

Effects of manipulating specific individual constraints on performance outcomes, emotions, and movement phase durations in Rugby Union place kicking.

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MANIPULATING INDIVIDUAL CONSTRAINTS IN PLACE KICKING

1 Running Head: MANIPULATING INDIVIDUAL CONSTRAINTS IN PLACE KICKING

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3 Effects of manipulating specific individual constraints on performance outcomes, emotions,
4 and movement phase durations in Rugby Union place kicking

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32

33

Abstract

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Place kicks present valuable opportunities to score points in Rugby Union, contributing

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almost half of all points scored at international level. From an ecological dynamics

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perspective, place kickers adapt to interacting task, environmental, and individual constraints

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in performance environments. The aim of this study was to analyse effects of specific

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manipulations of individual constraints (fatigue; expectation for success) on place kicking

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performance, movement phase durations, heart rate and self-reported emotions. Under

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representative task and environmental constraints on an outdoor training pitch, 12

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experienced, male place kickers completed four testing sessions under every combination of

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manipulated high/low expectation for success and manipulated levels of high/low acute

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fatigue. Within each session of 12 place kicks, performance outcomes from three kicking

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locations of varying difficulty were recorded. ANOVA revealed a two-way interaction

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between fatigue and expectation manipulations on mean success percentage ($p < 0.05$), with

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higher success under low fatigue + low expectation ($M \pm SD = 58 \pm 13\%$) and high fatigue +

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high expectation ($M \pm SD = 56 \pm 14\%$), compared with separate manipulations of high

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expectation ($M \pm SD = 49 \pm 14\%$) or high fatigue ($M \pm SD = 51 \pm 14\%$). There were no

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significant effects on any movement phase durations. Manipulating expectation significantly

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heightened mean heart rate ($p < 0.05$) and influenced emotions reported by place kickers,

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including higher anger scores when there was high expectation for success. Coaches are

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encouraged to integrate place kicking into representative game scenarios in practice

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environments to faithfully represent key performance constraints (e.g. fatigue; expectation for

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success) in preparing kickers for competitive situations.

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Key words: Constraints manipulations, ecological dynamics, expectation, fatigue, place kick,

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practice environments

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58 **1. Introduction**

59 In sporting domains such as Rugby Union, skilful behaviour can be viewed through
60 the theoretical lens of ecological dynamics as the (re)organisation of functionally adaptive
61 movements, which satisfy interacting task, environmental, and individual constraints to
62 achieve performance aims (Davids, Araújo, Vilar, Renshaw, & Pinder, 2013; Newell, 1986).
63 A key implication for practitioners and researchers adopting an ecological dynamics
64 approach to skill acquisition is to design learning environments that offer opportunities to
65 practice under interacting constraints which closely simulate those of competitive
66 performance environments (Woods, McKeown, Shuttleworth, Davids, & Robertson, 2019).
67 Manipulation of key task constraints in practice environments, such as distance between
68 defenders and pitch boundaries, has been suggested to improve decision-making and
69 movement exploration within open play scenarios in Rugby Union (e.g. Correia, Araújo,
70 Duarte, Travassos, Passos, & Davids, 2012; Passos, Araújo, Davids, & Shuttleworth, 2008;
71 McKay, Davids, Robertson, & Woods, 2021). However, to date, no empirical studies have
72 focused on manipulating task, environmental, or individual constraints to study performance
73 of discrete skills in Rugby Union, such as a lineout throw or place kick. Given the
74 contribution of place kicking to the outcome of Rugby Union matches (45% of all
75 international points scored during 2002 – 2011; Quarrie & Hopkins, 2015), it is important to
76 understand key constraints on place kicking. Furthermore, understanding key constraints on
77 place kicking can support the design of practice environments which faithfully represent
78 performance environments to enhance skill transfer.

79 Since the conceptualisation of the Representative Learning Design framework
80 (Pinder, Davids, Renshaw, & Araújo, 2011a), comparisons of practice and performance

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81 environments have been the focus of investigation in several sports, such as cricket (Pinder,
82 Davids, Renshaw, & Araújo, 2011b), tennis (Krause, Farrow, Reid, Buszard, & Pinder,
83 2018), and springboard diving (Barris, Davids, & Farrow, 2013). Within these comparisons,
84 researchers have studied the influence of task (e.g. ball projection versus live bowler
85 delivery; Pinder et al., 2011b) and environmental constraints (e.g. dry versus aquatic
86 environments; Barris et al., 2013) on movement patterns and showed significant differences
87 in emerging behaviours when these constraints were manipulated. To extend these
88 comparisons of task and environmental constraints in practice and performance contexts,
89 more recent studies have recognised the important role of emotions and cognitions as
90 individual constraints which can influence performers in practice and competition (e.g.
91 Connor, Farrow, & Renshaw, 2018; Maloney et al., 2018). The Affective Learning Design
92 framework, proposed by Headrick et al. (2015a), recognises the powerful influence that
93 thoughts and emotions have on performers when in competitive performance environments,
94 partly due to fluctuating contextual factors (e.g. score margin, time remaining). Individual
95 constraints, such as thoughts, emotions, and fatigue induced during competition, are therefore
96 important to consider when designing practice environments which aim to faithfully represent
97 the demands of competitive performance.

98 To understand key constraints in Rugby Union place kicking, performance analytical
99 approaches have revealed fluctuations in performance as specific task constraints (e.g.
100 distance and angle to goalposts) and contextual factors (e.g. score margin, time remaining and
101 previous performance of the kicker) vary (Nel, 2013; Pocock, Bezodis, Davids, & North,
102 2018; Quarrie & Hopkins, 2015). Furthermore, experiential knowledge of professional place
103 kickers and experienced coaches has highlighted key individual constraints on place kicking
104 performance, such as feelings of expectation for success and acute fatigue (Pocock, Bezodis,

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105 Davids, Wadey, & North, 2020). Understanding the experiential knowledge of practitioners
106 and athletes, as well as insights from performance analysis, can help to identify key
107 performance constraints which should be simulated in representative practice designs
108 (Rothwell et al., 2020). The present study combines the findings of performance analyses of
109 place kicking (e.g. Pocock et al., 2018; Quarrie & Hopkins, 2015) and experiential
110 knowledge of professional place kickers and experienced coaches (Pocock et al., 2020) to
111 inform a novel experimental design of individual constraints in place kicking. Manipulating
112 specific individual constraints, such as expectation for success and acute fatigue, in a
113 representative learning environment can also develop an understanding of their effects on
114 emotions of place kickers during performance. Therefore, the aim of this study was to analyse
115 effects of specific manipulations of individual constraints (fatigue; expectation for success)
116 on place kicking performance, movement phase durations, heart rate and self-reported
117 emotions.

118 **2. Methods**

119 ***2.1. Participants***

120 Twelve experienced male place kickers ($M \pm SD$ age = 21 ± 2 years; height = $1.79 \pm$
121 0.03 m; body mass = 81.1 ± 5.9 kg) were recruited. All participants had at least three years of
122 place kicking experience ($M \pm SD$ experience = 7 ± 3 years) at university ($N = 6$), club ($N =$
123 4), or school ($N = 2$) level. Eight participants were right-foot dominant and four were left-
124 foot dominant. Ethical approval was granted by the lead author's University ethics
125 committee. Prior to testing, all participants completed a Physical Activity Readiness
126 Questionnaire (PAR-Q) and provided written informed consent.

127 ***2.2. Procedure***

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128 Participants attempted 12 place kicks in four separate testing sessions over a six-week
129 period on a full-sized, outdoor Rugby Union pitch. The four testing sessions were counter-
130 balanced, with each of the four sessions designed to manipulate one of the four possible
131 combinations of fatigue and expectation for success (high or low fatigue; high or low
132 expectation).

133 Participants were not cognisant of the specific aims of the study, and, to represent
134 high expectation for success, each participant was informed of being matched with an
135 anonymous participant who had achieved 9/12 successful place kicks. Participants were
136 challenged to equal or better their matched participant's score of 75%, to earn themselves and
137 the anonymous participant a monetary reward of £10, similar to the approach used by
138 Runswick et al. (2018) to induce pressure through expected performance levels. No monetary
139 rewards or challenges were offered in the two testing sessions with low expectation for
140 success. All participants were paid a total of £20 each, following completion of the study,
141 regardless of performance.

142 To represent high fatigue, participants performed Rugby Union related exercises for
143 three minutes before each place kick to represent acute fatigue induced by a prior passage of
144 play. The fatigue protocol repetitions were adapted from the Bath University Rugby Shuttle
145 Test (BURST) (Roberts, Stokes, Weston, & Trewartha, 2010), which is a specific exercise
146 protocol for Rugby Union forwards that has been shown to be reproducible (Roberts et al.,
147 2010) and previously used to be representative of Rugby Union match demands (Green, Kerr,
148 Olivier, Meiring, Dafkin, & McKinon, 2017). Minor alterations to the BURST were made to
149 be representative of a place kicker's match demands, which is typically in the position of fly-
150 half. Therefore, the fatigue protocol repetitions included passing, kicking out of hand and
151 carrying the ball, which are the most frequent actions completed by fly-halves during a

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152 competitive match (James, Mellalieu, & Jones, 2005), combined with periods of walking,
153 jogging and sprinting.

154 Each fatigue protocol repetition started and ended with a 15 m sprint, which was used
155 as a performance test and was recorded using timing gates (Brower Timing Systems, Utah,
156 USA). The fatigue protocol repetition lasted approximately one minute in duration and
157 included a 20 m walk, 180° turn, 20 m cruise, 10 m jog before performing one of three
158 actions (pass, kick out of hand, 10 m carry), and a 10 m jog. This sequence was repeated
159 three times before each place kick so that the participant could complete each of the three
160 actions in a randomised order.

161 Within each testing session, participants performed four sets of place kicks from three
162 locations, which were completed in a non-sequential order to ensure changes in task
163 constraints between every kick, representing competitive environments. Therefore, the order
164 of place kicks was different in each of the four testing sessions for each participant. The
165 categorisation of the three kicking locations were made relative to the distance and angle
166 from the goalposts (Figure 1). These locations of varying task difficulty were based on
167 evidence from the experiential knowledge of professional place kickers and experienced
168 coaches (Pocock et al., 2020), and based on data from performance analysis of place kicking
169 in the 2015 Rugby World Cup (Pocock et al., 2018). The first kicking location was situated
170 directly in front of the goalposts (0° to goalposts) on the 22 m line, categorised as an “easy”
171 location. The second kicking location was situated 15 m infield from the left touchline for
172 right-footed participants (symmetrically positioned for left-footed participants), which had a
173 distance of 32 m to the goalposts and was categorised as a “threshold” location. The third
174 kicking location was situated on the left touchline (symmetrically positioned for left-footed

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175 participants). This kick location was 42 m from the goalposts and was categorised as a
176 “difficult” location, designed to be a challenging place kick for experienced place kickers.

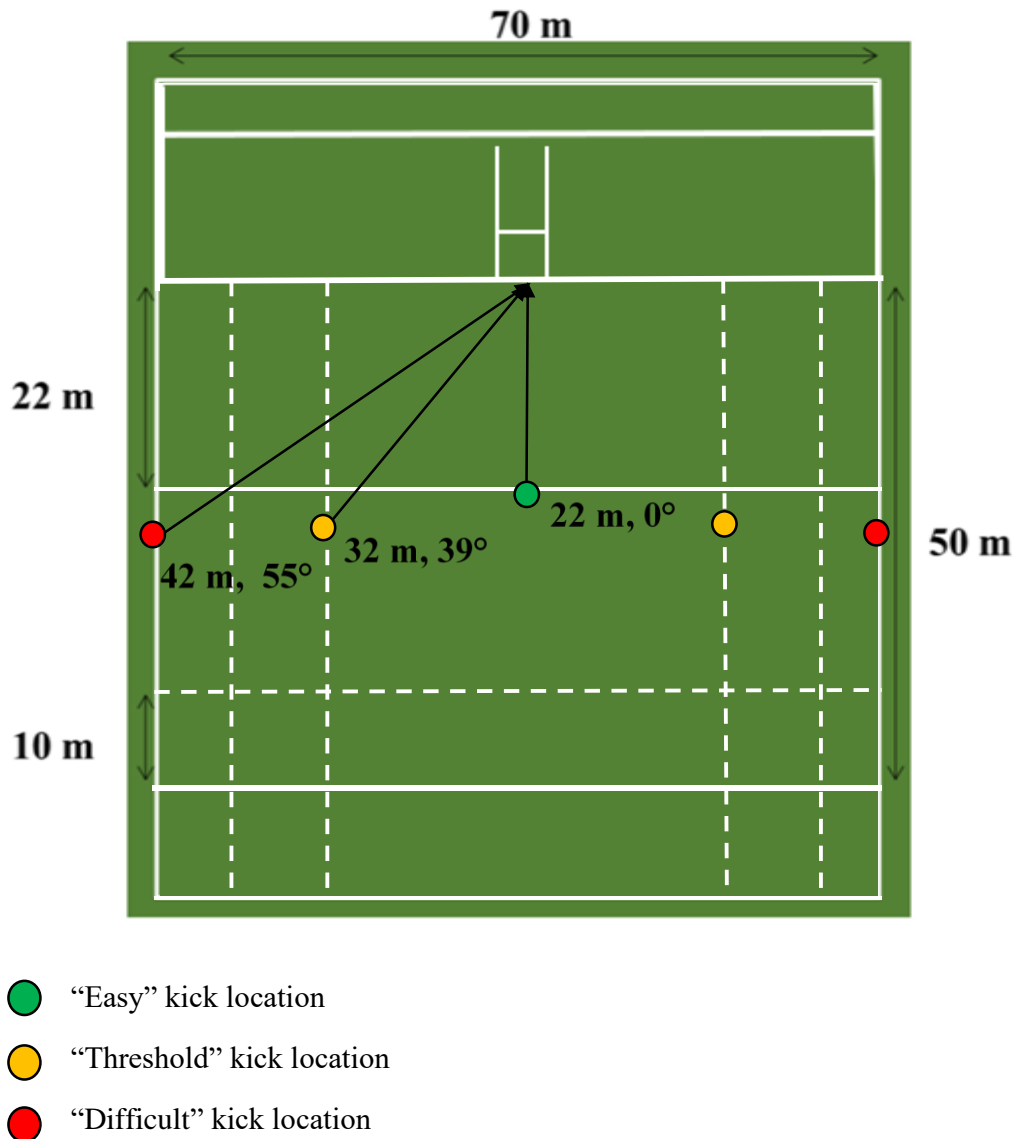


Figure 1. Kicking locations for right footed and left footed place kickers. Angles annotated on the figure are relative to a kick from directly in front of the goalposts being 0°.

Locations for the right-footed kickers are on the left side of the pitch; locations for left-footed kickers are on the right side of the pitch and are reflections about the 0° line.

177 Participants used size 5 Gilbert G-TR 3000 Rugby Union balls throughout the study,
178 which were fully inflated before each testing session. For familiarity, participants used their

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179 own kicking tees and no instructions regarding routines or kicking preparation were provided.
180 Participants completed each testing session individually, with two researchers recording
181 dependent measures and no other participants present. Before each testing session,
182 participants completed a self-directed warm-up and were allowed two practice kicks from any
183 location. Two 50 Hz cameras (Panasonic HC-V210 HD Camcorder, Panasonic, Berkshire,
184 U.K.) were positioned behind the goalposts to assist with recording kicking performance
185 measures. To determine the phase durations of participants' movements whilst completing
186 each kick, a camera recording at 50 Hz (Panasonic HC-V720 HD Camcorder, Panasonic,
187 Berkshire, U.K.) was used for the preparation phase and a portable electronic tablet (Apple
188 Inc., California, USA) recording at 240 Hz was used for the approach phase, kicking phase
189 and follow through phase (see *Phase Durations* for definitions). Participants wore a heart rate
190 monitor (Polar V800, Polar Electro Oy, Kempele, Finland) to record heart rate continuously
191 during testing sessions. Full heart rate data were available for 41 of 48 testing sessions, which
192 allowed mean heart rate to be calculated for each of the four combinations of experimental
193 manipulations. Heart rate data for seven testing sessions were unavailable due to a technical
194 fault.

195 Testing sessions only took place in dry weather conditions with a wind speed below 8
196 m/s, which is categorised as a moderate breeze on the Beaufort Scale. Before each testing
197 session, the air temperature was recorded ($M \pm SD$ temperature = $16.0 \pm 3.8^\circ\text{C}$) and wind
198 speed ($M \pm SD$ wind speed = 1.7 ± 1.4 m/s) was measured to ensure that extremely varying
199 environmental conditions did not interfere with the study outcomes.

200 ***2.3.Dependent Measures***

201 *2.3.1. Performance Measures*

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202 Each place kick was recorded as successful (ball passed between goalposts and above
203 crossbar) or unsuccessful (ball did not pass between goalposts and above crossbar), to record
204 mean success percentage as a performance outcome.

205 2.3.2. *Phase Durations*

206 For each place kick, four temporal phases (Figure 2) were identified based on
207 definitions from previous research (Bezodis, Atack, & Winter, 2017; Jackson & Baker, 2001)
208 and the durations of each phase were determined using Kinovea (version 0.8.15). The first
209 phase, the preparation phase, began when both hands of the participant were no longer
210 touching the ball, and ended when one of the participant's feet first left the pitch as they
211 initiated their movement towards the ball. The second phase, the approach phase, began from
212 this movement initiation instant and ended when the non-kicking foot (support foot)
213 contacted the pitch next to the ball. The third phase, the kicking phase, began at support foot
214 contact and ended when the kicking foot first contacted the ball. The fourth phase, the follow
215 through phase, began at ball contact and ended when the kicking foot first contacted the pitch
216 following the kicking action.

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219

Hands leave ball

Forward movement initiation

Support foot contact

Ball contact

Kicking foot lands



220

221

222

← Preparation Phase →

← Approach Phase →

← Kicking Phase →

← Follow Through Phase →

223

224

Figure 2. Start and end frames for each of the four phase durations, with events identified above the images (see methods for full definitions) and corresponding phases between each event identified below the images. Note: the spacing and sizing of the images are not scaled to time.

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228 2.3.3. *Psychological Measures*

229 To measure emotions of participants during testing sessions, two questionnaires were
230 used. The Mental Readiness Form-Likert (MRF-L; Krane, 1994) was completed by
231 participants at five time points in each testing session; before the first kick, after three kicks,
232 after six kicks, after nine kicks, and after 12 kicks. The three scales required participants to
233 rate their cognitive anxiety (1 = calm, 11 = worried), somatic anxiety (1 = relaxed, 11 =
234 tense), and their confidence (1 = confident, 11 = scared).

235 The Sport Learning and Emotions Questionnaire (SLEQ; Headrick, Renshaw, &
236 Davids, 2015b) was used to measure the emotions of participants before the first place kick
237 and after the 12th place kick of each testing session, consistent with previous research
238 (Connor et al., 2018). The SLEQ is comprised of 17 words which participants rated on a scale
239 from 0 (not at all) to 4 (extremely). The 17 ratings are categorised into four main themes
240 (enjoyment, nervousness, fulfilment, anger). The shorter MRF-L was used during testing
241 sessions and the longer SLEQ was used before and after testing sessions to maintain the
242 timings of the fatigue protocol.

243 2.3.4. *Physiological Measures*

244 Mean heart rate was recorded throughout the testing session for all four combinations
245 of experimental manipulations. Consistent with previous research of kicking tasks under
246 fatigue manipulations (e.g. Coventry, Ball, Parrington, Aughey, & McKenna, 2015), 15 m
247 sprint times were compared throughout the 12 fatigue protocol repetitions.

248 2.4. *Statistical Analysis*

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249 Several, separate, two-way repeated measures ANOVAs were used to analyse effects
250 of experimental manipulations (fatigue; expectation) on mean success percentage, mean heart
251 rate, and each phase duration. A number of separate three-way repeated measures ANOVAs
252 were used to analyse effects of experimental manipulations (fatigue; expectation) and kicking
253 location on mean success percentage; experimental manipulations (fatigue; expectation) and
254 time point on MRF-L and SLEQ scores. A one-way repeated measures ANOVA was used to
255 analyse effects of fatigue protocol repetition number on 15 m sprint times. Any violations of
256 sphericity for repeated measures variables ($p < 0.05$ on Mauchly's test) were corrected for by
257 adjusting the degrees of freedom using the Greenhouse-Geisser correction when Epsilon (ϵ)
258 was less than 0.75 and the Huynh-Feldt correction when ϵ was greater than 0.75. Post hoc
259 analyses using pairwise comparisons included a Bonferroni correction. Effect sizes are
260 reported using partial eta squared (ηp^2) and alpha level (p) for statistical significance was set
261 at 0.05.

262 **3. Results**

263 ***3.1. Performance Measures***

264 ***3.1.1. Mean Success Percentage***

265 ANOVA revealed a significant two-way interaction between fatigue and expectation
266 manipulations on mean success percentage of kicks ($F(1,11) = 7.53, p < 0.05, \eta p^2 = 0.41$).
267 There were no significant main effects of fatigue manipulation ($p > 0.99$), or expectation
268 manipulation ($p = 0.52$) as mean success percentage was higher in the low fatigue, low
269 expectation manipulation ($M \pm SD = 58 \pm 13\%$) and in the high fatigue, high expectation
270 manipulation ($M \pm SD = 56 \pm 14\%$), compared with low fatigue, high expectation
271 manipulation ($M \pm SD = 49 \pm 14\%$) and high fatigue, low expectation manipulation ($M \pm SD$
272 $= 51 \pm 14\%$) (Figure 3).

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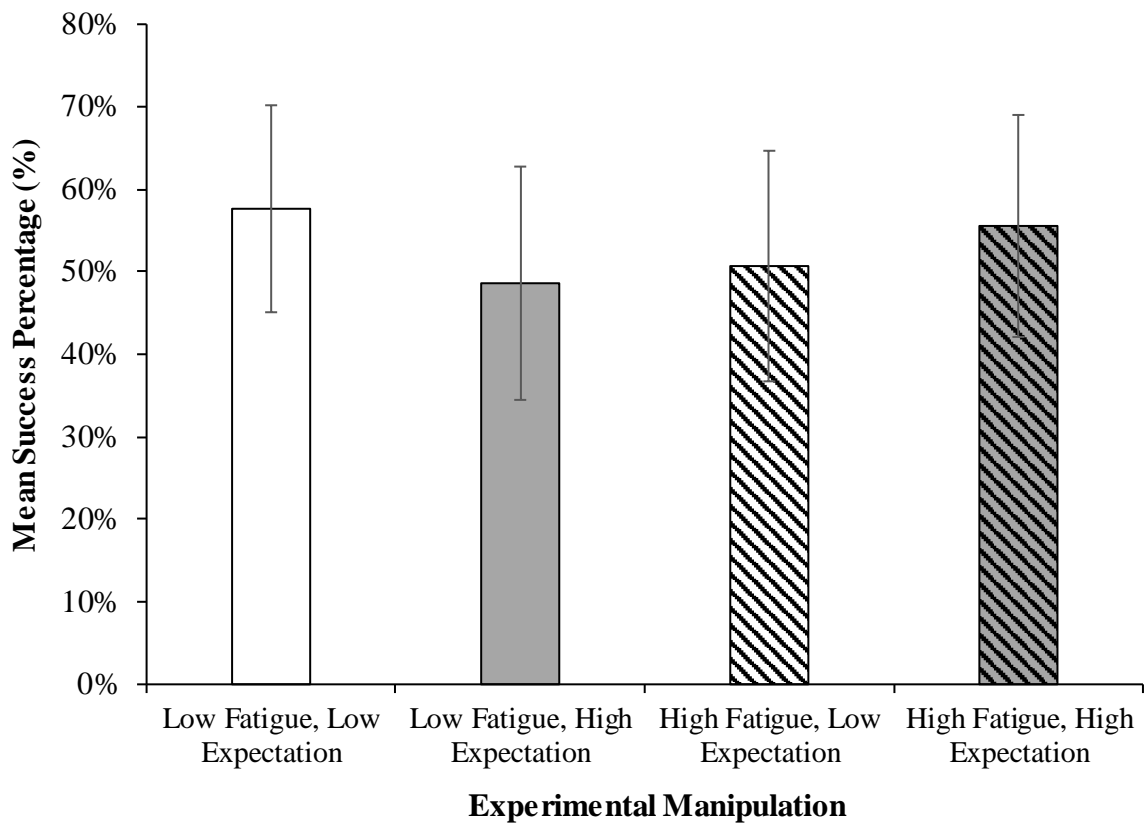


Figure 3. Mean \pm SD success percentages under manipulations of fatigue (diagonal shading if high) and expectation (light grey fill if high). A significant two-way interaction between fatigue and expectation was present.

273 3.1.2. Success Percentages across Different Kicking Locations

274 ANOVA revealed no significant three-way interaction between fatigue manipulation,
275 expectation manipulation and kicking location on mean success percentage ($F(2,22) = 0.69$,
276 $p = 0.51$, $\eta p^2 = 0.06$). There were no significant two-way interactions between fatigue
277 manipulation and kicking location ($p = 0.75$), or between expectation manipulation and
278 kicking location ($p = 0.26$). There were no significant main effects of fatigue ($p > 0.99$), or
279 expectation manipulation ($p = 0.52$) on mean success percentage. There was a significant
280 main effect of kicking location on mean success percentage ($F(2,22) = 124.91$, $p < 0.05$, ηp^2

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281 = 0.92). Post hoc analyses revealed that mean success percentage was significantly higher
 282 from the “easy” location ($M \pm SD = 83 \pm 18\%$) compared with the “threshold” location ($M \pm$
 283 $SD = 63 \pm 26\%$; $p < 0.05$), from the “threshold” location compared with the “difficult”
 284 location ($M \pm SD = 14 \pm 22\%$; $p < 0.05$), and from the “easy” location compared with the
 285 “difficult” location ($p < 0.05$) (Figure 4).

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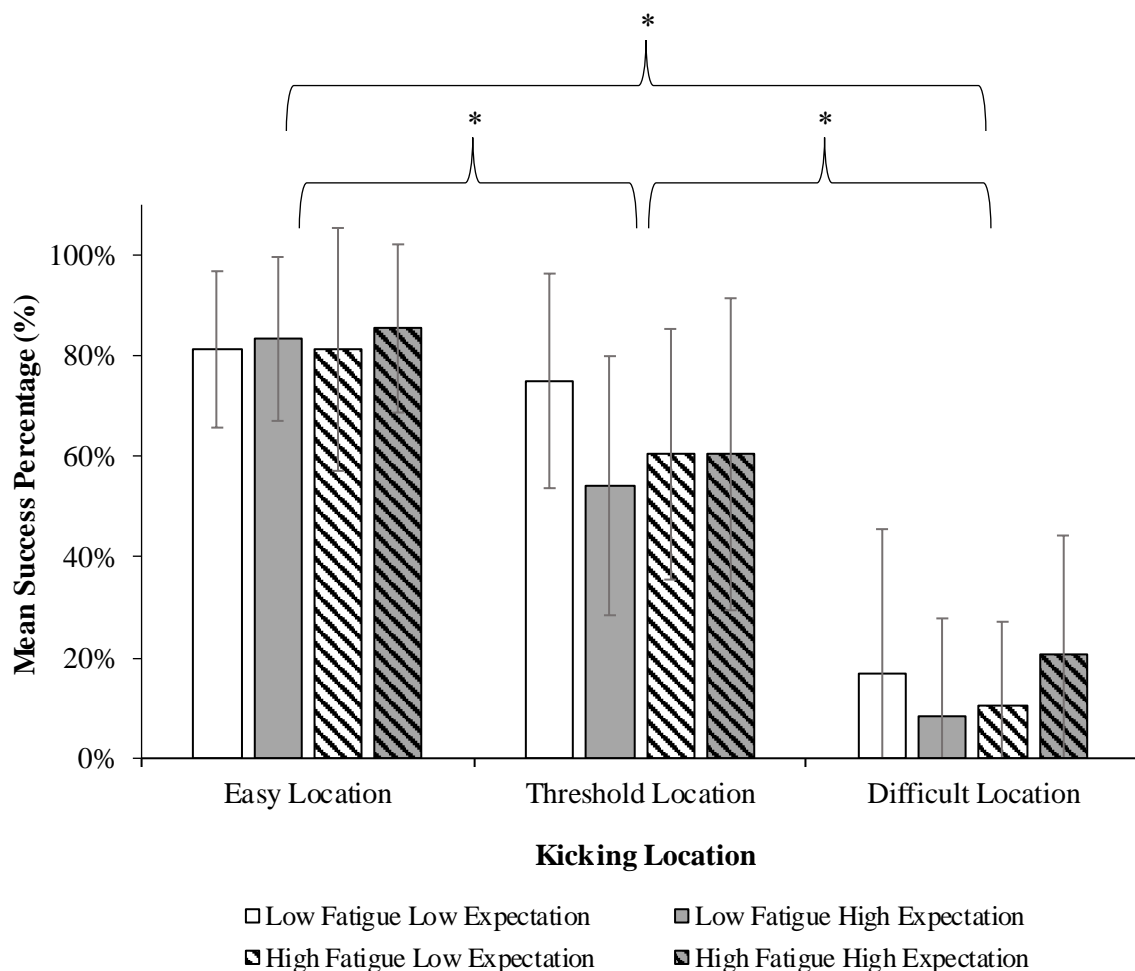


Figure 4. Mean \pm SD success percentages from the “easy” location, “threshold” location, and “difficult” location under manipulations of fatigue and expectation. * indicates significant differences in mean success percentage between kicking locations ($p < 0.05$).

287 **3.2. Phase Durations**

288 Mean \pm SD phase duration values for each of the four phases are presented in Table 1.
 289 ANOVAs revealed no significant interaction between fatigue and expectation manipulations
 290 on mean duration time of the preparation phase ($p = 0.20$), approach phase ($p = 0.59$), kicking
 291 phase ($p = 0.95$) or follow through phase ($p = 0.82$).

Table 1. Mean \pm SD phase duration values under manipulations of fatigue and expectation.

Phase Duration	Low Fatigue, Low Expectation	Low Fatigue, High Expectation	High Fatigue, Low Expectation	High Fatigue, High Expectation
Preparation Phase (s)	18.71 \pm 8.88	18.07 \pm 6.98	17.75 \pm 7.03	18.73 \pm 6.87
Approach Phase (s)	2.09 \pm 0.62	2.10 \pm 0.54	2.02 \pm 0.50	2.00 \pm 0.53
Kicking Phase (s)	0.11 \pm 0.01	0.11 \pm 0.01	0.11 \pm 0.01	0.11 \pm 0.01
Follow Through Phase (s)	0.37 \pm 0.10	0.36 \pm 0.10	0.37 \pm 0.09	0.35 \pm 0.08

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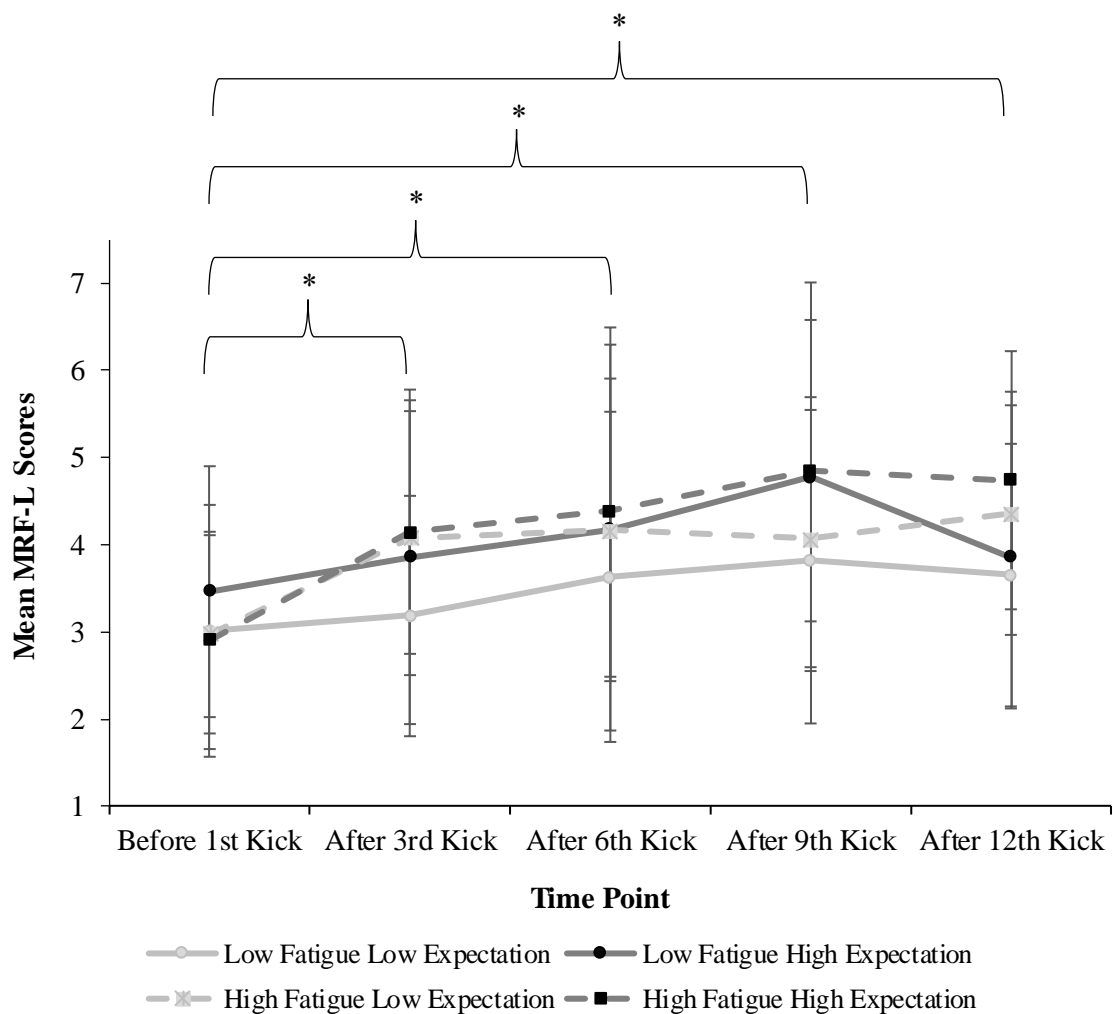
293 **3.3. Emotions**

294 **3.3.1. Mental Readiness Form – Likert (MRF-L)**

295 ANOVA revealed no significant three-way interaction between fatigue manipulation,
 296 expectation manipulation and time point on mean MRF-L scores ($p = 0.70$). There were no
 297 significant two-way interactions between fatigue manipulation and time point ($p = 0.06$),
 298 expectation manipulation and time point ($p = 0.18$), or fatigue and expectation manipulations
 299 ($p = 0.41$).

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300 There was a significant main effect of time point on mean MRF-L scores ($F(2.01,$
 301 $22.08) = 14.55, p < 0.05, \eta p^2 = 0.57$), with post hoc analyses revealing that mean MRF-L
 302 scores were significantly higher after three kicks ($M \pm SD = 3.82 \pm 1.58; p < 0.05$), six kicks
 303 ($M \pm SD = 4.09 \pm 1.93; p < 0.05$), nine kicks ($M \pm SD = 4.38 \pm 1.84; p < 0.05$), and 12 kicks
 304 ($M \pm SD = 4.15 \pm 1.67; p < 0.05$), compared with before first kick ($M \pm SD = 3.09 \pm 1.30$).
 305 There were no significant main effects of fatigue manipulation ($p = 0.30$) or expectation
 306 manipulation ($p = 0.17$) on mean MRF-L scores (Figure 5).



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Figure 5. Mean \pm SD Mental Readiness Form – Likert (MRF-L) scores before the first place kick, after three place kicks, after six place kicks, after nine place kicks, and after 12 place kicks, under manipulations of fatigue and expectation.* indicates a significant pairwise difference ($p < 0.05$).

307 3.3.2. *Sport Learning and Emotions Questionnaire (SLEQ)*

308 ANOVA revealed a significant three-way interaction between fatigue manipulation,
309 expectation manipulation, and time point on mean SLEQ scores ($F(1, 11) = 5.07, p < 0.05,$
310 $\eta p^2 = 0.32$). There were no significant two-way interactions between fatigue manipulation
311 and time point ($p = 0.32$), expectation manipulation and time point ($p = 0.54$), or fatigue
312 manipulation and expectation manipulation ($p = 0.48$) on mean SLEQ scores. There were no
313 significant main effects of fatigue manipulation ($p = 0.70$) or expectation manipulation ($p =$
314 0.15).

315 There was a significant main effect of time point ($F(1, 11) = 14.85, p < 0.05, \eta p^2 =$
316 0.57), with mean SLEQ scores significantly higher after the 12th kick ($M \pm SD = 1.43 \pm 0.34$)
317 compared with before first kick ($M \pm SD = 1.20 \pm 0.36$). After the 12th kick, mean SLEQ
318 scores were higher in the high fatigue, high expectation manipulation ($M \pm SD = 1.51 \pm$
319 0.28), compared with low fatigue, low expectation manipulation ($M \pm SD = 1.36 \pm 0.39$), low
320 fatigue, high expectation manipulation ($M \pm SD = 1.42 \pm 0.41$), and high fatigue, low
321 expectation manipulation ($M \pm SD = 1.41 \pm 0.30$).

322 ANOVAs revealed no significant three-way interaction between fatigue manipulation,
323 expectation manipulation and time point on sub-sections of Enjoyment ($p = 0.44$),
324 Nervousness ($p = 0.63$), Fulfilment ($p = 0.54$), or Anger ($p = 0.60$) within the SLEQ.

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325 There was a significant two-way interaction between expectation manipulation and
326 time point on Anger scores ($F(1, 11) = 5.74, p < 0.05, \eta p^2 = 0.34$; Figure 6), with Anger
327 scores in the high expectation manipulations higher after 12 kicks ($M \pm SD = 1.36 \pm 0.86$),
328 compared with low expectation manipulations after 12 kicks ($M \pm SD = 0.96 \pm 0.75$). There
329 was a significant main effect of time point on Anger scores ($F(1, 11) = 38.40, p < 0.05, \eta p^2 =$
330 0.78), but no significant main effect of expectation manipulation ($p = 0.17$). There were no
331 significant two-way interactions of fatigue manipulation and time point ($p = 0.15$), or fatigue
332 manipulation and expectation manipulation ($p = 0.91$) on Anger scores.

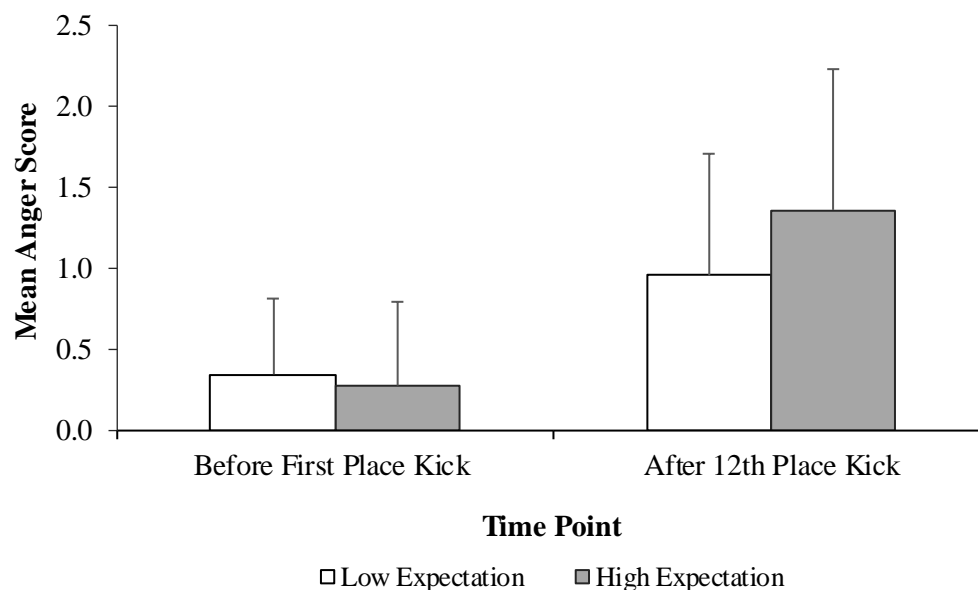


Figure 6. Mean \pm SD Anger scores (SLEQ) before the first place kick and after the 12th place kick under low and high manipulations of expectation. A significant two-way interaction between time point and expectation manipulation was present.

333 3.4. Physiological Responses

334 3.4.1. Heart Rate

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335 ANOVA revealed no significant interaction between fatigue and expectation
336 manipulations on mean heart rate ($p = 0.90$). There was a significant main effect of fatigue
337 manipulation on mean heart rate ($F(1, 6) = 41.65, p < 0.05, \eta p^2 = 0.87$), with mean heart rate
338 in high fatigue manipulations ($M \pm SD = 137 \pm 15$ bpm) higher than in low fatigue
339 manipulations ($M \pm SD = 109 \pm 11$ bpm). There was also a significant main effect of
340 expectation manipulation on mean heart rate ($F(1, 6) = 10.23, p < 0.05, \eta p^2 = 0.63$), with
341 mean heart rate in high expectation manipulations ($M \pm SD = 124 \pm 20$ bpm) higher than in
342 low expectation manipulations ($M \pm SD = 122 \pm 18$ bpm).

343 3.4.2. *Sprint Times in Fatigue Protocol*

344 ANOVA revealed there was a significant main effect of fatigue protocol repetition
345 number on mean 15 m sprint times ($F(3.59, 82.51) = 8.15, p < 0.05, \eta p^2 = 0.26$). Post hoc
346 analyses revealed that mean sprint times in repetition 12 ($M \pm SD = 2.91 \pm 0.32$ s) were
347 significantly longer than in repetition 1 ($M \pm SD = 2.72 \pm 0.15$ s; $p < 0.05$), repetition 2 ($M \pm$
348 $SD = 2.74 \pm 0.16$ s; $p < 0.05$), repetition 3 ($M \pm SD = 2.81 \pm 0.29$ s; $p < 0.05$), and repetition
349 4 ($M \pm SD = 2.80 \pm 0.28$ s; $p < 0.05$) (Figure 7).

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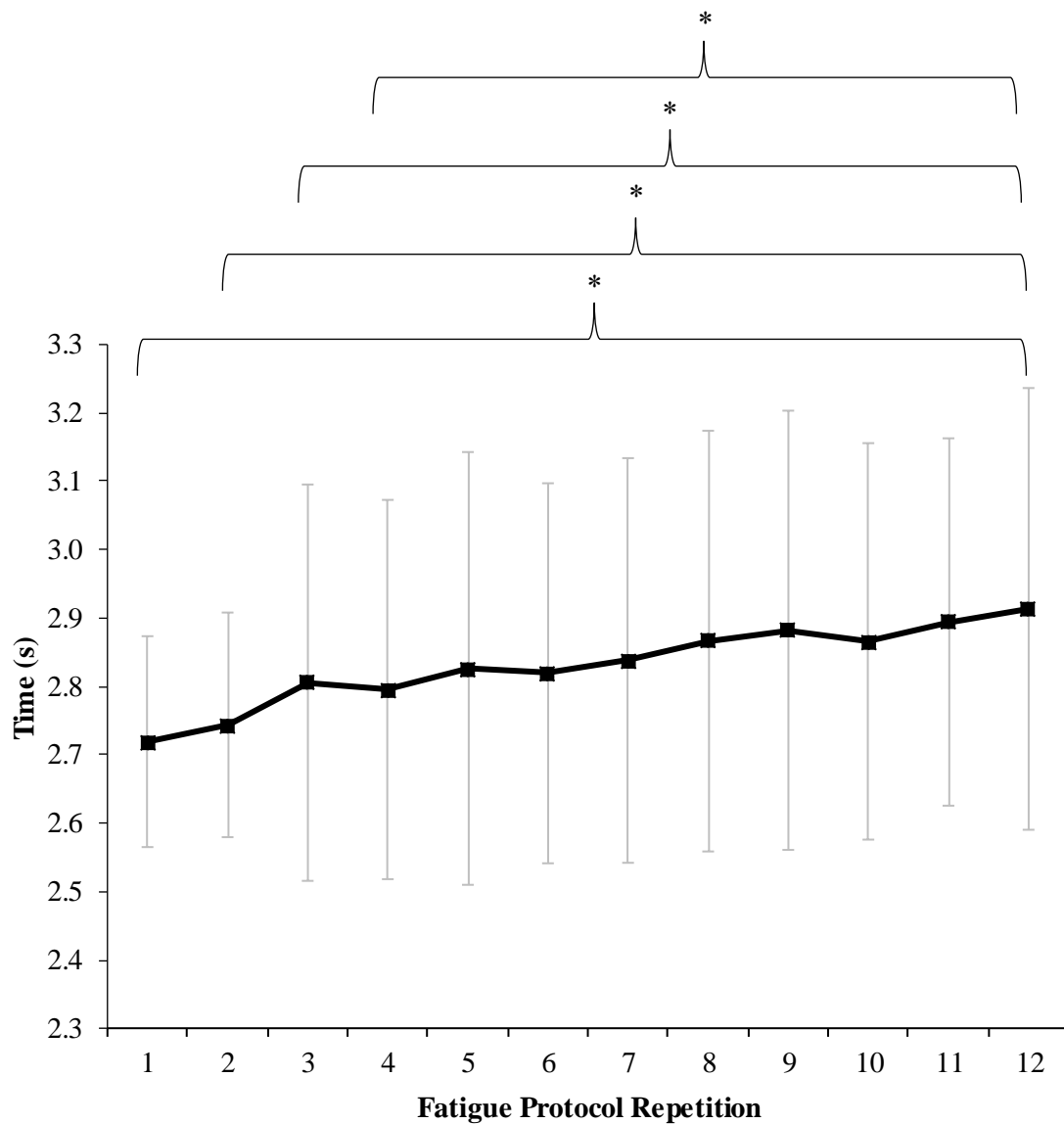


Figure 7. Mean \pm SD 15 m sprint times before each place kick within high fatigue manipulations. * indicates a significant pairwise difference ($p < 0.05$).

359 4. Discussion

360 The aim of this study was to analyse effects of specific manipulations of individual
361 constraints (fatigue; expectation for success) on place kicking performance, movement phase
362 durations, heart rate and self-reported emotions. A significant two-way interaction between
363 fatigue and expectation manipulations showed that mean success percentage was higher in

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364 the low fatigue, low expectation manipulation and the high fatigue, high expectation
365 manipulation, compared with separate manipulations of high fatigue or high expectation.
366 Results suggested that the acute fatigue protocol used in this study was effective, with
367 participants recording significantly longer 15 m sprint times in later repetitions compared
368 with the first repetition of the fatigue protocol in high fatigue manipulations. Moreover,
369 participants recorded significantly higher mean heart rate in high fatigue manipulations,
370 compared with low fatigue manipulations. There was also a significant main effect of
371 expectation on mean heart rate and a significant two-way interaction between expectation
372 manipulation and time point on Anger scores.

373 Expectation for successful performance has been associated with increased anxiety,
374 with similar manipulations to those used in this study (e.g. peer comparison; monetary
375 rewards) showing performance decrements (e.g. Runswick et al., 2018; Wilson, Vine, &
376 Wood, 2009). Mean success percentage of place kickers was lowest under low fatigue and
377 high expectation, particularly at the threshold location, which has previously been shown as a
378 pitch area where place kicking performance drops below mean success (Pocock et al., 2018).
379 However, the interaction between high expectation for success and high fatigue, and their
380 combined effects on performance, is more complex.

381 Previous research has shown that manipulating fatigue and increasing pressure using
382 expected success levels can influence additive effects of manipulations, leading to lowest
383 performance levels when fatigue and expectation are both high (e.g. Vickers & Williams,
384 2007). In contrast, the present study demonstrates that place kicking performance can be
385 maintained under high fatigue and high expectation for success, where manipulations were
386 designed to be representative of performance environments. This maintenance of
387 performance is consistent with that previously observed in military environments, where

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388 shooting accuracy was higher under high fatigue and high expectation for success, compared
389 with low fatigue and high expectation for success (Nibbeling, Oudejans, Ubink, & Daanen,
390 2014). Furthermore, Nibbeling et al. (2014) observed performance on cognitive tasks, such as
391 mathematical performance, to decline under fatigue. Unlike generic fatiguing protocols which
392 may be laboratory based or unrelated to the task, designing representative fatiguing protocols
393 which simulate demands of performance environments appear to potentially enable a
394 maintenance in performance under high fatigue and high expectation for success. Place
395 kicking with *either* high fatigue *or* high expectation decoupled the combination of high
396 fatigue and high expectation (e.g. typical performance environment) or low fatigue and low
397 expectation (e.g. typical practice environment; Pocock et al., 2020) and this was detrimental
398 to performance. These findings highlight the powerful, interactive influence that key
399 individual constraints (e.g., fatigue; expectation for success) can have on place kicking
400 performance and that their interactions should be considered when designing practice
401 environments. For example, manipulating high expectation for success without considering
402 the fatigue induced by previous passages of play may be detrimental to performance in
403 practice. Moreover, this manipulation is not representative of performance environments due
404 to the perceived unfamiliarity of kicking under pressure without the presence of any acute
405 fatigue effects, which may influence the reciprocal relationship between perception and
406 action. To maintain perception-action coupling, key constraints should be represented in
407 practice to ensure that place kickers are attuning to similar affordances (opportunities for
408 action) to those encountered in competition (Passos et al., 2008). Specialist place kicking
409 coaches are encouraged to incorporate place kicking into game situations in practice to
410 represent the combination of high fatigue and high expectation for success and to enhance
411 skill transfer to performance environments.

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412 To extend beyond the analysis of performance outcomes, timings of place kickers’
413 actions were analysed during four specific phases (preparation phase, approach phase,
414 kicking phase, follow through phase). Despite fluctuations in performance outcomes under
415 different combinations of manipulations, perhaps unsurprisingly, there were no significant
416 differences in timings of any of the four specific phases. It is therefore suggested that aspects
417 other than these temporal movement phase durations were changing to shape the fluctuating
418 performance outcomes under manipulations of fatigue and expectation. For example, changes
419 in any spatial aspects of technique during the kicking action could contribute to the
420 fluctuations in performance observed. Future research would benefit from kinematic
421 measures of the techniques of place kickers in representative environments. This type of
422 research can help to understand the movement patterns which contribute to observed
423 performance fluctuations under varying levels of fatigue and expectation of success.

424 Analyses of MRF-L (Krane, 1994) and SLEQ (Headrick et al., 2015b) results
425 revealed various changes in emotions throughout testing sessions. These changes included a
426 significant main effect for time point on mean MRF-L and SLEQ scores, which suggest that
427 emotions were heightened during and after the 12 place kicks. Within the SLEQ, which is
428 made up of four constructs (Enjoyment, Nervousness, Fulfilment, Anger), there was a
429 significant two-way interaction between expectation manipulation and time point on Anger
430 scores. Mean Anger scores were comprised of three statements: “annoyed”, “angry”, and
431 “frustrated”; and scores were significantly higher after the 12th kick in manipulations of high
432 expectation, compared with before the first kick. Most place kickers did not achieve the
433 expected target of 9/12 successful place kicks under high expectation (92% of testing
434 sessions). These findings suggest that the deliberate manipulation of a challenging target
435 influenced athlete task engagement, reflected in the reported increase in feelings of

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436 annoyance, anger and frustration. Coaches are encouraged to introduce similar manipulations,
437 or vignettes, with meaningful consequences in practice environments to allow place kickers
438 to practice under varying emotional states and learn to self-regulate when facing potential
439 emotional perturbations to performance. However, this decision is dependent on individual
440 needs and differences since more achievable performance targets relative to skill level could
441 be also used, which may increase engagement through enhanced enjoyment and fulfilment.
442 Previous research has highlighted the reduced frequency of emotions in practice
443 environments, compared with performance environments (e.g. Maloney et al., 2018). The
444 Affective Learning Design framework (Headrick et al., 2015a) advocates greater recognition
445 of emotions in practice environments to enhance athlete engagement, opportunities for self-
446 regulation, skill transfer and adaptability. Therefore, coaches are encouraged to design
447 scenarios in practice environments which simulate emotional perturbations of competitive
448 performance environments to encourage adaptability and self-regulation in place kickers.

449 Several measures were used to check that the fatigue protocol was successful. Sprint
450 times were significantly slower in later repetitions, compared with earlier repetitions and
451 mean heart rate was significantly higher in high fatigue manipulations, compared with low
452 fatigue manipulations. Interestingly, mean heart rate values were also significantly higher
453 under high expectation manipulations, compared with low expectation manipulations.
454 Increased heart rate is generally assumed to provide an indication of increased anxiety in
455 tasks with comparable levels of physical exertion (see Oudejans & Pijpers, 2009). This
456 observation suggests that manipulations of high expectation may have induced increased
457 levels of performance anxiety in participants, compared with manipulations of low
458 expectation. To further explore effects of manipulating expectation for success on place
459 kicking preparation, gaze behaviours and verbal reports of place kickers could be studied to

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460 understand effects of participant perceptions of task difficulty. The recording of physiological
461 measures such as heart rate, combined with psychological measures of emotions, provide
462 initial insights into the influence of individual constraints on place kicking. Furthermore,
463 these insights highlight the need for future interdisciplinary research to understand key
464 underpinnings of expertise when performing skills (Gobet, 2018). Within applied sport
465 performance and practice settings, Rugby Union clubs can apply the theoretical concepts of
466 ecological dynamics to guide practice designs during training, intended to prepare athletes for
467 competition (McKay et al., 2021). Clubs can use the collaborative expertise of coaches,
468 performance analysts, strength and conditioning trainers, sport psychologists, and skill
469 acquisition specialists in a department of methodology (Rothwell et al., 2020) to understand
470 the influence of key interacting task, environmental and individual constraints on place
471 kicking performance and inform representative practice design.

472 **5. Conclusion**

473 Effects of key individual constraints (fatigue; expectation for success) on place
474 kicking performance were analysed in a representative Rugby Union environment. Fatigue
475 and expectation for success had a significant interaction effect on performance outcomes,
476 with mean success percentage higher under manipulations of low fatigue, low expectation
477 and high fatigue, high expectation, compared with separate manipulations of high expectation
478 or high fatigue. However, there were no significant differences in any of the four specific
479 movement phase durations of a place kick across any manipulations.

480 Whilst there were no significant changes in reported emotions under manipulations of
481 fatigue, anger scores of place kickers increased significantly under high expectation, which
482 highlights the influence of expectation for success on emotions of place kickers. There was a

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483 significant main effect of expectation on heart rate of place kickers and it is suggested that
484 this was a potential indication of increased anxiety, whilst the significant main effect of
485 fatigue on heart rate and significant changes in sprint times were indications of an effective
486 fatiguing protocol.

487 The present study highlighted how manipulating key individual constraints of fatigue
488 and performance expectations, whilst standardising task constraints in a representative
489 practice environment, influenced mean success percentage outcomes of place kicking
490 performance. Given the influence of key individual constraints on performance in this study,
491 coaches are encouraged to design representative practice environments for place kickers
492 which simulate cognitions, emotions and fatigue experienced in performance environments.

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