (TT_{102%} and TT_{105%}), elicited similar improvements in performance
305 times of 1.4% (23.4 s) and 1.3% (21.6 s) respectively, compared to performing alone. These
306 improvements are at least two times greater than the previously reported minimal worthwhile
307 change in performance of 0.6% (representative of 10 s in the present study) (27). In support of
308 previous research, despite different methodological approaches, the presence of simulated
309 competitors improved TT performances greater than athletes' previous best performance
310 (TT_{FBL}) (7,36,43). This includes improvements when misleading feedback is presented as a
311 competitor representing a performance 2% greater than the athlete's previous best performance
312 (36). Whilst the present study supports such findings it must be noted that the 2% increase in
313 power output manipulation in the previous study will represent a 0.7% increase in speed during
314 comparisons to the present investigation (13).

315

316 Important to note however, is that whilst the findings of facilitation even when against a 2%
317 increase in performance correspond with previous research, the present study informed the
318 participants differently as to the nature of their competitor. During the present study
319 participants were informed their visual opponent was a cyclist of a similar ability to themselves.
320 In contrast, during Stone et al's (2012) research, participants were informed the avatar

321 represented their own previous performance. Caution must be sought when directly comparing
322 such results as performing against self or an opponent will alter the intrinsic and extrinsic nature
323 of competitive motivation and could influence the behavioural strategy one chooses during
324 competition (40). Nevertheless, the present methodology enabled a true comparison of
325 manipulation magnitudes between 100%, 102% and 105% of the same performance variable,
326 and a novel finding is that performance also improved when misleading feedback is presented
327 as a competitor representing a performance 5% greater in speed than the athlete's previous best
328 performance.

329

330 Simultaneous with similar improvements in performance times across the conditions, there
331 were also no significant differences in the physiological or psychological responses between
332 TT_{102%} and TT_{105%}. There was no significant difference between trials for RPE, affect, and
333 athlete's self-efficacy to continue at the chosen pace. Participants did however report a
334 significantly greater during-task self-efficacy to compete with their opponent during TT_{102%}
335 compared to TT_{105%} and interestingly, both trials resulted in more positive affect than TT_{FBL}
336 despite an increase in exercise intensity. The findings during TT_{102%} support the proposal that
337 greater affective valence is observed despite an increase in pace, if the subject successfully
338 stays in contact with a competitor (29). Alternatively it has previously been proposed that
339 athletes who realise that they are failing to achieve meaningful goals during competition,
340 represented in the present study as lower self-efficacy to compete with the simulated
341 competitor, experience a negative affective state labelled 'competitive suffering' (5,12). If the
342 subject cannot stay in contact with the competitor, a reduced affect and increased RPE might
343 be expected. This however, was not evident during TT_{105%}, despite participants indicating an
344 inability to stay with their opponent through their reduced self-efficacy responses, and post-
345 trial interviews, in which half the participants expressed they could not sustain the pace. There

346 was a significantly lower self-efficacy to compete during TT_{105%} than during TT_{102%}, yet they
347 expressed similar affect to TT_{102%}, which was more positive than during TT_{FBL}. Notably,
348 during post-trial feedback half the participants reported that they abandoned competing with
349 the avatar and continued to ride the trial for time, rather than as a competition, during TT_{105%}.
350 This supports that people with low task- or self-efficacy may avoid such goal attempts (33),
351 and that if an athlete is not in close proximity to their competitors, pacing is better focused on
352 producing an optimal individual performance (32). However the temporal aspects of such
353 decision making require further consideration. Whilst the two magnitudes of deceptive
354 manipulations produced similar improvements in performance time when competed against as
355 a single competitor, their differential influence on perceptions of self-efficacy is noteworthy.
356
357 The summative effect of competing against two avatars during the same trial has not previously
358 been investigated. Whilst the presence of competitors during each condition (TT_{102%}, TT_{105%}
359 and TT_{102%,105%}) elicited similar improvements in performance time (1.4%, 1.3% and 1.7%
360 respectively), the collective influence of the two competitors (TT_{102%,105%}), creating a different
361 competitive environment (albeit representative of the same pacing profiles experienced within
362 the single competitor conditions), produced different psychological responses. A significantly
363 greater RPE was observed during TT_{102%105%} and TT_{102%} than during TT_{FBL}. However RPE
364 during TT_{105%} was not significantly greater than TT_{FBL}. The contrasting responses could be
365 explained by the decision in TT_{105%} to change the performance goal away from competing with
366 the avatar, as expressed by participant's post-trial. Thus the perceptions of exertion are
367 significantly increased when competing with opponents, compared to striving to reach personal
368 goals, such as during alone conditions and TT_{105%} (30). Notably, research has recently
369 documented performance improvements in the absence of elevated RPE when competing with
370 an avatar, which was ascribed to the greater external attentional focus during the task (43).

371 However, this former study employed an avatar representing 100% of previous performance,
372 whereas the present study used greater intensity magnitudes of 102% and 105%. Such
373 increased work-rate may negate any processing of external information through greater
374 salience of physiological feedback. As such, competing against opponents who are superior to
375 an athlete's previous fastest performance elevates RPE (36).

376

377 There was also significantly lower affect during TT_{102%,105%} than TT_{105%}. Competing against
378 two opponents evoked meaningful performance improvements despite participants
379 experiencing higher RPE and lower affect. An explanation for the more negative affective
380 responses and heightened perceived exertion during TT_{102%,105%} could be the 'framing effect'
381 of the feedback provided (29). Emotional responses and the interpretation of afferent
382 physiological sensations are dependent on the circumstances in which information is presented
383 to the individual (23,30). Therefore performing against two competitors could have been
384 perceived as more stressful than against a single competitor or performing alone, encouraging
385 more negative perceptions. Additionally, affective and psychological responses could have
386 been influenced by self-efficacy appraisals. There is a proposition that variations in self-
387 efficacy are antecedents of variability in affective responses (11) and that sensations of fatigue
388 are interpreted differently according to one's degree of self-efficacy (21). During TT_{102%105%}
389 participants reported significantly lower self-efficacy to compete than during TT_{102%}. One's
390 perceived progress towards goal achievement is important in the generation of affect responses
391 (14). Therefore the lower self-efficacy during TT_{102%105%}, possibly generated according to a
392 perceived greater risk towards the achievement of their overall goal when competing against
393 two opponents, may have resulted in reduced affective valence. The self-efficacy question was
394 not separate for each avatar during TT_{102%,105%}, prohibiting investigations as to which opponent
395 they were anchoring their appraisal of self-efficacy. The values were, however, similar to those

396 reported during TT_{105%}, and both (TT_{105%} and TT_{102%,105%}) had significantly lower self-
397 efficacy than TT_{102%}. Additionally it could be assumed that during TT_{102%,105%} the influence
398 of the 102% avatar, in closer proximity, motivated the choice to continue competing despite
399 worse affective and efficacy responses. This as 41.7% of the participant's specified that they
400 chose to concentrate on the closer competitor. As previous findings have elucidated (38),
401 similar deception methods allow for the association of negative affect with successful
402 performances through an enhanced motivation to withstand a workload otherwise considered
403 unsustainable.

404

405 A further explanation for the similar improvement in performance despite worse affective and
406 efficacy responses during TT_{102%,105%}, could be due to the influence of two competitors during
407 the initial 4 km. Whilst the cyclists' speed profiles across all trials was illustrative of the
408 commonly reported parabolic pacing strategy (1), during TT_{102%,105%} there was a greater
409 percentage of mean speed displayed in the initial quarter of the trial (Figure 1). This suggests
410 participants did not select their initial pace from their perceived optimal strategy, but adjusted
411 their speed to that imposed by the competition (39). Extending the findings of previous
412 research, individuals are likely to select work rates based on the behaviour of competitors and
413 be less influenced by afferent information relating to their personal status (29). In which, during
414 TT_{102%,105%} a faster start was found to be significantly associated with greater RPE and a
415 reduced affect. The presence of competition, in particular two competitors, may have induced
416 greater motivation (2), encouraging acceptance of a high level of unpleasant sensations in an
417 attempt to achieve a goal of beating the opponents.

418

419 The selection of an unsustainable power output at the start of TT_{102%,105%} possibly led to the
420 necessity to slow down during the third quarter (15). Consciously reducing power output during

421 the third quarter (37), in response to a greater initial 4 km pace, is further evidence supporting
422 a psychophysiological pacing decision as an active step to maintain overall pacing strategy and
423 preventing a physiological catastrophe (39). This was also demonstrated in previous research
424 using a 105% speed manipulation (24). Furthermore, the pacing profile for TT_{102%,105%}
425 illustrated that athletes were still able to increase pace in the final quartile, which is indicative
426 of the presence of a reserve. The motivational influence of competition (7,43), could be
427 considered an incentive that in spite of unpleasant experiences (increased RPE and reduced
428 affect) during TT_{102%,TT105%} performance was not debilitated. This provides further support for
429 previous findings of a significant negative association between affect and power output during
430 16.1 km time trials (20), and between affect and increased task performance (38).

431

432 **Conclusion**

433 In conclusion, data from the current study confirms the beneficial effect of the surreptitiously
434 augmented feedback of a previous performance. Deceptive employment of dynamic
435 competitors to disguise the intensity manipulation enabled cyclists to accomplish performance
436 improvements, even with a magnitude increase of 2% and 5% greater speed than previous
437 performance. Although supporting previous findings that deception magnitudes of 105% speed
438 were too large to be sustained for the whole task, when this magnitude is presented as direct
439 competition, participants may change their performance goal to prevent a reduced performance
440 and negative emotions. Notably, participant's willingness to achieve their competitive goal
441 when against two opponents, increased persistence of performance by counteracting negative
442 psychological responses of greater RPE, and permitted the acceptance of reduced affect.
443 Finally, the magnitude to which the feedback is augmented and the way in which it is presented
444 to athletes stimulates different psychological influences. When implementing this strategy into
445 practice or training, consideration must therefore be given to the implications associated with

446 different magnitudes of deception and the use of competitive environments upon previously
447 unexamined psychological constructs.

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Table 1. Mean \pm SD completion time and whole TT average power output, speed, and heart rate for the three experimental conditions.

Condition	Completion Time (min)	Power Output (W)	Speed (km/h)	Heart Rate (bpm)
TT _{FBL}	27.2 (2.1)	252 (45)	35.8 (2.6)	159 (14)
TT _{102%}	26.8 (1.6)	259 (38)	36.2 (2.0)	162 (11)
TT _{105%}	26.8 (1.6)	258 (37)	36.2 (2.8)	159 (11)
TT _{102%,105%}	26.7 (1.9)	260 (44)	36.3 (2.4)	159 (12)

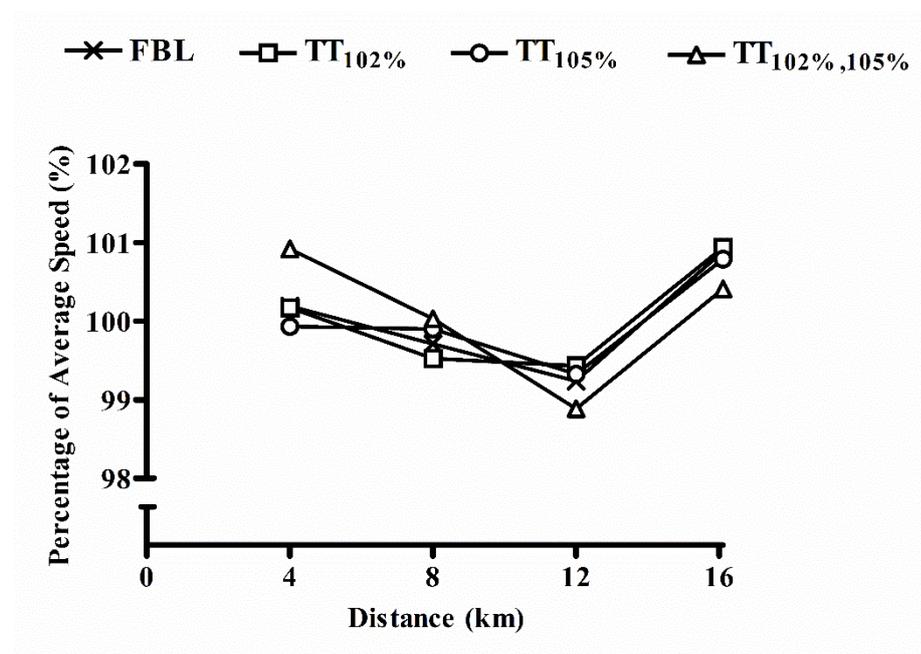


Figure 1. Percentage of mean speed during each time trial. Error bars are omitted for clarity.

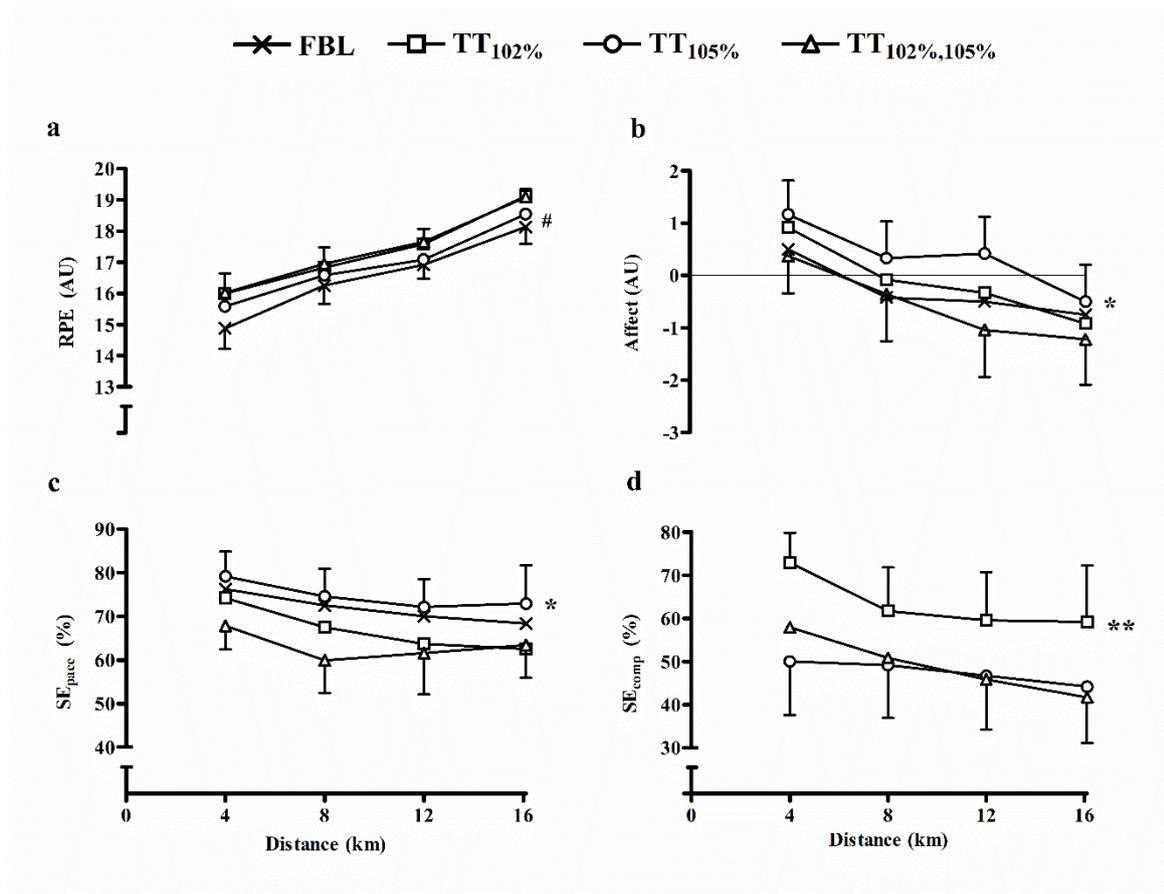


Figure 2. Psychological responses to the TT conditions. a) Ratings of perceived exertion, b) Affect, c) SE_{pace}, d) SE_{comp}. Error bars illustrate SEM. (#) Denotes main effect for condition, TTFBL significantly different to TT_{102%} ($p < 0.001$) and TT_{102%,105%} ($p < 0.001$). (*) denotes main effect for condition, TT_{105%} significantly different to TT_{102%,105%} ($p \leq 0.05$). (**) denotes main effect for condition, TT_{102%} significantly different to TT_{105%} ($p = 0.001$) and TT_{102%,105%} ($p = 0.004$).