

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

Michael McGreary

@mike_mcgreary

Keele University

M.j.mcgreary@keele.ac.uk

*corresponding author

Patricia Jackman

@Trish_Jackman

University of Lincoln

PJackman@lincoln.ac.uk

David W. Eccles

@DavidWEccles

Florida State University

Deccles@admin.fsu.edu

Amy Whitehead

@a_whitehead1

Liverpool John Moores University

a.e.whitehad@ljmu.ac.uk

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

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

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

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

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

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

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

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

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

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

Despite the growing use of the TA method to explore in-task cognitions of athletes and exercisers since the development of this approach by Ericsson and Simons (1993), there has been no review of how this method has been used in sport and exercise. Given the emphasis placed on methodological rigour and high-quality research in sport and exercise psychology (Schinke et al., 2021; Smith & McGannon, 2018), it appears timely and important to synthesise and appraise current use of the TA method within sport and exercise psychology, to aid researchers who wish to use this method in future. Therefore, the aim 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. Specifically, we aimed to answer the following research questions in relation to sport and exercise psychology research: (a) what is the

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

Method

Design and Protocol

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

Eligibility Criteria

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

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

Information Sources and Search Strategy

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

Screening Process

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

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

Data Extraction and Synthesis

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

Transparency and Openness

The study design, methods used, and data are described in detail. We cited the research articles included in the review appropriately in the text and in the reference list. As outlined, we followed the Evidence for Policy and Practice Information-Centre methods and procedures for a systematic mapping review and synthesis (Gough et al., 2003). The review was not pre-registered, but all materials relevant to the review are presented in the main article or supplementary files.

Results

Of the 5,340 records identified through the electronic and manual searches, 36 studies published in 32 articles published between 2008 and 2023 satisfied the eligibility criteria (see flow chart; Appendix 4). The main reason for exclusion at the full-text stage was that articles did not fully satisfy the inclusion criteria pertaining to the TA method, which was reporting using Ericsson and Simon's (1980, 1993) TA method.

[INSERT TABLE 1 AROUND HERE]

Main Synthesis

The synthesis of key information related to each of the review questions is presented in Table 1. Findings pertinent to each research question are presented in the following sections.

Nature of Method Employed

In the majority of studies, the TA method employed appeared to be consistent with Ericsson and Simon's (1980, 1993) proposed method ($k = 32$; 88.89%). Although claiming to have used Ericsson and Simon's (1980, 1993) TA method, the remaining four studies (11.11% - Oliver et al., 2021; Rose & Parfitt, 2010; Welsh et al., 2018; Whitehead et al., 2015) were coded as 'other' for TA method employed because the description within the study of the TA method was not consistent with and, in some cases, was antithetical to the TA method described by Ericsson and Simon (1980, 1993). In three of these other studies, participants were encouraged to explain their thought processes (i.e., provide Level 3 verbal reports, which Ericsson and Simon's method is explicitly designed to avoid) rather than to simply verbalise their thoughts as they occurred (i.e., provide Level 1 or Level 2 verbal reports),

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

Research Questions

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

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

Contextual Information

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

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

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

Study Design and Research Paradigm

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

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

TA Training

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

Discussion

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

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

Theoretical Misconceptions

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

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

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

Methodological Considerations

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

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

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

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

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

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

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

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

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

Future Research and Applied Implications

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

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

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

Limitations of the Review

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

Conclusion

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

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

Disclosure Statement

The authors report there are no competing interests to declare.

Data Accessibility Statement

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

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