1

2 **Talent development – Early specialization and critical periods in acquiring**

3 **expertise: A comparison of Traditional vs. Detection Talent Identification in**

4 **Team GB Cycling at London 2012**

5

6 Toby Staff

7 Brunel University London

8 Fernand Gobet

9 London School of Economics and Political Science

10 Andrew Parton

11 Brunel University London

12

13 Word Count: 5278

14 **Author Note**

15 Correspondence concerning this article should be addressed to Toby Staff,

16 Department of Psychology, Brunel University London, Middlesex, UB8 3PH, U.K.

17 Email: Toby.Staff@brunel.ac.uk

18

19

20

21
22
23
24
25
26
27
28
29
30
31

32
33
34
35 **Abstract**
36
37   The aim of this study was to compare two methodologies employed by the

38 British Cycling talent identification programme. Specifically, we investigated cyclists

39 selected to represent GB cycling team at the London 2012 Olympics using (a) a

40 traditional talent identification methodology (British Cycling Olympic Development

41 Programme), where selection is based upon race results and (b) a detection talent

42 identification methodology (UK Sport Talent Team Programme), which is a multi-

43 Olympic event initiative that identifies athletic potential from a range of generic,

44 physical and skill-based tests. To facilitate this comparison, we calculated the speed

45 with which expertise was acquired. A Mann-Whitney U test ($U = 16.0$, $p = 0.031$)

46 indicated that the speed of acquiring expertise was quicker in detection talent

47 identification (*Mdn.* = 5.4) than traditional talent identification (*Mdn.* = 7.2). Practice

48 started later with detection talent identification than with traditional talent

49 identification (14.12 years vs. 11.23 years, respectively), which affected the period to

50 excellence. Thus, detection talent identification resulted in an absence of early

51 specialization, which suggests a critical period for attaining cycling expertise. We

52 hypothesize a genetic basis of talent and propose that a detection talent identification

53 programme provides a better starting point of deliberate practice, traditionally a

54 weakness in calculating the period to excellence.

55

56 **Keywords:** early specialization, critical period, deliberate practice, period to
57 excellence, talent.
58
59
60

61   **Introduction**

62   Talent identification attempts to identify factors that collectively predict an

63   individual's future performance potential, selecting the best candidates for advanced

64   training. Since the late 1990s, British cycling received funding through the UK

65   National Lottery and commercial sponsorship from British Sky Broadcasting Group

66   Plc. Both funding and focused talent identification measures have contributed to a

67   considerable increase in Olympic medal success in cycling for the UK: Sydney 2000

68   (4 medals), Athens 2004 (4 medals), Beijing 2008 (14 medals), London 2012 (12

69   medals and Rio 2016 (12 medals). However, there is little available empirical data

70   directly comparing the merits of the different talent identification processes utilized.

71   We focus on two methods used for talent identification in British Cycling, *traditional*

72   and *detection*, which afforded the opportunity of directly comparing the outcomes for

73   individuals selected based on either of these two different approaches.

74   Traditional talent identification methods consist of selecting athletes who are

75   currently involved in their chosen sport (Lidor, Côté, & Hackfort, 2009) by using

76   achievement measures (e.g., race results, rankings, etc.), expert assessment of

77   performance by coaches and talent scouts within that sport. Thus, motor performance

78   is a key factor in selection and comparative levels of initial motor learning have been

79   achieved through interaction with the task. In sports, the traditional talent

80   identification methodology is the predominant pathway for identifying potential, and

81   80% of elite performers were selected using this approach in 12 major sports (English

82   Sports Council, 1998)**.**

83   An alternate approach is talent identification by detection, which measures

84   components of successful performance (e.g., power, anaerobic capacity, etc.). It is

85   possible to apply this approach to those with no history in the defined sport (Williams

86   & Reilly, 2000) and those displaying embryonic abilities with little task knowledge.

87 This approach thus potentially widens the available pool of performers to any

88 participant willing to attend testing. Furthermore, the generic tests do not require

89 expert facilities and can occur in schools, halls and clubs. Therefore, this provides the

90 potential to identify talented athletes with no prior experience and experienced late

91 developers.

92   British Cycling talent development pathway, the "Rider Route", utilizes these

93 two talent identification methodologies and provides suitable data that facilitates the

94 comparison of traditional and detection talent identification. The traditional route

95 consists of competitive opportunities resulting in cyclists positioning themselves in

96 the British Cycling Rider Route talent development pathway, which consists of

97 regional and national development centers; placement depends upon maturity and

98 experience. Selection occurs from the age of five (British Cycling, 2020), and

99 competitive results determine progression into the Olympic Development Programme

100 based on race results performance. The detection route is the Talent Team

101 Programme, a multi-Olympic event initiative by UK Sport and coordinated by each

102 governing body (in this case, British Cycling) that identifies athletic potential from a

103 range of generic physical and skill-based tests. Identification occurs by testing

104 candidates between the ages of 11 to 16 years in schools or performance centers.

105 Testing ethics stipulates that the age of 11 years is the earliest testing age (British

106 Cycling, 2020). The selection consists of physiological performance on a Wattbike

107 (turbo trainer), with measures such as power output and peak cadence assessed. Upon

108 selection, cyclists join the Rider Route in preparation for membership of the Great

109 Britain Cycling Team. Apart from age and experience-related differences, the process

110 of motor development for both groups follows a similar path (British Cycling, 2020).

111   The two different selection processes mirror, in part, the theoretical debate in

112 which researchers focus on the importance of practice (Ericsson, Krampe, & Tesch-

113   Römer, 1993; Ericsson, Prietula, & Cokely, 2007; Helsen, Starkes, & Hodges, 1998;

114   Helsen, Hodges, Van Winckel, & Starkes, 2000; Law, Côté, & Ericsson, 2007) or

115   talent (Hambrick, Burgoyne, Macnamara, & Ullén, 2018; Lombardo & Deaner, 2014;

116   Staff, Gobet, & Parton, 2020) in achieving expertise. Those researchers who

117   emphasize the importance of practice largely deemphasize the role of talent. Ericsson

118   et al. (1993) stated that, for children, early practice is significant and must coincide

119   with biological and cognitive development. Furthermore, early specialization is

120   relevant in children, as later starters would not be able to "catch up" (Ericsson et al.,

121   2007). However, there is still a considerable debate as to the impact of early practice

122   to expertise (Baker, Joseph, Cobley, & Fraser-Thomas, 2009; Crisp, 2019; DiFiori et

123   al., 2017; Yustres et al., 2019) and negative outcomes have been reported, including

124   its potential to reduce overall motor skill development (Myer et al., 2016) and its

125   influence in facilitating burnout and injury (Malina, 2010).

126   By contrast, researchers who argue for a contribution from innate talent in

127   acquiring expertise highlight the importance of critical periods (Chassy & Gobet,

128   2010; Tucker & Collins, 2012), which are hypothesized to rely upon genetic

129   programming (Viru et al., 1999). Such talents result in accelerating expertise

130   (Lombardo & Deaner, 2014) and providing an opportunity for early diversification

131   (Staff et al., 2020) that can lead to a growth in motor development (Myer et al., 2016).

132   Researchers investigating elite performers have focused on developmental

133   history and talent identification programmes for an explanation of individual

134   differences (Ford & Williams, 2012; Güllich & Emrich, 2014; Güllich, 2014; Güllich,

135   2017), although direct comparisons between elite performers having followed these

136   two routes have been infrequent (Barth, Emrich, & Güllich, 2019). To compare both

137   selection methods, we utilized methodologies developed to assess the Deliberate

138   Practice hypothesis (Ericsson et al., 1993) and in particular applied its definition of

139 the start of practice and the attainment of expertise. This enabled us to calculate a

140 chronological measure for expert achievement. We termed this the "period to

141 excellence", which consisted of practice and recovery periods associated with

142 developmental expertise (Bompa & Carrera, 2005; Gibala, MacDougall, Tarnopolsky,

143 Stauber, & Elorriaga, 1995). These recovery periods are important in reducing

144 overtraining and injury as well as allowing other life activities (Grandou, Wallace,

145 Impellizzeri, Allen, & Coutts, 2020) and do not include practice that mitigate burnout

146 (Lopes & Vallerand, 2020).

147   To quantify the effectiveness of these talent identification methods in selecting

148 potential elite performers, we compared how quickly cyclists acquired expertise (elite

149 proficiency), operationalized as their period to excellence. We anticipated that a

150 natural talent selection process, which focused on the specific task demands, would

151 lend itself to the quicker acquisition of expertise. Our hypothesis is that those

152 individuals selected by detection talent identification would develop faster than those

153 selected using traditional talent identification.

154   **Method**

155 **Participants**

156   The study includes data on all 27 cyclists (12 women and 15 men) selected for

157 Team GB in the London 2012 Olympics. Cyclists were aged 17 to 34 years (Men: M

158 $= 20.36$, $SD = 1.23$; Women: $M = 21.23$, $SD = 4.62$) when they achieved expertise.

159 The starting point of deliberate practice ranged from 5.00 to 27.02 years of age. The

160 cyclists were divided into two talent identification groups: detection talent

161 identification ($n = 9$) and traditional talent identification ($n = 18$). A comparison of

162 medals awarded shows that athletes selected by detection talent identification gained

163 three individual medals and five team medals and that athletes selected by traditional

164 talent identification gained five individual medals and five team medals.

165 **Data Collection**
166
167   We identified all Team GB cyclists selected for the London 2012 Olympics

168 and collected their date of birth as well as the starting and finishing points of

169 deliberate practice. The following sources were used. First, the British Cycling

170 (n.d.) website contained riders' biographies and provided many basic data points such

171 as age and cycling history. Second, public domain biographical information was

172 obtained from Internet sources, local newspaper reports, cycling magazines and social

173 media, with particular focus on the cyclists' initiation of deliberate practice. Finally,

174 the British cycling website provided a list of athletes' agents and representatives, who

175 were contacted with the following questions regarding the athlete they represented:

176 (a) When did you start to focus on your sport? (b) At what age were you first coached

177 for your sport? and (c) Did you train at any other sport prior to you focusing on your

178 main sport? If yes, which sport(s)?

179 **Measures**
180
181   We utilized the parameters used by the deliberate practice framework

182 (Ericsson et al., 1993) to calculate cyclists' period to excellence, which was defined as

183 the difference between the starting point of formal training (defined as joining a club

184 and/or obtaining regular coaching) and the first selection in a senior international

185 competition (either the Commonwealth games, European championships, World Cup

186 or the Olympic games).

187   To estimate when cyclists first joined the British cycling talent identification

188 programme, we used the publicly available information on the British cycling website

189 and/or athletes' personal websites. Cyclists' talent identification selections were

190 divided into traditional and detection. Traditional talent identification cyclists were

191 selected based on competitive results and were placed in the Riders Route at a stage

192 that was consummate with their performance and experience. Detection talent

193 identification cyclists were selected based on threshold measures, usually through

194 testing days in the school environment; these athletes had no formal competitive

195 experience. Upon selection, they entered the Olympic talent team programme, the

196 initial stage of the Riders Route.

197 **Results**

198
199   Tables 1, 2 and 3 show the means for traditional and detection talent

200 identification. Table 1 displays the results for the period to excellence, Table 2 for

201 starting age, and Table 3 for expertise age.

202
203 *Table 1*. Period to excellence for traditional and detection methods

		Period to excellence			
Talent identification method	N	Mean	SD	Minimum	Maximum
Traditional	18	9.94	5.55	5.00	27.02
Detection	9	5.79	2.32	3.24	9.86

204
205
206 *Table 2*. Starting age for traditional and detection methods

		Starting age			
Talent identification method	N	Mean	SD	Minimum	Maximum
Traditional	18	11.23	5.55	5.00	27.02
Detection	9	14.12	1.45	11.01	16.01

207
208
209 *Table 3*. Expertise age for traditional and detection methods

		Expertise age			
Talent identification method	N	Mean	SD	Minimum	Maximum
Traditional	18	21.17	3.75	16.71	33.70
Detection	9	19.91	1.24	18.25	22.87

210
211
212
213 **Period to Excellence as a function of Starting Age**

214   A linear regression was computed with starting age as predictor and period to

215 excellence as criterion variable. The regression equation was: period to excellence =

216   15.250 – (.549 × starting age); $p < .001$; adjusted $r^2 = .541$. Thus, each additional

217   starting year *reduced* period of excellent by about half a year. After removing two

218   athletes who started after 20 years of age (20 years and 27 years, respectively), the

219   equation becomes: period to excellence = 19.250 – (.937 × starting age); $p < .001$;

220   adjusted $r^2 = .821$. The later start resulted in faster expertise and each additional

221   starting year now reduces period of excellent by nearly one entire year. Inserting the

222   relevant mean starting age (respectively, 11.23 years and 14.12 years) in the

223   regression equation yields a predicted period to excellence of 8.73 years for

224   traditional talent identification and 6.02 years for detection talent identification.

225

226   **Starting and Expertise Age as a function of talent identification pathway**

227   Shapiro-Wilk test of normality indicated that the data violated the assumptions

228   of normality: Period to excellence, $W = 0.926$, $p = 0.054$; Start Age, $W = 0.854$, $p <$

229   0.001; End Age, $W = 0.739$, $p < .001$. A Mann-Whitney U test was conducted to

230   compare the starting age and expertise age for detection ($n = 9$) and traditional talent

231   ($n = 18$) identification selection processes. Results indicated that there was a

232   significant difference for starting age ($U = 37.0$, $p = 0.025$) between detection talent

233   identification (*Mdn.* = 14.01) and traditional talent identification (*Mdn.* = 10.51) but

234   there was no statistically significant difference with respect to expertise age *(p =*

235   *0.348)*.

236

237   **Period to Excellence as a function of talent identification pathway**
238
239   We hypothesized that the speed of expertise achieved in British Cycling talent

240   identification was quicker with detection when compared with traditional methods. To

241   attain an equitable comparison of the different talent identification methodologies, we

242   removed all data from the traditional talent identification group with a starting age of

243   less than eleven, which is the minimum age that athletes enter the training programme

244   based on talent identification. A Mann-Whitney U test indicated that the period to

245   excellence was quicker in detection talent identification (*Mdn.* = 5.4, *n* = 9) than

246   traditional talent identification (*Mdn.* = 7.2, *n* = 9), U =16.0, p = 0.031.

247   All nine cyclists (100%) selected using detection talent identification and ten

248   traditional talent identification cyclists (56%) reached elite level in under 10-years. A

249   single sample t-test was conducted to determine if there was a statistically significant

250   overall difference between the observed period to excellence and the ten-year period

251   of deliberate practice predicted by Ericsson et al. (1993) . The period to excellence

252   for the entire sample (*M* = 8.55 years, *SD* = 3.50 years) was statistically significantly

253   lower than 10 years, t (26) = -2.15, p = .041.

254   **Discussion**

255   This paper tested the hypothesis that the time required to become an expert

256   cyclist varies depending on the type of talent identification methodology (traditional

257   or detection) used for the initial selection. We used data from the cyclists

258   representing Team GB in Cycling at London 2012 Olympics selected by the British

259   Cycling talent identification programme. We predicted that those cyclists selected by

260   the detection talent identification route would develop to expertise quicker (shorter

261   period to excellence) than those chosen using the traditional talent identification route.

262   The results show that the median period to excellence of British Cyclists

263   representing Team GB at London 2012 was significantly quicker when selection was

264   made by detection talent identification (*Mdn.* = 5.4 yrs.) than traditional talent

265   identification (*Mdn.* = 7.2 yrs.). This result indicates that the introduction of detection

266   measures in the Talent Team Programme by UK Sport has resulted in Cyclists

267   acquiring elite expertise faster than traditional talent identification methods. We

268   therefore postulate that faster motor learning and development may be a consequence

269   of attendant talent and an interaction with starting age, individual differences and

270   talent identification methodology. This result is inconsistent with previous claims that

271   the journey to expertise is 10 years (Ericsson et al., 1993) and concurs with previous

272   sport research such as sprinting plus track and field (Lombardo & Deaner, 2014; Staff

273   et al., 2020) indicating that the average mean period to excellence was less than 10

274   years, which suggests that talent contributes to performance.

275   **Starting Age**

276

277   When comparing talent identification methodologies in cycling using the

278   period to excellence measures, the difference between detection talent identification

279   (M = 5.79 yrs., n = 9) and traditional talent identification (M = 9.94 yrs., n = 18)

280   resulted in a 4.15-years acceleration of expertise. The 4.15-years acceleration in the

281   speed of expertise for detection talent identification is calculated by a later starting

282   age and the faster motor development period. The later starting age accounted for 2.89

283   years = (14.12 – 11.23) (see Table 2). These results question the necessity of early

284   practice in acquiring expertise, which for becoming an Olympic medalist has been

285   claimed to be significant (Ericsson et al., 1993; Ericsson et al., 2007).

286   A Mann Whitney U test also indicated a significant difference between start

287   age for detection (*Mdn.* = 14.01 yrs.) and traditional (*Mdn.* = 10.51 yrs.) talent

288   identification. The ethics that guide the minimum physiological testing age in children

289   led us to anticipate a considerable contribution from the starting age in the overall

290   acceleration of expertise. This research identifies eleven years as the earliest testing

291   age for detection talent identification in British Cycling but accepts children as young

292   as five into their traditional talent identification program (British Cycling, 2020). The

293   six-year difference between these two talent identification methods potentially results

294   in detection cyclists having a greater diversification on skills which can have a

295   positive effect of skill acquisition (Güllich, 2014; Güllich, 2017; Staff et al., 2020;

296 Vaeyens, Güllich, Warr, & Philippaerts, 2009). Conversely, traditional cyclists have

297 specialized in their sport from an early age. Our results indicate that this was not

298 advantageous, which agrees with research across multiple sports (Baker et al., 2009;

299 Crisp, 2019; DiFiori et al., 2017; Yustres et al., 2019).

300   A comparison of cyclists from both talent identification methods with similar

301 starting dates indicated a significant difference between the period to excellence in

302 detection talent identification (*Mdn.* = 5.4) when compared with traditional talent

303 identification (*Mdn.* = 7.2). Thus, a later engagement in the development of expertise

304 resulted in faster skill acquisition, which supports the idea of critical periods in which

305 individuals are likely to make an above normal response to exercise (Armstrong,

306 Williams, Balding, Gentle, & Kirby, 1991; Baxter-Jones, 1995; Malina, 1994; Malina,

307 Eisenmann, Cumming, Ribeiro, & Aroso, 2004). This concept is hypothesized to be

308 reliant upon genetic programming (Viru et al., 1999) and suggests that developmental

309 factors should align with task demands to facilitate skill acquisition (Armstrong,

310 Williams, Balding, Gentle, & Kirby, 1991; Baxter-Jones, 1995; Malina, 1994; Malina,

311 Eisenmann, Cumming, Ribeiro, & Aroso, 2004). This research suggests that the

312 critical period for cycling detection talent identification is 11 to 16 years.

313   Therefore, we believe that a later starting age will be a consistent feature of

314 research using physiological measures and that critical periods should be a feature of

315 talent identification processes throughout sports. For example, a critical period of six

316 years (11 to 16 years) for detection results in a more focused approach to talent

317 identification when compared with the broad range of 22 years (5 to 27 years) of

318 traditional talent identification, considerably narrowing the target field for selection.

319 **Expert Age**
320
321   Those participants selected by detection talent identification resulted in

322 acquiring expertise 1.26 years (i.e., 21.17 – 19.91) quicker (see Table 3). Our results

323   indicated that the period to excellence was significantly quicker for the detection

324   cyclists. Therefore, the concept of critical periods (Viru et al., 1999) leads us to

325   speculate that the synergy between talent and developmental factors which facilitated

326   the later starting date and the specialized training also brought about enhanced

327   opportunities for the further development of expertise (Svetlov, 1972). Although this

328   research indicates acceleration in expertise, this does not necessarily occur at a

329   uniform rate across the acquisition period (Scott, 1986).

330

331   **Genetics and Individual Differences**

332

333   British cycling utilizes measures of power output and anaerobic capacity

334   within detection talent identification, considering these factors important for cyclists

335   progressing faster in sport. An often-cited definition of talent states that it has "its

336   origin in genetically transmitted structures" (Howe, Davidson, & Sloboda, 1998, p.

337   406) . Some researchers state that "the potential impact of genetics could be great, and

338   thus further research in this area is warranted, in particular in relation to specific

339   performance genes, training/learning genes and genes underpinning injury proneness"

340   (Rees et al., 2016, p. 1044). Associations between component abilities and

341   performance have been identified by genetics research, which has shown that a

342   positive genetic profiling benefits performance. The ACE gene (Angiotensin-

343   converting enzyme) has been associated with positive cardiovascular system and

344   skeletal muscle adaptations (Montgomery et al., 1998; Yang et al., 2003). The

345   ACTN3 gene (Alpha-actinin skeletal muscle isoform 3) has been found to be

346   beneficial in elite power and sprint athletes (Chan et al., 2008; Yang et al., 2003) and

347   the CKM gene (Creatine Kinase Muscle) has been associated with the response to

348   training of VO_2max (Pennington Biomedical Research Centre, 2013). Although the

349   current research suggests that detection talent identification leads to acceleration in

350 acquiring expertise, it does not suggest that it is talent alone that determines the period

351 to expertise. Research that specifically identifies the genetic determinants of expert

352 performance is still very much in its infancy (see Ahmetov & Fedotovskaya, (2012) .

353 In addition, it is likely that expert performance will be a result of a combination of

354 genes rather than a single gene variant.

355   Indeed, the explanation of critical periods in acquiring motor expertise relies

356 upon genetic programming for the appearance of new events such as growth,

357 maturation and development (Viru et al., 1999). We speculate that innate individual

358 differences can lead to variability in the period to excellence. Our results indicate the

359 implementation of the Talent Team Programme by UK Sport as applied to British

360 Cycling affects the speed of motor learning and development, we suggest it is utilized

361 across multiple sports (see also https://www.uksport.gov.uk/our-work/talent-

362 id/previous-campaigns).

363
364 **Selection of talent identification measures**
365
366   Traditional talent identification occurs by choosing high performing children

367 with the expectation that their motor learning and development will lead to the same

368 comparative expertise as adults. As sports developed, talent identification

369 practitioners evolved their approach. Coaches deconstructed expertise into

370 information processing components (Schneider & Shiffrin, 1977; Shiffrin &

371 Schneider, 1977), reassembling into the complete performance (Griffin, n.d.; Lydiard

372 & Gilmour, 2000). Tests involving subcomponents of cycling are identified as

373 significant contributors to performance (Paton & Hopkins, 2001; Wattbike, 2010).

374 However, it is likely that contributions from other factors such as anthropometric

375 measures (Foley, Bird, & White, 1989) and genes not associated with these measures,

376 (Davids & Baker, 2007) influence these results.

377   Thus, the measuring of subcomponents broadens the number of potential

378 cyclists at the sampling period of 11 to 16 years of age, offering the opportunity to all

379 within that age group to try-out. Selection by the appropriate genetic profile provides

380 the opportunity for selection from other sports with a genetic profile akin to cycling.

381 The qualitative analyses of the two track endurance gold medalists selected by these

382 measures agree with this suggestion; both had keen interests in athletics and

383 swimming before being tested in cycling. These results conflict with the idea that

384 expertise is associated solely with practice (Ericsson et al., 1993) and agree with the

385 hypothesis that innate ability contributes to expertise (Hambrick et al., 2018). Indeed,

386 innate ability can accelerate expertise and is identifiable by specific talent

387 identification methods.

388   It seems you might also consider how the different talent ID method may

389 broaden the net at different sampling periods such that it identifies people with the

390 appropriate genetic profile and potential for cycling but who for whatever reason may

391 have been interested in a different sport and/or just did not realize that cycling fit their

392 body type, etc.

393 **Period to Excellence**
394
395   Theorists who do not subscribe to a single factor hypothesis to explain

396 expertise – the practice vs. talent dichotomy – endorse a multi-component explanation

397 to expertise (Ackerman, 2014; Gobet, 2015). We suggest that our measure of the

398 period to excellence offers a more holistic approach to identifying the time applied to

399 acquiring expertise, as this not only includes practice but also recovery periods, which

400 allows for physiological adaptations. Therefore, given the same level of expertise, it

401 would be expected that times for the period to excellence would exceed deliberate

402 practice.

403   There are pitfalls in determining the starting point of deliberate practice and

404   correspondingly our measures, which we utilized to ascertain our period to excellence

405   measure. This is highlighted in our data by the responses from the most decorated GB

406   Olympic cyclist to the following questions:

407   When did you start to focus on your sport?

408   Response: 17.

409   At what age were you first coached for your sport?

410   Response: 24.

411   Ericsson et al. (1993) suggest that the starting point can be identified by either

412   of these questions; yet the 7-year variation in this response highlights the difficulty in

413   obtaining the actual starting point of deliberate practice. As a result, we took the most

414   cautious approach by using the date the athlete first focused on their sport.

415   In addition, in the achievement of expertise we have selected the first senior

416   international competition. Some athletes make the transition from junior to senior

417   competition seamlessly and therefore the junior achievement date would seem to be

418   applicable. We consider that, due to the importance of physiological capabilities in the

419   cycling task, it would be prudent to choose the senior, or later attainment measure.

420   There are also operational differences between the calculation of the deliberate

421   practice period (Ericsson et al., 1993) and period to excellence. This is largely brought

422   about by the different domains of research, e.g., violinists and cyclists. Deliberate

423   practice is defined as effortful activities designed to optimize improvement; it can be

424   intermittent and is a measure of practice activities only. Our measure, the period to

425   excellence takes into account practice, injury and physiological adaptation that require

426   rest (Rivera-Brown & Frontera, 2012). Ericsson recently added to the deliberate

427   practice hypothesis by stating that "the most important point is that high-intensity

428   physical activity can only be maintained for a short period and thus its effectiveness

429   for stimulating change and improvement of performance cannot be measured by its

430   duration" (Ericsson, 2020, p. 170). Conversely, we contend that bringing about

431   positive improvements in motor development are important and that high intensity

432   physical activity in combination with rest contributes to expertise in cycling; for

433   examples isometrics (Kordi et al., 2020), weight training (Tiberiu et al., 2020) and

434   oxygen uptake (Paton & Hopkins, 2001) and should not be dismissed.

435   In order to attain cycling expertise, research suggests that maximal and

436   submaximal physiological performance need to be achieved (Mujika & Padilla, 2001).

437   To realize these physiological milestones, it is possible to apply a "power law"

438   (Newell & Rosenbloom, 1981), equating the amount of time in acquiring expertise

439   (the period to excellence) with physiological performance. Thus, the greater time

440   applied equated to larger physiological gains. Indeed, cycling research indicates that

441   the levels of aerobic fitness and off-road cycling performance were significantly

442   associated (Impellizzeri, Rampinini, Sassi, Mognoni, & Marcora, 2005).

443   **Deliberate practice**
444
445   Although it may not seem immediately clear as to why research into music

446   expertise should be used in sport, it is evident from the popularity of the deliberate

447   practice framework in sports research that many researchers have taken the intention

448   of Ericsson et al.'s (1993) paper to refer to expertise in general. Furthermore, in that

449   paper the section in the literature review "Distinct Physical Characteristics of Elite

450   Performers" (Ericsson et al., 1993, p. 394) largely focuses on the physiological

451   adaptation that become apparent as sport expertise is attained – heart, lungs, bones

452   and muscles including the quantity of fast and slow twitch fibres. Therefore, it is not

453   surprising that it has consistently been applied to sport (for examples see, Baker, J.,

454   Côté, & Deakin, 2005; Helsen et al., 1998; Helsen et al., 2000; Hodges, Kerr, Starkes,

455 & Weir, 2004; Lombardo & Deaner, 2014; Ward, P., Hodges, N.J., Williams, A.M. &

456 Starkes, J., 2007).

457   The deliberate practice hypothesis largely claims that talent (except height and

458 weight in some sports, and the ability to engage in long durations of deliberate

459 practice) does not contribute to the speed of acquiring expertise and that a minimum

460 of 10 years of motivated practice is required to acquire expertise (Ericsson et al.,

461 1993). The current research suggests a different hypothesis: it takes less than 10 years

462 to achieve expertise, with disparities being a function of individual differences, in part

463 related to talent (Lombardo & Deaner, 2014; Staff et al., 2020) but also associated

464 with sport selection (Baker et al., 2005; Helsen et al., 1998).

465 **Medalists**
466
467   At the London Olympics, twenty-seven GB cyclists were selected across

468 events that included track sprint and endurance, time trials, road race, BMX and

469 mountain bike. The details of the medals awarded are listed in table 4. Eighteen were

470 selected from the traditional group, of whom seven won medals consisting of eight

471 gold and two bronze medals in of track and time trials only. British Cycling did not

472 win a medal on either the road race, BMX or mountain biking.

473

474 *Table 4.* Talent identification and its contribution to the Cycling medal total at
475 London 2012 Olympics.

	Quantity of Events		Medal (Gold-Silver-Bronze)	
Event	Traditional	Detection	Traditional	Detection
Track Sprint	3	5	2-0-0	4-1-0
Track Endurance	7	4	5-0-1	3-0-0
Road Time Trial	3	1	1-0-1	0-0-0
Road Race	4	1	0-0-0	0-1-0
BMX	2	0	0-0-0	0-0-0

Mountain	2	0	0-0-0	0-0-0
Total	21	11	8-0-2	7-2-0

476

477   The detection group consisted of nine of participants, of whom two had no

478 prior experience, and seven had some cycling experience. These participants were

479 selected to compete in track sprint, endurance and road race events. They won 45% of

480 Team GB Cycling medals at London Olympics 2012 (see Table 4). The two

481 inexperienced cyclists both won track team pursuit Gold Medals. Five with

482 experience won five golds and two silvers in track and road race events; two cyclists

483 did not win any medal.

484

485   At the 2012 London Olympics traditional talent identification follows the

486 historical convention of selection since the first Modern Olympic Games in 1896,

487 approximately 116 years ago. Conversely, we estimate detection identification has

488 been taking place for at only about 12 years. The medal haul for talent identification

489 method in London was yielded ten medals for traditional talent identification and nine

490 detection talent identification. Thus, it would seem detection talent identification has a

491 future in selecting our next Cycling Olympians.

492 **Limitations**
493
494   Our sample size was relatively small, which might result in skepticism with

495 respect to the generalization of the results into other fields. However, it should be

496 noted that it is normally accepted that sample size is context-dependent (Lenth, 2001)

497 and our statistical tests were suited to small populations (Field, 2009). While not

498 perfect, our methodology is recommended in hard-to-reach populations such as elite

499 athletes (Staff et al., 2020). We attempted to mitigate this by using online data

500 collection methods, which are considered at least as good as in-person data (Casler,

501 Bickel, & Hackett, 2013; Gosling, Gaddis, & Vazire, 2007; Vazire & Gosling, 2004).

502   The current research provides an important comparison between talent

503 identification methodologies within British Cycling. We are somewhat surprised that

504 such comparisons are not published or are not the norm in performance overviews and

505 the assessment of resource efficiency. Is there an expectation that detection will

506 produce expertise and the comparison with traditional methods is unproductive?

507 Researchers have suggested that talent identification consists of highly rationalized

508 myths rather than highly efficient norms (Barth et al., 2019); we suggest that the lack

509 of such research is a good example of this attitude.

510 **Summary and Conclusions**
511
512
513   What are the implications for resources utilized in developing methods that

514 contribute to the acceleration of expertise? The objective of talent identification is to

515 assess athletes, identify potential for senior elite performance and recruit them into

516 sport-specific programmes. Once athletes are selected, the financial imperative is to

517 ensure that all practical means are used to accelerate the acquisition of expertise. This

518 involves optimizing coaching, competitive opportunities, medical and scientific

519 interventions (Vaeyens, Güllich, Warr, & Philippaerts, 2009) . The detection

520 methodology has a number of benefits for talent identification: (a) increasing the pool

521 of athletes suitable for potential Olympic selection, potentially leading to greater

522 competition for places and higher performance standards; (b) increasing the efficiency

523 in the allocation of resources brought about by faster skill acquisition; (c) providing

524 information on associations between genetic factors and likely performance

525 outcomes; and (d) introducing a wider range of potential participants to Olympic

526 sports. UK Sport has utilized this methodology across other Olympic sports

527 (https://www.uksport.gov.uk/our-work/talent-id). Further research would be required

528 to determine if these results could be generalized across all sporting domains.

529   This research has shown that the speed of acquiring elite performance utilizing

530 detection talent identification was superior when compared to traditional talent

531 identification and proposes a methodology that associates individual differences with

532 the speed of acquiring expertise. These results indicate that detection talent

533 identification is a quicker route to develop expertise and supports the introduction of

534 the Talent Team Programme introduced by UK Sport as a precursor to individual

535 Olympic Sports talent identification programmes. It questions the assumption that

536 early learning is necessary for acquiring expertise and supports the hypothesis that

537 both critical periods and therefore genetic factors align with tasks, contributing to

538 accelerating the acquisition of expertise in sports. Innate talent is a rare commodity in

539 motor learning and development, and to ignore athletes' genetic potential in talent

540 identification is not rational. It is hoped this paper will promote debate into a more

541 rounded understanding of factors that contribute to the acceleration of expertise.

542

543

544   References

545 Ackerman, P. L. (2014). Nonsense, common sense, and science of expert

546   performance: Talent and individual differences. *Intelligence, 45*, 6-17.

547   doi:10.1016/j.intell.2013.04.009

548 Armstrong, N., Williams, J., Balding, J., Gentle, P., & Kirby, B. (1991). The peak

549   oxygen uptake of British children with reference to age, sex and sexual

550   maturity. *European Journal of Applied Physiology and Occupational*

551   *Physiology, 62*(5), 369-375.

552   Baker, J., Côté, J., & Deakin, J. (2005). Expertise in ultra-endurance triathletes

553   early sport involvement, training structure, and the theory of deliberate

554   practice. *Journal of Applied Sport Psychology, 17*(1), 64-78.

555   Baker, J., Cobley, S., & Fraser-Thomas, J. (2009). What do we know about early

556   sport specialization? Not much! *High Ability Studies, 20*(1), 77-89.

557   Barth, M., Emrich, E., & Güllich, A. (2019). A machine learning approach to

558   "revisit" specialization and sampling in institutionalized practice. *SAGE Open,*

559   *9*(2), 2158244019840554.

560   Baxter-Jones, A. D. (1995). Growth and development of young athletes. should

561   competition levels be age related? *Sports Medicine, 20*(2), 59.

562   Bompa, T. O., & Carrera, M. (2005). *Periodization training for sports* (2nd ed.).

563   Leeds: Human Kinetics.

564   British Cycling. (2020). *British cycling handbook 2020* (2020th ed.)

565   British Cycling. (n.d.). *Rider biographies.* Retrieved 07/09, 2013, from

566   http://www.britishcycling.org.uk/gbcyclingteam/article/Gbrst_Great-

567   Britain-Cycling-Team-Olympic-Programmes

568   Casler, K., Bickel, L., & Hackett, E. (2013). Separate but equal? A comparison of

569   participants and data gathered via amazon's MTurk, social media, and face-

570   to-face behavioral testing. *Computers in Human Behavior, 29*(6), 2156.

571   Chassy, P., & Gobet, F. (2010). Speed of expertise acquisition depends upon

572   inherited factors. *Talent Development and Excellence, 2*(1), 17-27.

573   Crisp, P. (2019). Sidestepping talent ID models: Avoiding early specialisation,

574   maintaining participation, and focusing on the participant as an athlete.

575   *Journal of Sport and Games, 1*(4), 16-21.

576   Davids, K., & Baker, J. (2007). *Genes, environment and sport performance: Why the*

577   *nature-nurture dualism is no longer relevant*. New Zealand: Adis

578   International.

579   DiFiori, J. P., Brenner, J. S., Comstock, D., Côté, J., Güllich, A., Hainline, B., et al.

580   (2017). Debunking early single sport specialisation and reshaping the youth

581   sport experience: An NBA perspective. *British Journal of Sports Medicine,*

582   English Sports Council. (1998). *The development of sporting talent 1997: An*

583   *examination of the current practices for talent development in English sport,*

584   English Sports Council.

585   Ericsson, K. A. (2020). Towards a science of the acquisition of expert

586   performance in sports: Clarifying the differences between deliberate

587   practice and other types of practice. *Journal of Sports Sciences, 38*(2), 159-

588   176.

589   Ericsson, K. A., Krampe, R. T., & Tesch- Römer. (1993). The role of deliberate

590   practice in the acquisition of expert performance. *Psychological Review, 100*,

591   363-406.

592   Ericsson, K. A., Prietula, M. J., & Cokely, E. T. (2007). *The making of an expert.*

593   United States.: Harvard Business School Press.

594   Field, A. P. (2009). *Discovering statistics using SPSS: And sex and drugs and rock 'n'*

595   *roll.* London: SAGE.

596   Foley, J. P., Bird, S. R., & White, J. A. (1989). Anthropometric comparison of

597   cyclists from different events. *British Journal of Sports Medicine, 23*(1), 30-

598   33.

599   Ford, P. R., & Williams, A. M. (2012). The developmental activities engaged in by

600   elite youth soccer players who progressed to professional status compared

601   to those who did not. *Psychology of Sport and Exercise, 13*, 349-352.

602   Gibala, M. J., MacDougall, J. D., Tarnopolsky, M. A., Stauber, W. T., & Elorriaga, A.

603   (1995). Changes in human skeletal muscle ultrastructure and force

604   production after acute resistance exercise. *Journal of Applied Physiology,*

605   *78*(2), 702-708.

606   Gobet, F. (2015). *Understanding expertise: A multidisciplinary approach.* . London:

607   Palgrave.

608   Gosling, S. D., Gaddis, S., & Vazire, S. (2007). Personality impressions based on

609   facebook profiles. *International Conference on Weblogs and Social Media,*

610   Boulder, Colorado, USA.

611   Grandou, C., Wallace, L., Impellizzeri, F. M., Allen, N. G., & Coutts, A. J. (2020).

612   Overtraining in resistance exercise: An exploratory systematic review and

613   methodological appraisal of the literature. *Sports Medicine, 50*(4), 815-828.

614   Griffin, G. :. (n.d.). *Core skills for*

615   *hockey.*http://www.whitfordhockey.asn.au/cms/wp-

616   content/uploads/2012/02/hockey-core-skills.pdf

617   Güllich, A. (2014). Many roads lead to Rome - developmental paths to Olympic

618   gold in men's field hockey. *European Journal of Sport Science, 14*(8), 763-771.

619   Güllich, A. (2017). International medallists' and non-medallists' developmental

620   sport activities - a matched-pairs analysis. *Journal of Sports Sciences, 35*(23),

621   2281-2288.

622   Güllich, A., & Emrich, E. (2014). Considering long-term sustainability in the

623   development of world class success. *European Journal of Sport Science, 14*

624   *Suppl 1*(sup1), S383-S397.

625   Hambrick, D. Z., Burgoyne, A. P., Macnamara, B. N., & Ullén, F. (2018). Toward a

626   multifactorial model of expertise: Beyond born versus made. *Annals of the*

627   *New York Academy of Sciences, 1423*(1), 284-295.

628   Helsen, W. F., Hodges, N. J., Van Winckel, J., & Starkes, J. L. (2000). The roles of

629   talent, physical precocity and practice in the development of soccer

630   expertise. *Journal of Sports Sciences, 18*(9), 727-736.

631   Helsen, W. F., Starkes, J. L., & Hodges, N. J. (1998). Team sports and the theory of

632   deliberate practice. *Journal of Sport and Exercise Psychology., 20*(1), 12-34.

633   Hodges, N. J., Kerr, T., Starkes, J. L., & Weir, P. L. &. N., A. (2004). Predicting

634   performance times from deliberate practice hours for triathletes and

635   swimmers: What, when and where is practice important. *Journal of*

636   *Experimental Psychology: Applied., 10*(4), 219-237.

637   Impellizzeri, F. M., Rampinini, E., Sassi, A., Mognoni, P., & Marcora, S. (2005).

638   Physiological correlates to off-road cycling performance. *Journal of Sports*

639   *Sciences, 23*(1), 41-47.

640   Kordi, A. M., Folland, J., Goodall, S., Menzies, C., Patel, T. S., Evans, M., et al. (2020).

641   Cycling-specific isometric resistance training improves peak power output

642   in elite sprint cyclists. *Scandinavian Journal of Medicine & Science in Sports,*

643   Law, M., Côté, J., & Ericsson, K. A. (2007). Characteristics of expert development

644   in rhythmic gymnastics: A retrospective study. *International Journal of Sport*

645   *Psychology, 5*, 82-103.

646   Lenth, R. V. (2001). Some practical guidelines for effective sample size

647   determination. *The American Statistician, 55*(3), 187-193.

648   Lombardo, M. P., & Deaner, R. O. (2014). You can't teach speed: Sprinters falsify

649   the deliberate practice model of expertise. *PeerJ, 2*, e445.

650   Lopes, M., & Vallerand, R. J. (2020). The role of passion, need satisfaction, and

651   conflict in athletes' perceptions of burnout. *Psychology of Sport and Exercise,*

652   , 101674.

653   Lydiard, A., & Gilmour, G. (2000). *Running with Lydiard* Meyer & Meyer Verlag.

654   Malina, R. M. (1994). Physical growth and biological maturation of young

655   athletes. *Exercise and Sport Sciences Reviews, 22*, 389.

656 Malina, R. M. (2010). Early sport specialization: Roots, effectiveness, risks.

657   *Current Sports Medicine Reports, 9*(6), 364-371.

658 Malina, R. M., Eisenmann, J. C., Cumming, S. P., Ribeiro, B., & Aroso, J. (2004).

659   Maturity-associated variation in the growth and functional capacities of

660   youth football (soccer) players 13–15 years. *European Journal of Applied*

661   *Physiology, 91*(5), 555-562.

662 Mujika, I., & Padilla, S. (2001). Physiological and performance characteristics of

663   male professional road cyclists. *Sports Medicine, 31*(7), 479-487.

664 Myer, G. D., Jayanthi, N., DiFiori, J. P., Faigenbaum, A. D., Kiefer, A. W., Logerstedt,

665   D., et al. (2016). Sports specialization, part II: Alternative solutions to early

666   sport specialization in youth athletes. *Sports Health, 8*(1), 65-73.

667 Newell, A., & Rosenbloom, P. S. (1981). Mechanisms of skill acquisition and the

668   law of practice. In J. R. Anderson (Ed.), *Cognitive skills and their acquisition*

669   (pp. 1-55). Hillsdale: Lawrence Erlbaum Associates.

670 Paton, C. D., & Hopkins, W. G. (2001). Tests of cycling performance. *Sports*

671   *Medicine, 31*(7), 489-496.

672 Rivera-Brown, A. M., & Frontera, W. R. (2012). Principles of exercise physiology:

673   Responses to acute exercise and long-term adaptations to training. *PM&R*

674   *4*(11), 797-804.

675 Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic human

676   information processing: I. detection, search, and attention. *Psychological*

677   *Review, 84*(1), 1-66.

678   Scott, J. P. (1986). Critical periods in organizational process. In F. Falkner and J.M.

679   Tanner (Ed.), *Human growth. vol. 1. Developmental biology, prenatal growth.*

680   (pp. 181-196.). New York: Plenum Press.

681   Shiffrin, R. M., & Schneider, W. (1977). *Controlled and automatic human*

682   *information processing: II. perceptual learning, automatic attending, and a*

683   *general theory*

684   Staff, T., Gobet, F., & Parton, A. (2020). Investigating the period of practice

685   needed to acquire expertise in Great Britain 2012 track and field Olympic

686   athletes.

687   Svetlov, P. G. (1972). Ontogenesis as a purposeful (teleonomic) process. *Arkhiv*

688   *Anatomii, Gistologii i Embriologii, 63*(8), 5-16.

689   Tiberiu, P., Mihai, B., Cristian, N., Nicoleta, M. S., Cerasela, D., Martin, D., et al.

690   (2020). Is the strength training a key for performance in cycling? – A case

691   study. *6th International Conference of Universitaria Consortium "FEFSTIM:*

692   *Physical Education, Sports and Kinesiotherapy–implications in Quality of Life".*

693   pp. 31.

694   Tucker, R., & Collins, M. (2012). What makes champions? A review of the relative

695   contribution of genes and training to sporting success. *British Journal of*

696   *Sports Medicine, 46*(8), 555-561.

697   Vaeyens, R., Güllich, A., Warr, C. R., & Philippaerts, R. (2009). Talent identification

698   and promotion programmes of Olympic athletes. *Journal of Sports Sciences,*

699   *27*(13), 1367-1380.

700   Vazire, S., & Gosling, S. D. (2004). E-perceptions: Personality impressions based

701   on personal websites. *Journal of Personality and Social Psychology, 87*(1),

702   123-132.

703   Viru, A., Loko, J., Harro, M., Volver, A., Laaneots, L., & Viru, M. (1999). Critical

704   periods in the development of performance capacity during childhood and

705   adolescence. *European Journal of Physical Education, 4*(1), 75-119.

706   Ward, P., Hodges, N.J., Williams, A.M. & Starkes, J. (2007). The road to excellence

707   in soccer: A quasi-longitudinal approach to deliberate practice. *High Ability*

708   *Studies, 18*, 119-153.

709   Wattbike. (2010). *An introduction to the wattbike.* Retrieved 07/13, 2013, from

710   http://youtu.be/i6cCcB1jorY

711   Williams, A. M., & Reilly, T. (2000). Talent identification and development in

712   soccer. *Journal of Sports Sciences, 18*(9), 657-667.

713   Yustres, I., Santos del Cerro, J., Martín, R., González-Mohíno, F., Logan, O., &

714   González-Ravé, J. M. (2019). Influence of early specialization in world-

715   ranked swimmers and general patterns to success. *PloS One, 14*(6),

716   e0218601.

717
718