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Think aloud research in sport and exercise psychology: A focused mapping review and synthesis.

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Abstract

Use of Ericsson and Simon's (1980, 1993) think aloud (TA) method within sport and exercise psychology research has increased in recent years. The purpose of this review was to map current research that has used the TA method with athletes and exercisers by synthesising published literature that has adopted the TA method to investigate athlete or exerciser cognitions during task performance. Seven electronic databases were searched three times, with a final search conducted in April 2023. Thirty-six studies satisfying the eligibility criteria were included. Several methodological issues were identified including misunderstandings about the nature of the TA method, leading to the use of methods different from and sometimes antithetical to those proposed by Ericsson and Simon (1980, 1993). Other issues identified concerned participant samples, TA training, ecological validity of tasks, and defining the standard of participants. Theoretical misconceptions, methodological considerations, and recommendations for future research using the TA method to generate understanding of participant cognitions during task performance in sport and exercise are discussed. This review documents the extent and nature of the use of the TA method within sport and exercise psychology research and can guide researchers seeking to conduct high-quality research involving the TA method in future.

Keywords: Cognition, Concurrent verbalisations, Cognitive process tracing, Think aloud method, best practice, Research methods

1 **Think aloud research in sport and exercise psychology: A focused mapping review and synthesis**

2 For some time, the cognitions of athletes, exercisers, and processes underlying expertise have
3 been of significant interest to researchers in the field of sport and exercise psychology (Eccles, 2012;
4 Moran et al., 2019). In seeking to understand what athletes and exercisers think about in sport,
5 researchers have used a variety of qualitative and quantitative methods. For example, cognitive
6 processes have been studied through qualitative methods such as interviews (e.g., Bennet et al.,
7 2016), video recordings coupled with interviews (e.g., Macquet, 2009; Macquet et al., 2012; Mulligan
8 et al., 2012), and researcher observations combined with interviews (e.g., Macquet & Fleurance,
9 2007). Similarly, quantitative methods, including psychometrics (e.g., Mansell & Turner, 2022),
10 electroencephalographic (EEG) measures (e.g., Holmes & Wright, 2017), and functional near infrared
11 spectroscopy (fNIRS; e.g., Robinson et al., 2021), have been employed to study cognitive processes.
12 More recently, researchers have sought to expand understanding of cognitions in sport by adopting
13 an alternative method to collect data during athletic performance – the think aloud (TA) method.
14 Originally proposed by Ericsson and Simon (1980, 1993), the TA method was developed to generate
15 information about thought processes mediating task performance by asking participants to verbally
16 think aloud while performing a task or verbally recalling thoughts immediately following completion
17 of a task.

18 Prior to the proposal of Ericsson and Simon’s (1993) method, researchers often had been wary
19 of individuals’ verbal reports about their thinking, such as those elicited by researcher-posed
20 questions like, “In this game situation, why did you decide to pass the ball rather than keep it?” and
21 “When you look at a menu, how do you decide what to eat?” Researchers had provided evidence that
22 people asked such questions often provided inaccurate verbal reports about their cognitions and had
23 theorized that this was because people have limited conscious access to these thoughts (Nisbett &
24 Wilson, 1977). Ericsson and Simon’s (1980, 1993) response to these concerns was to suggest that
25 people can verbalize accurately about their cognitions when they are provided with specific elicitation
26 conditions and proposed a method (i.e., the TA method) that enabled researchers to achieve these

27 conditions within their studies. Thus, the method of eliciting thoughts that they proposed offered
28 researchers with a new opportunity to obtain rich verbal data proposed to provide insights into the
29 cognitions underpinning human performance.

30 Ericsson and Simon (1993) proposed a theoretical framework as the basis for their TA method.
31 This framework set out the ways that verbal reports of thinking might be generated when an individual
32 is asked to TA during the execution of a task (e.g., Arsal et al., 2016; Kaiseler et al., 2013; Nicholls &
33 Polman, 2008). This framework is termed the *verbalisation framework*. Level 1 verbalisation was
34 described as the vocalisation of inner speech. For instance, participants would simply verbalise their
35 inner thoughts during task performance. Level 2 verbalisation was proposed to involve the verbal
36 encoding and vocalisation of an internal representation that is not originally in verbal code;
37 verbalisations are proposed to reflect stimuli within the participants' attentional focus (e.g., verbal
38 encoding and vocalisation of scents, visual stimuli, or movement). Their assumption was that Level 1
39 and 2 verbalisations offered a representation of information in short-term memory (STM) during task
40 performance (Ericsson & Simon, 1993). As such, Ericsson and Simon (1993) argued that Level 1 and 2
41 verbalisations could provide a representation of information involved in the mediation of ongoing task
42 performance and typically aligned with a postpositivist/cognitivist underpinning.

43 By contrast, Level 3 verbalisation were proposed to move beyond simply verbalising
44 information heeded in STM during task performance and instead involve the individual providing
45 explanations for their thought processes. The provision of such explanations requires retrieval of
46 information from long-term memory, and therefore involve more than simply verbalising information
47 present in STM during task performance. Consequently, Level 3 verbalisations were not considered as
48 representative of thoughts mediating ongoing performance (Ericsson & Simon, 1993). Ericsson and
49 Simon (1993) proposed that most traditional forms of researcher-posed questions afforded
50 respondents the opportunity to provide Level 3 verbalisations. Furthermore, the likelihood that
51 respondents provide Level 3 verbalisations was considered to be increased when they were unable to
52 provide Level 1 and 2 verbalisations, as it was suggested that their thoughts were not available within

53 working memory; that is, when the respondent had no conscious access to these thoughts. When an
54 individual is asked to report on their cognitions but is unable to access them, it is proposed that they
55 often access implicit theories about these cognitions, which are fundamental assumptions about how
56 the world generally works, to provide the report (Ericsson & Simon, 1993). The problem with implicit
57 theories is that they are often unrelated to the individual's actual cognitions. Consequently, Ericsson
58 and Simon (1993) proposed that what was needed to obtain valid and reliable insights into the
59 thoughts mediating task performance was a method of eliciting verbal reports of thinking that
60 constrained the respondent as much as possible to provide only Level 1 and 2 verbalisations. To this
61 end, Ericsson and Simon (1980) proposed the TA method of eliciting verbal reports of thinking, which
62 was aimed at maximising the provision of Level 1 and Level 2 verbalisations and minimising the
63 provision of Level 3 verbalisations.

64 The TA method Ericsson and Simon (1980) proposed included two variations. The first
65 variation was termed *concurrent reporting*. The procedures involved in this variation provided
66 directions to the participant to: think out aloud as they perform a task and as if they were alone, think
67 out aloud only thoughts that occur to them naturally as they perform the task, and avoid describing
68 or explaining their thoughts as if in the presence of another. The second variation was termed
69 *immediate retrospective reporting*. Ericsson and Simon proposed that, after task completion, some
70 information remains in the STM briefly and may be elicited by asking participants to recall thoughts
71 experienced during the task immediately following task completion. The emphasis within the
72 directions provided to the participant when recalling these thoughts was to report only those thoughts
73 they could distinctly report having, however few they might be, and not to describe or explain these
74 thoughts.

75 There has been a recent increase in research involving use of the TA method within sport and
76 exercise, with researchers adopting the method to study cognitions underlying the performance of
77 various sport and exercise tasks. For example, researchers have used the TA method in studies of
78 cricket (McGreary et al., 2021), cycling (Whitehead et al., 2018, 2019), golf (Arsal et al., 2016; Nicholls

79 & Polman, 2008), outdoor running (Samson et al., 2017), indoor 5km running (Johnson et al., 2023),
80 tennis (Swettenham et al., 2018), a postural wall sitting task (Gunn & Taylor, 2021), and snooker
81 (Welsh et al., 2018). These studies have developed novel, psychological understanding across a variety
82 of topics, including challenge and threat states (e.g., McGreary et al., 2020), stressors and coping
83 (Nicholls & Polman, 2008; Swettenham et al., 2018; Welsh et al., 2018), and pacing and attentional
84 focus (Whitehead et al., 2018, 2019). Furthermore, researchers have demonstrated that a strength of
85 the TA method is its flexibility in terms of analytic approaches, with studies to date having involved
86 quantitative approaches (e.g., McGreary et al. 2020; Swettenham et al., 2018), qualitative approaches
87 (McGreary et al., 2021; Welsh et al., 2018; Whitehead & Jackman, 2021), and a mix of these two
88 approaches (Elliot et al., 2020). Despite evidence of the popularity of the TA method among sport and
89 exercise psychology researchers, attempting to capture in-event cognitions can pose significant
90 practical challenges and may be difficult to achieve in some contexts (Eccles et al., 2006; Jackman et
91 al., 2022). For example, thinking out loud while performing tasks requiring increased respiration (e.g.,
92 during a sports game) is challenging, and could potentially lead to interference between these two
93 tasks (Eccles et al., 2006). However, in general, the aforementioned studies illustrate the potential
94 utility and value of the TA method in sport and exercise.

95 Despite the growing use of the TA method to explore in-task cognitions of athletes and
96 exercisers since the development of this approach by Ericsson and Simons (1993), there has been no
97 review of how this method has been used in sport and exercise. Given the emphasis placed on
98 methodological rigour and high-quality research in sport and exercise psychology (Schinke et al., 2021;
99 Smith & McGannon, 2018), it appears timely and important to synthesise and appraise current use of
100 the TA method within sport and exercise psychology, to aid researchers who wish to use this method
101 in future. Therefore, the aim of this review was to map current research that has used the TA method
102 with athletes and exercisers by synthesising published literature that has adopted the TA method to
103 investigate athlete or exerciser cognitions during task performance. Specifically, we aimed to answer
104 the following research questions in relation to sport and exercise psychology research: (a) what is the

105 nature of the TA method employed?, (b) what research questions has the TA method been used to
106 answer?, (c) with what populations and in what contexts has the TA method been used?, (d) what
107 study designs have been used that have included the TA method?, and (e) what specific procedures
108 have been adopted in the implementation of the TA method? By addressing these research questions,
109 we sought to advance understanding of the TA method in sport and exercise and provide researchers
110 with recommendations for designing and conducting high-quality research involving the TA method.

111 **Method**

112 **Design and Protocol**

113 As we aimed to map the existing research literature involving use of the TA method within
114 sport and exercise contexts, we decided that a systematic mapping review (Campbell et al., 2023)
115 would be a suitable approach to achieve this. Systematic mapping reviews provide an overview of a
116 research area (e.g., nature and coverage), highlight areas where research has been conducted, and
117 provide avenues for future research (Berg et al., 2016). This is in contrast to other review typologies,
118 such as systematic reviews, which are intended to systematically search for, appraise, and synthesise
119 research evidence in relation to a specific research question (Grant & Booth, 2009). We followed the
120 Evidence for Policy and Practice Information-Centre methods and procedures for a systematic
121 mapping review and synthesis (Gough et al., 2003). As we were using secondary data, this study was
122 exempt from institutional ethical approval.

123 **Eligibility Criteria**

124 The eligibility criteria were developed through consultation between all authors to clearly set
125 the boundaries of the review (Gough et al., 2003; Siddaway et al., 2019). To be included in the review,
126 a study needed to have: (1) been a peer reviewed journal article written in the English language; (2)
127 reported using the TA method (either concurrent or immediate retrospective reporting, as described
128 by Eccles, 2012) as proposed by Ericsson and Simon (1980, 1993) to capture data during performances;
129 (3) sampled athletes or exercisers; and (4) included original, empirical data. In this review, we
130 differentiated the TA method from other approaches that might be perceived as verbal reporting (e.g.,

131 delayed retrospective report – Eccles, 2012; or interviewing - Bennet et al., 2016; or video feedback
132 coupled with interviews - Macquet, 2009; Mulligan et al., 2012; or recall interviewing – McPherson &
133 Kernodle, 2007) on the basis that the TA method requires participants to verbalise during task
134 performance or recall thoughts immediately following the completion of a task/movement (Eccles &
135 Arsal, 2017). For the purpose of this review, we excluded studies that did not specify that participants
136 were required to TA (i.e., either concurrent or immediate retrospective reporting).

137 **Information Sources and Search Strategy**

138 Seven electronic databases were searched by the first author: Academic Search Complete
139 Premier, APA PsycINFO, MEDLINE, PubMed, Scopus, SPORTDiscus, and Web of Science. Database
140 searches took place initially in September 2021 and November 2022, with a final search conducted in
141 April 2023. As a research team, we had expertise in using the TA method and developed the search
142 string after initial scoping searches and discussions. Accordingly, the following two blocks of Boolean
143 terms were used: (1) “think aloud” OR “concurrent verbalisation*” OR “concurrent verbalization*” OR
144 “verbal report*” OR “verbal protocol” OR “verbalis*” OR “verbaliz*” AND (2) sport* OR athlete* OR
145 perform* OR exer* OR physical* activ*. The first block was searched in the title and abstract field,
146 with the second block searched at full-text level, where possible (see Appendix 1 for full electronic
147 searches). Limiters were applied, where possible, to include only articles published in the English
148 language in academic journals. All articles retrieved were added to reference management software
149 (RefWorks), with duplicates removed via the automatic duplication function and manual screening.
150 Manual searches for additional studies were conducted by reviewing reference lists of included
151 studies and searching 10 relevant sport, exercise and psychology journals (Appendix 2), using
152 keywords such as “think aloud” or “think aloud method”.

153 **Screening Process**

154 Screening of articles took place in two stages, with the articles screened independently by
155 two authors at each stage. At the first stage, the titles and abstracts of all articles were screened
156 against the eligibility criteria by the first and fourth author independently. After this, a meeting was

157 arranged between these authors to share their decisions and discuss any discrepancies. At the
158 second stage, the first and fourth author reviewed each remaining study against the inclusion and
159 exclusion criteria, and determined whether these studies satisfied the inclusion criteria. The authors
160 then met to discuss the outcomes of this process and agree on reasons for excluding studies (see
161 Appendix 3 for reasons for exclusion for studies at the full text stage). The level of agreement
162 between authors at the first and second screening stages was almost perfect ($\kappa = .86$) and
163 substantial ($\kappa = .71$), respectively.

164 **Data Extraction and Synthesis**

165 To answer our research questions, the following information was extracted and analysed by
166 the first author: nature of TA method employed; research questions being answered; sample
167 characteristics and context; and study design (e.g., TA training provided, philosophical position). Given
168 the exploratory nature of this review, we followed guidelines for narrative synthesis (Popay et al.,
169 2006). The first author read each study twice to become familiar with the dataset and obtain textual
170 information to inform the synthesis. Some studies included as part of this review also collected non-
171 TA data (e.g., eye tracking). However, given that the review was only concerned with the TA method,
172 only data relevant to answering the research questions were synthesised, although data gathered
173 from other techniques are discussed to offer context. To facilitate synthesis of findings related to the
174 five research questions, relevant information was extracted and organised into a table (see Table 1).
175 Following the synthesis of the included studies, members of the research team met to engage in a
176 process of critical peer debrief (Smith & McGannon, 2018). This involved the first author sharing initial
177 findings and members of the research team offering critical feedback to encourage the first author to
178 reflect on and challenge their initial synthesis, which helped to further develop the analysis and
179 findings presented (see below). Although mapping reviews do not involve study quality checks
180 (Campbell et al., 2023; Grant & Booth, 2009), as we sought to develop findings that could help
181 researchers seeking to use the TA method in sport and exercise in the future, we offer critique on the
182 TA methods used within the included studies in our results and discussion sections.

209 which Ericsson and Simon's method is explicitly designed to encourage. In the remaining study (Rose
210 & Parfitt, 2010), other instructions (i.e., an unspecified concurrent verbal reporting method) were
211 provided to participants that departed from the method proposed by Ericsson and Simon. For some
212 of the subsequent sections (research questions, contextual information, TA training) related to each
213 research question, we split the findings into two subsections: (1) those that were consistent with the
214 TA method proposed by Ericsson and Simon (1980, 1993), and (2) those that were not consistent with
215 the TA method proposed by Ericsson and Simon, despite reporting that this method was used.

216 ***Research Questions***

217 Studies that used the TA method as proposed by Ericsson and Simon (1980, 1993) did so to
218 explore a range of research questions; see Table 1 for detailed research questions. Broadly, skill-level
219 differences or skill acquisition was a topic area explored commonly ($k = 21$) and consisted primarily of
220 researchers exploring differences in thought processes between two or more differently skilled groups
221 of performers ($k = 18$), especially between novice/amateur/less-skilled and elite/professional/higher-
222 skilled ($k = 17$). A further six studies explored stressors and coping, with these studies underpinned by
223 theories such as the transactional model of stress and coping (Lazarus & Folkman, 1984), the cognitive-
224 motivational-relation approach (Lazarus, 1999), and the theory of challenge and threat states in
225 athletes (Jones et al., 2009). Similarly, within this topic, researchers also explored gender differences
226 in stressors and coping responses (study 1 and 2 by Kaiseler et al., 2013; Swettenham et al., 2018).
227 Researchers exploring gender differences also referred to both the dispositional hypothesis (Tamres
228 et al., 2002) and the situational hypothesis (Sigmon et al., 1995). Finally, there were several studies
229 that explored a wide variety of psychological constructs that can be broadly classified as attentional
230 foci. For example, researchers explored (meta)cognition (Whitehead & Jackman, 2021), attributional
231 retraining (Moffat et al., 2021), exercise cognitions (Gunn & Taylor 2021), differences in cognitions
232 between well-trained, trained and recreationally trained runners (Johnson et al., 2023), long-distance
233 running cognitions (Samson et al., 2017), pacing strategies/changes in cognitions (Whitehead et al.,
234 2018), and changes in cognitions/decision making (Whitehead et al., 2019).

235 Studies that did not use Ericsson and Simon's (1980, 1983) TA method, despite claiming that
236 this method was employed (i.e., those studies coded as 'other'), addressed topics that were broadly
237 similar. For example, researchers interested in attentional foci explored (meta)cognition (Oliver et al.,
238 2020) and exercise cognitions (Rose & Parfit, 2010). Welsh et al. (2018) explored cognitions related to
239 stressors and coping, and Whitehead et al. (2015) explored the congruence between verbal data and
240 retrospective interviews in golfers. Across these studies, researchers encouraged the participants to
241 verbalise both the the 'why' and 'what' with regards to verbal data, which goes against Ericsson and
242 Simon's (1980, 1993) method, who stated experimenters should not allow participants to "theorize
243 about their processes" (i.e., the why) but instead we should be "leaving the theory-building part of
244 the enterprise to the experimenter" (Ericsson & Simon, 1980, p. 221).

245 ***Contextual Information***

246 A total of 686 participants (603 males and 83 females) took part in the 32 studies ($M = 21.44$
247 participants, $SD = 13.74$, range = 5-64) that aligned with Ericsson and Simon's (1980, 1993) method.
248 For studies that provided age information ($k = 29$), the weighted mean age was: 16.27 years (range =
249 13.17-17.50) for youth-only studies (i.e., < 18 years of age; $n = 55$; $k = 5$); 19.93 years (range = 14.62
250 to 26.35; $n = 76$) for studies combining adults and youths ($k = 2$); and 25.83 years (range = 19.72 to
251 48.51; $n = 516$) for studies only recruiting adults ($k = 22$). In total, 31 of the 32 studies were conducted
252 in sport, with only one study involving exercise or an exercise-related activity (i.e., wall sitting postural
253 task, Gunn & Taylor, 2021). In terms of specific activities, most studies were conducted in golf ($k = 9$)
254 or cycling ($k = 6$), followed by cricket ($k = 5$), soccer ($k = 4$) and tennis ($k = 3$). There was an even split
255 between studies that collected data in a laboratory-based environment ($k = 16$) and in a more
256 naturalistic environment (e.g., golf course; $k = 16$). However, of those that collected data in a
257 naturalistic environment, the majority ($k = 12$) were researcher-simulated scenarios or competitions.
258 Only five studies collected data during a real, non-simulated, competitive scenario, including in cycling
259 (Whitehead et al., 2017, study 1 and 2 by Whitehead et al., 2018); cricket (McGreary et al., 2021), and
260 golf (Oliver et al., 2021).

261 Participants were sampled across a range of expertise and experience levels, ranging from
262 novices to elite athletes. However, inconsistency and ambiguity in the terminology used to describe
263 the level of participants made between-study comparisons difficult. To illustrate this heterogeneity,
264 the terminology adopted to define either the athletic ability or experience of participants included the
265 following: amateur ($k = 5$), skilled ($k = 4$), less skilled ($k = 4$), high-skilled ($k = 4$), competitive amateur
266 ($k = 4$), trained ($k = 4$), untrained ($k = 3$), low-skilled ($k = 2$), expert ($k = 2$), elite junior ($k = 2$), professional
267 ($k = 1$), elite senior ($k = 1$), intermediate ($k = 1$), beginner ($k = 1$), semi-elite ($k = 1$), sub-elite ($k = 1$),
268 semi-professional ($k = 1$), successful elite ($k = 1$), recreationally-trained ($k = 1$), well-trained ($k = 1$), and
269 moderately skilled ($k = 1$)

270 For studies coded as 'other' ($k = 4$), a total of 106 participants (59 males and 47 females) were
271 included ($M = 26.50$ participants, $SD = 25.25$, range = 7-60). Two studies recruited adults only (Rose &
272 Parfitt, 2010, Welsh et al., 2018), one study involved both youths and adults (Whitehead et al., 2015),
273 and one study did not state the age of their participants (Oliver et al., 2020). Three of the four studies
274 were conducted in sport (golf $k = 2$; snooker $k = 1$), with one study involving exercise or an exercise-
275 related activity (indoor treadmill-based running – Rose & Parfitt, 2010). Due to the smaller sample size
276 of studies, there was less heterogeneity in the categorisation of participant ability. Nevertheless,
277 descriptions of participants were still wide ranging and included skilled ($k = 1$), novice ($k = 1$), super-
278 elite ($k = 1$), elite ($k = 1$), professional ($k = 1$), club-level ($k = 1$), high active ($k = 1$) and low active ($k =$
279 1). Again, there was an even split between studies that collected data in a laboratory-based
280 environment ($k = 2$) and in a more naturalistic environment (e.g., golf course; $k = 2$); of the two
281 naturalistic environments, both were researcher-simulated scenarios (e.g., six holes on a golf course).

282 ***Study Design and Research Paradigm***

283 Our synthesis demonstrated the diverse range of study designs used in research involving the
284 TA method. Of the 36 studies reviewed, 17 studies were classified as quantitative, 12 were mixed
285 methods (i.e., presented qualitative and quantitative results), and seven were defined as qualitative.
286 Studies that quantified qualitative data (e.g., analysed the frequency of verbalisations) were classified

287 as quantitative papers if results were presented using numeric data. Twenty-three studies did not
288 explicitly state their research paradigm, including for quantitative ($k = 11$), mixed methods ($k = 9$), and
289 qualitative ($k = 3$) studies. In total, 13 studies stated their research paradigm and of the seven mixed
290 method studies, five qualitative studies, and one quantitative study that provided this information,
291 the majority ($k = 10$; 76.9%) were reported to be underpinned by post-positivism, two studies
292 (McGreary et al., 2021; Welsh et al., 2018) by subjectivism/constructivism, and one study (Whitehead
293 & Jackman, 2021) by critical realism.

294 ***TA Training***

295 Within research involving the TA method, training participants to TA during the task is an
296 important stage (Eccles & Arsal, 2017). All studies (100%) that used the TA method as proposed by
297 Ericsson and Simon's (1980, 1993) detailed the training procedures adopted. In contrast, only 75% of
298 the "other" studies (i.e., those that did not use Ericsson and Simon's TA method, despite claiming that
299 this method was employed) detailed the TA training procedures adopted. Of those that detailed the
300 instructions provided ($k = 35$) they cited either adopting Ericsson and Simon's (1980; 1993) training
301 protocol, an adapted version of this protocol (e.g., Birch & Whitehead, 2020; Eccles, 2012; Ericsson &
302 Kirk, 2001), or a combination of these recommendations (e.g., Elliot et al., 2020). The instructions
303 provided primarily involved non-task specific exercises, such as a mental arithmetic task, problem-
304 solving task, counting dots on a page, or a verbal-recall exercise. Birch and Whitehead (2020) also
305 suggested adding task-specific exercises alongside traditional TA training to increase familiarity.
306 Training was typically deemed sufficient when both (a) participants had completed some form of
307 training and (b) the researchers judged that the participant understood what TA involved and could
308 demonstrate that they could successfully TA during a task.

309 **Discussion**

310 In this systematic mapping review, we aimed to identify and synthesise published research
311 that has used the TA method with athletes and exercisers. A total of 36 studies were sourced from 32
312 independent journal articles. This review has highlighted the growing and contemporary nature of

313 studies involving use of the TA method within sport and exercise, with over two-thirds of such studies
314 published within the seven years prior to the review (2016-2023). Furthermore, the TA method has
315 also been used across a variety of youth and adult athlete samples, as well as across nine independent
316 sports and two exercise-related activities, although most studies ($k = 34$) were conducted in sport. By
317 examining the nature of the TA method employed, what TA was used for, contextual information,
318 study designs, and TA training in published studies involving the TA method in sport and exercise, this
319 review offers a number of contributions that can guide future research.

320 **Theoretical Misconceptions**

321 In this review, we identified some misconceptions of the verbalisation framework proposed
322 by Ericsson and Simon's (1993), which was used as the basis of the procedures employed to elicit TA .
323 The goal of the TA method proposed by Ericsson and Simon (1993) was to provide the participant with
324 instructions that encourage them to only verbalize information heeded in STM during task
325 performance. That is, Ericsson and Simon wanted participants to only provide Level 1 and Level 2
326 verbalizations. Studies that instructed participants to engage in Level 3 verbalisations while claiming
327 to be aligned to Ericsson and Simon's TA method did so erroneously, because their method was
328 concerned foremost with minimizing the extent to which participants engaged in Level 3
329 verbalisations. While Ericsson and Simon's method was designed to avoid Level 3 verbalisations,
330 studies in which researchers have encouraged these verbalisations have been published within the
331 last four years, indicating that researchers are interesting in using alternative methods of eliciting
332 verbal reports of thinking. Nonetheless, most researchers have used Ericsson and Simon's (1993)
333 method as it was intended by attempting to capture information within the short-term memory during
334 task performance (e.g., Level 1 and Level 2 verbalisations). They have also followed Ericsson and
335 Simon's guidance that researchers interested in understanding the functions of thoughts verbalized
336 during task performance should not be tempted ask performers to explain their thoughts (i.e., Level 3
337 verbalisations). As Ericsson and Simon proposed, performers asked to explain their thoughts might
338 not have conscious access to such information and instead might propose explanations based on

339 information unrelated to these thoughts such as implicit theories of thinking (Nisbett & Wilson, 1977).
340 Instead, given concerns about the reliability of participants' explanations of the functions of their
341 thoughts, Ericsson and Simon advised that researchers (i.e., not participants) generate such
342 explanations based on participants' Level 1 and Level 2 verbalisations and subsequently test their
343 hypotheses about these explanations via further experimentation.

344 As stated, some researchers have acted against these recommendations (and in some cases
345 while erroneously claiming that their methods are aligned with Ericsson and Simon's TA method) by
346 allowing and even promoting the elicitation of Level 3 verbalisations. The information obtained from
347 these studies might be useful in addressing various research aims but researchers must be clear that
348 these alternative methods of eliciting verbal reports about thinking are not associated with Ericsson
349 and Simon's (1993) TA method. In addition, before using the TA method, we encourage researchers
350 to consult accessible primers on the method with the aim of gaining a good understanding of the
351 theory and procedures associated with the method. In this regard, we recommend the 1980 journal
352 article by Ericsson and Simon because it is more accessible than the 1993 text by Ericsson and Simon,
353 and we also recommend the journal article by Eccles and Aarsal (2017) for its relative brevity and
354 plainness of language.

355 **Methodological Considerations**

356 Most studies required participants to complete tasks either in a lab-based setting (e.g., Roca
357 et al., 2021) or in a simulated environment, such as a simulated 6-hole golf match (e.g., Whitehead &
358 Jackman, 2021). Few studies collected data in an ecologically valid, naturalistic setting. Such a trend is
359 likely understandable in many sporting contexts, as generating TA data during competitive situations
360 may be practically unfeasible (e.g., during a rugby union match). That said, where possible and
361 practically feasible, researchers should consider exploring the cognitions and thought processes of
362 athletes and exercisers within ecologically valid settings. For example, McCreary et al. (2021) explored
363 the stressors and coping strategies of cricket bowlers during a competitive match, thus generating
364 novel information within a naturalistic setting. Studies set in more ecologically valid contexts would

365 afford greater insights into the range of contextual cues that performers draw from to inform their
366 thinking and decision-making during performance. For example, previous research (e.g., Williams et
367 al., 2011) has highlighted that expert performers are able to identify multiple contextual cues from
368 their environment (e.g., position of opponents, time remaining, current score etc.) to inform their
369 decision-making processes during performance. By contrast, studies set in laboratory environments
370 typically do not permit full representation of such cues and thus limit understanding of cognitive
371 processes underpinning sport performance.

372 Furthermore, most studies primarily used the TA method in a single data-collection session.
373 However, researchers have previously highlighted the potential limitations of such 'drive-by'
374 approaches in the case of qualitative interviews, arguing participants could be regarded as nothing
375 more than "data sources" (Chamberlain, 2012, p. 4). In the context of collecting data on athlete
376 cognitions via the TA method, a solitary data collection session only offers a researcher a single
377 snapshot into athlete/exerciser cognitions and limit what can be inferred from these data.
378 Furthermore, given the variations that can arise for athletes and exercisers within and between
379 activities, collecting data across multiple performances, for example, could open up new opportunities
380 for within-person analysis. Furthermore, we suggest that researchers should consider how the TA
381 method can be combined with other methods to generate novel—and potentially different—
382 perspectives on participants' cognitions. Methods such as event-focused interviews (Jackman et al.,
383 2022), observations, and visual media (e.g., head-mounted video recordings - Mackenzie & Kerr, 2012)
384 could be combined with the TA method to diversify the information generated. For example, during
385 ongoing performance, cognitions (e.g., by an equestrian) could be captured by the TA method, and
386 the behaviours these cognitions give rise to (e.g., changes in the spatial locations and actions of the
387 horse and equestrian) could be captured by head-mounted video camera. Furthermore, some
388 researchers have used TA in combination with eye-tracking (Murphy et al., 2016) and fNRIS (Robinson
389 et al., 2021), which hold promise as potential new ways integrate the TA method into multi-disciplinary
390 research.

391 Several studies within this review reported gender differences in athlete cognitions (e.g.,
392 Kaiseler et al., 2012a, 2012b; Swettenham et al., 2018). For example, Swettenham et al. (2018)
393 indicated gendered differences in the types of stressors verbalised during practice and competition,
394 with male athletes more likely to verbalise external and physical stressors during practice and
395 performance stressors during competition. In comparison, female participants were more likely to
396 verbalise performance stressors during practice and external stressors during competition. Their
397 findings offered support to the Situational Hypothesis (Rosario et al., 1988) which details gendered
398 differences in coping responses are as a result of male and female participants appraising the same
399 situation differently. While this research shows potential gendered differences in the cognitive
400 processes of athletes, over 80% of participants sampled by studies included in the review were male.
401 While the underrepresentation of participants that do not identify as male is a broader issue for sport
402 psychology (Walton et al., 2022) and sport science research (Cowley et al., 2021) rather than a specific
403 TA method issue, researchers that have used the TA method and examined gender differences have
404 identified some contrasts, albeit these differences are limited to a relatively small number of studies.
405 Therefore, aligned with calls for researchers to address gender inequalities that currently exist in sport
406 and exercise science (Cowley et al., 2021; Walton et al., 2022) and to utilise theoretical perspectives
407 that consider gender to explain findings (Walton et al., 2022), we encourage researchers seeking to
408 use TA in future to direct greater attention towards gendered aspects of cognition.

409 Another trend across the included studies was that most participants recruited were adults.
410 Specifically, of the 31 studies that provided information related to participants, 23 were adult-only
411 studies. However, as has been demonstrated by a small number of studies, use of the TA method
412 appears to be feasible, at least in youths aged 13-18 years, and findings from studies that have made
413 use of this method offer further insight into the thought processes of junior athletes and/or exercisers
414 during task performance. For example, Elliot et al. (2020) explored differences in thought processes
415 between adult and junior Australian Rules footballers during a set-shot goal attempt and findings such
416 as these could further enhance understanding of how different groups may develop and acquire skills,

417 which would have applied implications for coaches and practitioners. Therefore, to better understand
418 the development and acquisition of skills, more TA data needs to be collected from younger
419 participants.

420 The tendency to prioritise adult-only studies could be explained by the increased ethical
421 complexities of working with youth athletes, but on the other hand, researchers may have perceived
422 that the complexities required of ‘thinking aloud’ while performing might be too great for youths. It is
423 worth noting, however, that the training provided to youths and adults did not differ in any study in
424 our review that involved youth participants. Furthermore, no TA training approaches cited (e.g., Birch
425 & Whitehead, 2019; Eccles, 2012; Ericsson & Simons, 1993; Ericsson & Kirk, 2001) were developed
426 specifically for young people. Consequently, this begs the question as to whether the training provided
427 to youth participants in sport and exercise is fit for purpose. Future research should look to explore,
428 firstly, whether TA training is suitable for and acceptable to junior participants and, secondly, whether
429 there is a more suitable training protocol that could be offered to junior participants. Similarly, future
430 research should look to explore in more detail the cognitions of junior athletes during the performance
431 of tasks.

432 While many studies did not explicitly state their research paradigm, most of the studies
433 appeared to be underpinned by post-positivism. However, there was evidence of a growing number
434 of more recent studies (all published within the last four years) adopting more
435 subjectivist/interpretivist positions, once again highlighting the flexible nature of TA. Based on these
436 findings concerning philosophical positions and in keeping with recommendations for sport and
437 exercise psychology research (e.g., Smith & McGannon, 2018), it is important for future research to
438 consider the broad range of paradigms that can be adopted as a way to generate different forms of
439 knowledge. Nevertheless, it is important to recognise that results generated from different
440 philosophical approaches are simply different and not better or worse (Eccles & Aarsal, 2017).
441 Furthermore, it is important for researchers to note that we concur with the view that similar to other
442 forms of participant talk (e.g., interview conversation, see Randell & Phoenix, 2009), the TA method

443 does not “provide an insight into the subjectivity of participant experience” (Smith & Sparkes, 2016.
444 p. 108).

445 **Future Research and Applied Implications**

446 Across the included studies, there were several broad topic areas that researchers based their
447 research questions and objectives around. As most studies explored these topics within a sporting
448 context, researchers interested in understanding thinking within exercise populations could consider
449 using the TA method in future research. For example, researchers interested in the cognitions of
450 participants in physical activity could use the TA method to compare the cognitions of participants
451 who engage in low, moderate, and high levels of activity, or across different levels of exercise intensity
452 and viewed in line with contemporary theoretical frameworks (e.g., Ekkekakis’ [2005] dual mode
453 theory of affective responses to exercise). Such findings could be used to offer support to such theories
454 by allowing the researcher to better understanding cognitive processes (e.g., self-efficacy, goals,
455 attributions etc.) which have been theorised to influence individuals’ affective responses to exercise.
456 Similarly, findings could aid researchers and practitioners’ understanding of cognitive processes during
457 exercise, and potentially aid in the design and delivery of programmes aimed at increasing and
458 maintaining physical activity in insufficiently active populations. Furthermore, recent research, such
459 as the applied case study conducted by Moffat et al. (2021), has highlighted the novel and diverse
460 ways through which the TA method can be used. Specifically, the authors used the TA method to elicit
461 verbal reports that were then used as part of an attribution retraining process and showed how such
462 training improved athletes’ emotional control capabilities (although we ask the reader not to use the
463 authors’ description of the method as a guide to its use because the description contains some
464 misunderstandings about the theoretical basis for the method, even if the method appears to have
465 been used correctly). In turn, this demonstrates the flexibility of the TA method and offers preliminary
466 evidence of how it can be used in applied practice.

467 Furthermore, future research could explore the utility of TA as an applied tool for sport and
468 exercise psychology interventions, the TA method, as Ericsson and Simon presented it, could be used

469 when we are interested in understanding, and changing via intervention, a performer's thinking. The
470 TA method could align well with cognitive-behaviourally-focussed approaches, such as rational
471 emotive behaviour therapy (REBT), by allowing the practitioner to collect verbalised data during
472 performance and collaboratively work with the athlete to identify irrational beliefs and replace them
473 with more rational beliefs (Turner, 2016). Similarly, it could be used to explore aspects of a performer's
474 use of pre-performance routines (PPR) by examining the extent to which there is evidence of desirable
475 and less desirable components of the PPR such as self-talk or cue words and then to use it again, over
476 time, during and following PPR training to examine how the PPR has changed over time according to
477 verbalized thoughts following the training. Finally, further exploration of non-Western-centric usage
478 of TA could also be a potential line of inquiry for future researchers.

479 **Limitations of the Review**

480 In this review, we aimed to identify and synthesise published literature that has used the TA
481 method in studies that sampled athletes and exercisers. While there are a number of key strengths
482 associated with this review, such as the thorough trustworthiness process at each stage of the review
483 (search strategy to data extraction), it is important to recognise a number of limitations. First, as this
484 was a mapping review, the focus was on investigating the use of the TA method, with less focus on
485 synthesizing results from included studies to draw overall conclusions. Second, papers were excluded
486 if they had not sampled athletes or exercisers (e.g., coaches, judges); therefore, the issues discussed
487 relate only to studies involving the TA method that have been employed with these population
488 samples. Third, eligible papers that were not peer-reviewed articles or had not been written or
489 translated into the English language may have been excluded, leaving the findings potentially open to
490 publication and language bias. While we recognise these limitations due to the nature of the mapping
491 review we employed, many of these limitations could not be avoided.

492 **Conclusion**

493 In this review, we aimed to identify and synthesise TA research within sport and exercise. We cover
494 15-years' of publications and found that the majority of publications within the previous seven years.

495 The review is the first of its kind to detail the nature of TA method employed, what the TA method
496 was used for, contextual information, study designs, and TA training in published studies that have
497 used the TA method in sport and exercise. By doing so, we identified several limitations associated
498 with previous research that has involved the TA method, while also offering suggestions for future
499 research to ensure consistent and best methodological practice when adopting the TA method.
500 Finally, this review provides directions for future researchers using the TA method to further expand
501 the scope of research and enhance methodological rigour.

502 **Disclosure Statement**

503 The authors report there are no competing interests to declare.

504 **Data Accessibility Statement**

505 The authors confirm that the data supporting the findings of this study are available within the
506 article [and/or] its supplementary materials.

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