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Pushing the Envelope: Implications of the Special Issue on the Impact of the Work of K. Anders Ericsson for Future Research and Application in the Area of Expertise and Expert Performance

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Abstract

The mission of this concluding paper of the special issue on the impact of the work of K. Anders Ericsson is to consider how we can "push the envelope" in relation to research and application in the area of expertise and expert performance. To this end, we present an integration of some of the points made in the special issue papers and interpret these in the light of our own understanding of research and practice in relation to expert performance. The paper begins with reflections on our own personal perspectives on Ericsson and his work and continues with a consideration of the influence of Ericsson's work in terms of scholarship and in the public domain. The paper then follows with two considerations about how we might now attempt to advance research and two considerations about how we might advance application, regarding the work of Anders Ericsson.

Keywords

Deliberate practice, expert team, mental representation, skill acquisition, skilled performance

Introduction

The mission of this concluding article of the special issue on the impact of the work of K. Anders Ericsson is to consider how we can "push the envelope" in relation to research and application in the area of expertise and expert performance. One of the seven principles of deliberate practice outlined by Ericsson and Pool (2016), pushing the envelope involves taking the performer, in this case the researcher or practitioner, outside their normal comfort zone in an attempt to try skills just beyond their current abilities. To this end, we will attempt to integrate and interpret some of the points made in the special issue articles in the light of our own understanding of research and practice in relation to expert performance.

We begin the paper by thanking the authors of the special issue papers for their contributions. We then offer reflections on our own personal interactions with Ericsson and a consideration of the influence of his work in terms of scholarship and in the public domain. We then present two considerations about how we might now attempt to advance research, and two considerations about how we might advance application, regarding the work of Ericsson. Our considerations are partly personal and undoubtedly partial views, but we feel that,

along with the other fine contributions that this issue comprises, these considerations will help push the envelope in this important and interesting field.

Acknowledging the Contributions of the Authors of the Special Issue

We (David Eccles and Kevin Harris) would like the thank the journal editors, Guillermo Campitelli and Zach Hambrick, for the invitation to edit the special issue, and the authors of the contributions of the issue: Joe Baker, Jeffrey Barsuk, Tiffany Bisbey, Neil Charness, Kyle Harwell, S. Barry Issenberg. William McGaghie, Eduardo Salas, Daniel Southwick, Allison Traylor, Diane Wayne, A. Mark Williams, and Bradley Young. We would like to thank the authors first for the quality of the articles. They were a pleasure to read, review, and learn from, and they offer much for the reader interested in research and application concerning Ericsson's work on expert performance. In addition, we would like to thank the authors for their celebration of Ericsson's life and work, and their accounts of personal interactions with him. One legacy of Ericsson's work is a friendly, collaborative, and competent community of researchers who are motivated to continue to work on the puzzles involved in becoming an expert and usefully disseminate the results of this work to help others.

Understanding Ericsson's Work by Understanding a Little More About Ericsson

The authors contributing to this special issue have done a good job highlighting Ericsson's superlative academic standing and pronounced influence in the public domain. How many scientists have published one of the most cited papers in the first 100 years of the leading journal in their field, in this case *Psychological Review* (Ericsson & Simon, 1980; see Kintsch & Cacioppo, 1994), and have also influenced the songwriting of a pop star, in this case Justin Bieber (see Harwell & Southwick, 2021, this issue)?

I, David Eccles, recall that in 2003, on arrival at Florida State University (FSU) as new Assistant Professor, I was intimidated by Ericsson. For one thing, it was his height. He was a tall man! But more than anything, it was his academic standing. An early encounter with him involved a lunch meeting. When I arrived at the restaurant, Ericsson was sitting with a gentleman who turned out to be Roy Baumeister, another member of FSU's faculty. Baumeister is one of the world's most cited psychologists, so he and Ericsson were both very well known. I felt enormous imposter syndrome!

So how did Ericsson end up being a giant in the field of the psychology of expert performance? It's said that to know the person one must know the work, and so we present here a few anecdotes about our personal knowledge of Ericsson. Of course, our recollections offer only two narrow perspectives on the person who was Ericsson, but we think they tell a useful story, nonetheless.

Ericsson would sometimes begin talks by describing how, when he was a child in his native Sweden, his father would say to him that "anybody can do anything, but the challenge is to figure out how." Harris and Eccles (2021, this issue) report that Ericsson described how his father created natural experiments and asked his son to generate hypotheses to explain the phenomena he observed. Ericsson clearly received some early socialization in terms of the origins of human performance, as well as encouragement of his intellectual curiosity and application of scientific methods.

Ericsson's work habits also indicated that the "anything" he had decided to do was become an expert scientist—and that he had figured out how to do that. He described how he rose early in the morning to undertake some work while he was fresh, and the world was quiet. He showered before travelling to his office, and he liked to live just a few minutes' drive from there, so he could come and go with ease. Until dinner time, he worked in his office, then returned home. After dinner, he traveled back to the office staying until about 10 p.m. when he returned home to bed. Ericsson claimed that he more or less followed this routine each day of the year except Christmas Day, when he would work only for half a day. He also had a couch in his office, which he said enabled him to rest when needed during the day. I

(Eccles) can recall being at a conference together, where Ericsson was invited to a late evening social event, which he politely declined saying that he needed an early night to be fully recovered for the following day.

Readers familiar with the deliberate practice framework (Ericsson et al., 1993) will observe parallels between these work practices and this framework. Ericsson's route to becoming an expert scientist appears consistent with an attempt to accumulate thousands of hours of deliberate practice. In addition, consistent with the effort constraint on deliberate practice proposed within the framework, Ericsson appeared to attempt to obtain the rest and sleep required in a given day in order to recover in time to re-engage in deliberate practice the following day, with the overarching aim of being able to sustain this pattern of behavior for almost every day of the year. Regardless of one's position in the enduring nature-nurture debate, Ericsson was impressive to the extent that he appeared to embody and live out his theories about the origins of human performance.

Ericsson's Scientific Contributions

The papers in this special issue indicate that in two major ways Ericsson has informed, and in many cases transformed, the thinking and practices of scientists, practitioners, and the broader public. First, as Charness (2021, this issue) proposes, Ericsson and Herbert Simon (1980) helped reintroduce verbal reports as a method for understanding thinking after an absence of the use of verbal methods, which were deemed "suspect," during the behaviorist era (Ericsson & Simon, 1980, p. 216). Ericsson and Simon proposed that there were, indeed, reasons to treat verbal reports as suspect, as Nisbett and Wilson (1977) had demonstrated earlier in their own review of the reliability of verbal data. However, Ericsson and Simon proposed that these reports are reliable under specific conditions, and they proposed a theory of verbalization as a basis for these conditions and then outlined research methods that would satisfy these conditions for use by researchers. This work was transformative, affording researchers a way to reliably, and under controlled conditions, trace cognitions, and identify mental representations underpinning ongoing observable behaviors.

Second, as most of the papers in the special issue highlighted, Ericsson has helped swing the pendulum in the enduring nature-nurture debate back from nature and towards nurture by proposing two related concepts: (a) expertise is identified on the basis of observable, reproducible superior performance and is unrelated to social status or experience in a given domain and (b) expert *performance* is acquirable by most people via engagement in extensive deliberate practice. We believe we can capture why this challenge by Ericsson is transformative, and even, to use Young et al.'s (2021, this issue) word, provocative, by considering the implications of this challenge at a societal level.

For one thing, the Expert Performance Approach first proposed by Ericsson and Smith (1991) places an emphasis on defining expertise on the basis of observable, objectively measurable, and reliable superior performance on representative tasks; that is, on "real" tasks that represent the essence of a given domain such as, in medicine, placing a central line (Harris et al., 2020). Thus, Ericsson's approach rejects social status or experience as a basis for identifying expertise. Expert performance, as proposed by the Ericsson approach, is unrelated to reputation, professional success or popularity, family background, experience or tenure in a given field, titles, number of presentations or performances, and so on. Plainly, the approach says, "It is what you can do, not who you are, that matters." This apparent irreverence is, of course, consistent with the Enlightenment principles of equality and egalitarianism that inform modern democratic constitutions. Nonetheless, the approach remains transformative and even provocative by the way that it divests the power of individuals, such as those in professional domains, with much accumulated experience and elevated social status.

A second transformative proposal is that superior and expert performance is accessible by most people via engagement in extensive deliberate practice. The proposal challenges what McGahie et al. (2021, this issue) eloquently describe as the historical premise in academic psychology that individual differences in the

formation of expertise are grounded in heredity (Galton, 1869). In addition, Ericsson's approach involves pinpointing the extent to which cognitive adaptations following extensive engagement in deliberate practice account for and explain observed increases in performance. To the neophyte, experts' performance standards can appear so extraordinary that it is tempting to view them largely as the product of innate talent; consider in this regard one of the well-worn go-to phrases of the excited sports commentor, which is "you just can't teach that."

However, if researchers are able to identify (a) that expert performance can be explained, at least in part, by the use of acquired cognitive strategies and (b) how these strategies are learned via engagement in practice, then the initial developmental steps to expertise instantly appear more accessible and thus the achievement of expertise more realistic (Eccles & Arsal, 2015). The exemplar research here, of course, is the memory training studies by Ericsson et al. (1980) in which several individuals, including the well-known subject SF, transformed their memory abilities by an order of magnitude following engagement in hundreds of hours of deliberate practice. Careful use of cognitive process tracing methods, including Ericsson and Simon's (1980) think aloud method, revealed that these increases in performance were mediated by acquired memory strategies.

The evidence for these strategies, and similar strategies that appear to explain superior and expert performance in other domains, led Ericsson and Kintsch (1995) to propose a more general memory theory, long-term working memory (LTWM). LTWM proposed that following extensive deliberate practice, performers need not be constrained by the limits of working memory, which impose limits on more novice performers. Consider that individual differences in working memory are considered predictive of (i.e., place limits on) cognitive functioning, particularly during the ongoing performance of tasks, and thus are predictive of the ability to acquire skills and attain occupational and professional success. However, Ericsson and Kintsch (1995) proposed that extensive deliberate practice in a given domain results in the development of cognitive mechanisms such as retrieval structures that effectively leverage both the unlimited capacity of long-term memory and the rapid and reliable access afforded to working memory.

Consider once again the social implications of this theory. As described, the historical premise in academic psychology is that individual differences in the formation of expertise are grounded in heredity, and, historically, the evidence of individual differences in working memory capacity does not invite the reader to challenge this premise. But a key message sent by Ericsson and Kintsch (1995) is that aspiring experts need not be concerned about individual differences in working memory. They need only to focus on engaging in extensive deliberate practice because, over time, they will adapt in ways that effectively allow them to circumvent these natural limits on memory and processing (Eccles, 2008).

To summarize, Ericsson's emphasis on observable superior performance as the definition of expertise means that one cannot be held back on the basis of a lack of experience, reputation, and rank, or an "inappropriate" family background or social status. In addition, his proposal that expert performance can be attained via especial cognitive strategies acquired via engagement in deliberate practice, and irrespective of individual differences in basic cognitive abilities, means that one cannot be held back on the basis of one's genetics. Again, we can see here how these approaches are consistent with enlightenment values including egalitarianism, and in turn with the rhetoric of the New World: Expertise is obtained based on what you do (hard work), not who you are (social status, genetics). And we are not alone in our social interpretation of Ericsson's work. Consider Sternberg's (1997, p. 300) summary of Ericsson's position: "Ericsson, of Swedish origin, represents the American philosophy even more extremely than do Americans—the philosophy that everyone is equal means that everyone can do anything that anyone else can do." Be reminded that we are not proposing here our particular stance in relation to the nature-nurture debate; we offer some thoughts on this debate elsewhere in this special issue (Harris & Eccles, this issue). What we are doing here is to illustrate how Ericsson's work has been transformative within

academia and at a societal level.

Two Considerations for Future Research Directions Concerning Ericsson's Work

We tasked the authors of the special issue with identifying remaining questions and future research directions concerning Ericsson's work. The authors responded with some general calls to action: To work collaboratively in order to move beyond advocating for extreme stances concerning nature or nurture, to consider the role that artificial intelligence or machine learning could play in augmenting deliberate practice, and to continue refinement of our understanding of what deliberate practice encompasses, along with why it should lead to improved performance. The authors also proposed a range of more specific lines of research that would help answer some of these calls. We have room here to discuss only two of the most common lines of research proposed by these special issue authors: (a) detailed retrospective studies of the qualities of deliberate practice accounting for the development of expert performance and (b) longitudinal studies of the development of expert performance, with a particular focus on understanding the development of mental representations.

Detailed Retrospective Studies of the Qualities of Deliberate Practice Accounting for the Development of Expert Performance

There have been few detailed studies of the qualities of deliberate practice engaged in by experts during their development, and especially few studies of adjustments to deliberate practice activities made over the development period as the performers increased their level of skill (e.g., Charness, this issue; Young et al., this issue). Most extant studies of the developmental practice profiles of experts have involved tests of the monotonic benefits assumption of the deliberate practice framework, which is that the amount of time an individual engages in deliberate practice is monotonically related to their acquired performance level. To this end, researchers have provided a definition of deliberate practice to expert performers and then asked them to retrospectively report the amounts of hours of deliberate practice they engaged in during each year of their careers (Eccles, 2020; Young et al., 2021, this issue). Typically, these studies have not considered what types of skills are being practiced in any great detail. As such, we call for research involving detailed examinations in a range of domains (e.g., aviation, medicine, sport, etc.) of the qualities of deliberate practice engaged in by expert performers.

One potential research approach with which to answer this call is the *detailed retrospective interview procedure* proposed by Côté et al. (2005). The approach is oriented to a sports science audience but offers a procedure that could be applied to a range of domains. In the procedure, experts are asked to think back over their careers, with reference to specific events, about the various practice and training activities they engaged in and developmental milestones they achieved. A limitation of the extant studies of quantities of deliberate practice is the use by of general questions about practice activities over broad time intervals such as during a typical week within a given year of development. The interview procedure proposed by Côté et al. (2005) attempts to address this shortcoming by guiding participants to draw on their episodic memory (i.e., memory for specific events), which typically yields more reliable data than do responses to general questions (Ericsson & Simon, 1980). An example of a specific event would include attending, as a child, a week-long math camp during a summer vacation that involved an hour per day of one-to-one instruction by a math tutor. The respondent would be guided to attempt to recall the details of a given session with regard to the instruction provided and the math exercises engaged in.

The procedure proposed by Côté et al. (2005) also includes careful considerations for assessing data reliability. The procedure directs the researcher to identify from within the expert's developmental timeline those events that are likely to be independently verifiable; in turn, the procedure directs that the researcher must attempt to verify these events. For example, a participant reporting completion of a particular professional skills course in medicine could be asked to provide evidence of attending this course—

evidence such as completion certificates with dates. Similarly, reports by an athlete that they were selected as a young person to attend a prestigious training camp might be documented in the archive of a local newspaper.

A side note here is that Young et al. (2021, this issue) also highlighted that there have been few studies of the three constraints on engagement in deliberate practice proposed in the deliberate practice framework (Ericsson et al., 1993). One of these is the resources constraint, which proposes that engagement in deliberate practice is constrained by a lack of resources including money, instructional expertise, and training facilities. The procedure proposed by Côté et al. (2005) provides an opportunity to assess one aspect of the resource constraint because it includes an examination of the quality of training resources available to expert performers during their development. Resulting data on training resources might lend themselves to independent verification. For example, reports by an expert musician about attendance as a young person at a renowned music school near home (i.e., indicating the availability of a convenient and available training resource) might be verifiable via available newspaper archives.

The procedure proposed by Côté et al. (2005) has been applied by researchers and mainly within studies in the sport domain. For example, Law et al. (2007) used the procedure to compare practice activities involved in the development of performance in rhythmic gymnasts at two performance levels: Olympic standard and international standard. However, closer examination of these studies typically reveals that, while researchers have assessed multiple types of deliberate practice, they typically still utilize only a few broad categories of practice types. For example, Law et al. (2007) assessed practice time spent in five gymnast practice activity types: warm-up, ballet, technique training, routines, and conditioning. Future studies should prioritize inclusion of greater detail in the variety of possible deliberate practice activities that characterize the domain of study with a view to pinpointing which activities, and which adjustments to activities over time, best predict current performance levels.

Longitudinal Studies of the Acquisition of Expert Performance, with a Particular Focus on Understanding the Development of Mental Representations

As Charness et al. (2021) and Young et al. (2021) (both this issue) propose, there are few longitudinal studies of the development of expert performance in which engagement in deliberate practice and the development of mental representations are carefully tracked over time. The memory studies involving SF provide one template for future studies of this kind (Ericsson et al., 1980). To elaborate, laboratory-based studies are needed in which novices' mental representations are tracked via think aloud protocols as they engage in controlled amounts of deliberate practice over relatively short time periods (e.g., months) on standardized representative tasks (see Harris et al., 2020). Examples might include simulated central line placement, math problem solving, and golf putting.

Also needed are more ecologically valid studies that involve regularly testing, such as twice yearly, intact populations of aspiring experts (i.e., not necessarily novices) in various domains as they increase their skill level across their careers. During testing, their half-yearly engagement in the deliberate practice of key representative tasks would be retrospectively assessed and their mental representation development would be assessed via think aloud protocols elicited during the performance of these representative tasks.

These types of studies would establish associations between engagement in deliberate practice with mental representation development and in turn with performance on tasks representative of a given domain. Thus, these studies would illuminate what types of practice result in the development of those mental representations responsible for superior performance. As Harwell and Southwick (2021, this issue) propose, the role of mental representations in mediating the expert performance has been overshadowed by a research interest in deliberate practice. While deliberate practice attracts interest because it is the driver of change on the pathway to becoming

an expert, it is worth considering that what is being driven, which is the enhancement and refinement of a set of mental representations, is actually the psychological agent of expertise. In fact, we have seen reviews provided for psychology-related journals of studies of the relationship between engagement in deliberate practice and current performance levels in which the reviewers have commented that the studies do not contain any psychological concepts!

Although not the primary emphasis here, longitudinal studies would also provide an opportunity to further disentangle the impact of environmental and genetic factors in relation to eventual performance. Do novices (particularly the youngest ones) on an "equal footing," in terms of objective measures of performance, when entering a domain remain closely matched or begin to diverge performance-wise following engagement in differential levels of deliberate practice over time? Similarly, do novices with disparate scores on entry to a domain become more alike performance-wise over time following engagement in similar levels of prolonged deliberate practice, or do the performance gaps remain over time? Such an endeavor would be quite consistent with the ambitious Study of Mathematically Precocious Youth in which a selection of the highest performing youth, based on standardized test scores, were to be tracked for a span of at least 50 years (e.g., Lubinski et al., 2001).

Of course, a well-recognized challenge of longitudinal studies is that, by definition, they require much time to complete, and even more time and labor is required where think aloud reports are used as a measure of mental representation development. These types of studies are easily foregone in a world concerned with "productivity." Charness (2021, this issue) proposes that grant funding is required to support time and labor-intensive work of this kind, yet it is a challenge to obtain grant funding. Still, if we are to push the envelope, we need to move beyond cross-sectional studies comparing differentially skilled performers (cf. Arsal et al., 2016) to begin the study of mental representation development as it occurs with engagement in deliberate practice.

Two Sets of Considerations for Enhancing Application of Ericsson's Work

Articles in this special issue of the *Journal of Expertise* present authors' observations of the perceived limits on the applications of Ericsson's work, as well as misapplications and misinterpretations of this work. Based in part on these observations, we now outline two sets of considerations for enhancing application in this area and help push the envelope. These considerations include (a) how to apply deliberate practice to training teams and (b) how to make Ericsson's work more accessible.

Considerations About Applying Deliberate Practice to Training Teams

Authors of several papers raised concerns about how the concept of deliberate practice is presented by Ericsson et al. (1993) as applicable only to individual performers when so many tasks and domains are characterized by people working in teams. Charness (2021, this issue) discussed that while the original 1993 paper on expert musicians considered the individual components of practice, such as an individual refining a technical aspect of playing their instrument, it did not consider the need by this individual, and the remaining musicians that orchestras comprise, to combine their playing in a coordinated way that produces coherent and enjoyable music. Bisbey et al. (2021), McGahie et al. (2021), and Young et al. (2021) (all this issue) also discuss how the focus on individuals in the deliberate practice framework does not help us understand how expert teams can be developed via deliberate practice.

We now offer some thoughts that we hope will contribute to understanding the possibilities for using deliberate practice in team contexts. Let us consider first why there is an emphasis on individuals in the deliberate practice framework. Ericsson et al. (1993) found that musicians rated practice alone as most relevant for improving performance and one of the most effortful activities, at a level comparable with performing competitively and taking lessons. In addition, accumulated time spent practicing alone across the musicians' careers also predicted their current level of performance, a relationship that Ericsson

et al. (1993) came to label as the monotonic benefits assumption. Ericsson et al. (1993) proposed that being alone during practice provides the environmental conditions allowing full effort and attention to be allocated to practice so that the performer can most effectively monitor ongoing performance and correct errors. The presence of others, by comparison, is distracting. Practicing alone is also under full control of the individual performer, so the performer can easily add individual practice sessions. By contrast, practice in a team setting requires others to be present. Consequently, the individual team member cannot add practice hours easily, which places a constraint on their accumulation of deliberate practice over time.

We have established why practicing alone is considered important in the deliberate practice framework. Now let us turn to the limits of the "practicing alone" component of deliberate practice within teams settings. As Bisbey et al. (2021, this issue) have proposed, an expert team appears to involve more than a team of individual experts (see also Eccles, 2010; Eccles & Tenenbaum, 2004). This is because individual experts in a team typically cannot operate alone during performance: Teamwork is required. Team members must coordinate their actions, which means that they must carefully relate their actions to those of others in terms of (1) action timing (I must do this before you do that), (2) action type (I will do task component A while you do task component B), and (3) action location (Place the clean clothes in Bin X for me to collect, and I will place the dirty clothes in Bin Y for you to collect). Consequently, it is not enough for a team member to draw only on their own mental representations of how to complete given team task because these mental representations might not relate effectively to other team members' own mental representations of the task. For example, I might think that I should do task component A while you do task component B, but you might think that you should do task component A while I do task component B. The result in this situation is we will get in each other's way trying to do task component A, and task component B will not get done at all.

Researchers have proposed that coordination in teams is made possible when teams achieve shared mental models (Bisbey et al. [2021], this issue). This means that team members get to the point mentally where their mental representations (a.k.a. models) are the same, as they relate to a given task the team is attempting to complete. For example, I know that I will do task component A and you will do task component B, and you know the same (i.e., that I will do task component A, and you will do task component B). In addition, we each know that the other person knows this (Eccles & Tenenbaum, 2007). This shared mental model state in teams manifests itself in our everyday language as "getting on the same page." In addition, in dynamic tasks, where the environment changes and requires the team to adapt their responses, the team must update and maintain their shared mental models during ongoing performance. Plainly, teams must not only get on the same page when they begin a task, but they must stay on the same page in the face of changes to the task. A final consideration is that, because teams involve more than one person, the only way that mental models can become shared across the various team members is via social interaction. Specifically, achieving and maintaining shared mental models (a) requires team members to communicate and (b) is made easier when team members are provided with leadership.

Thus, functioning in a coordinated way in a team involves attaining and maintaining shared mental models via effective communication and leadership, which involves interacting with others. At first glance, it might seem impossible to use deliberate practice to build skills when operating as part of a team, given that deliberate practice requires the individual to practice alone. However, we propose that forms of simulation can be used by learners to engage in deliberate practice in simulated team settings while actually alone, allowing them to concentrate effectively and to add hours of practice at their discretion (e.g., Harris et al., 2017). Simulations useful for this purpose are those that represent the presence of others, the requirement to coordinate with others, and the communication with others needed to achieve this coordination (i.e., via the development and maintenance of shared mental

models). Even low-level simulations, such as reading written scripts of scenarios (e.g., a sudden weapons system failure on a naval ship), can be used to support the learner's mental imaging of the various actions needed to achieve coordination (e.g., immediate communication of the weapons failure to others on the ship).

Consider also how a learner might use a low-level role-play approach of practicing communication with others so that coordination can be achieved. For example, the learner might be alone in a room and talk aloud, then imagining or speaking aloud the verbal responses of others, and then verbally responding to these imagined responses. Learners could also record their verbal interactions and listen to them later to identify weak areas to target during the next practice session. They could also solicit feedback from a more knowledgeable instructor to this same end. Of course, this low-level approach is unlikely to be as effective as practicing with a real team, but it does afford learners maximum concentration and control over how much they practice, in line with the deliberate practice framework. This trade-off between the fidelity of the practice environment and the advantages of practicing alone might be reduced with the use of highly realistic simulations. As technologies advance, become more portable, and become cheaper and thus widely available, high quality video presentations and use of virtual reality will allow performers, who are actually alone, to interact virtually with others in ways that closely represent real scenarios. Given the strides made in the last 50 years in the fidelity of flight simulators, as an example, it is entirely plausible that simulators will soon offer superlative quality scenarios in which to train alone but with virtual others—anywhere and at any time.

Considerations About How to Make Ericsson's Work More Accessible

The challenges of effectively applying and disseminating Ericsson's work have been highlighted by the following in this issue: Harris and Eccles (2021), Harwell and Southwick (2021), McGaghie et al. (2021), and Young et al. (2021). The attention paid to Ericsson's work by popular science writers and journalists is arguably both a blessing and curse. Ericsson was clearly keen to help a broad audience understand the individual's potential for performance gains through deliberate practice. Nonetheless, academics find effective dissemination of their work difficult for all kinds of reasons, which include various costs in terms of time and labor helping writers and journalists fully understand the science. And even when writers and journalists do a good job, and many do, in this time-constrained and information-rich modern world, people will always absorb simple, clear, and confident messages more easily than nuanced, complex, and cautious ones, yet the latter tend to characterize science. On this basis, we make a call here for increasing the accessibility of Ericsson's work so that academics, practitioners, and the broader public can understand and apply his important and useful work more easily.

As Harwell and Southwick (2021, this issue) document, not until late in his career did Ericsson engage in a popular science book, which was published with science writer Robert Pool (Ericsson & Pool, 2016). Nonetheless, as McGahie et al. (2021, this issue) acknowledge, Ericsson enjoyed helping others, including medical professionals, learn about the applied implications of his work. In what would be one of my (David Eccles) last in-person meetings with Ericsson, a Christmas Eve lunch with our colleague Bob Eklund at FSU, Ericsson said that he was looking forward in his upcoming retirement to spending more time consulting with professional organizations to help them understand his perspectives on skill development and how they might be beneficially applied.

We argue that one barrier to Ericsson's goal of helping others understand and apply his work is that it can be challenging to understand fully—even for academics—because the work is carefully researched and prepared, and concerns abstract and complex psychological concepts. For example, as a reader, reviewer, and editor of journals, at least in my own field of sport psychology, I (David Eccles) have found that scholars interested in using think aloud protocols often struggle to understand fully the underlying theory and so make mistakes in applying the methods. The Ericsson and Simon (1993) text in

particular is quite challenging for the reader. These problems led me to write a more accessible chapter in a methods text about these methods (Eccles, 2012) and, later, an even more accessible journal article on this topic with a PhD student (Eccles & Arsal, 2017). The journal article's title is designed to advertise the article's accessibility, being "The think aloud method: What is it and how can I use it?" The article presents worked examples from a published study, involving Ericsson, that employed these methods (Arsal et al., 2016). Both the chapter (Eccles, 2012) and the journal article (Eccles & Arsal, 2017) have been well received, with the latter becoming among the most cited articles in the journal that the article is published in. Clearly, there is an appetite for accessible presentations of Ericsson's work.

But perhaps the most urgent area for attention concerns clear and effective messaging to the broader readership. This readership includes practitioners such as instructors, educators, coaches, and support staff working in various fields from medicine to the military and from sport to our formal education systems. The readership also includes the public, who have enthusiastically embraced representations of Ericsson's work in popular texts and via the internet, as documented by Harwell and Southwick (2021, this issue). We continue to see misinterpretations of Ericsson's work, particularly as it relates to the concept of deliberate practice, in a range of outlets. For example, only recently did we find ourselves explaining that the proposal that deliberate practice is relatively unenjoyable does not mean that practice must be deliberately designed by instructors for learners so that it is definitely unenjoyable! But consider that, even in the popular text by Ericsson and Pool (2016), there is no way to quickly locate the key principles of deliberate practice because they are located within one of the middle chapters, and no succinct presentation of pitfalls that can occur when attempting to interpret and apply these principles. Yet these presentational considerations are key to making complex materials accessible to a broad audience. Therefore, we take the opportunity below to present the principles of deliberate practice and pitfalls to avoid when attempting to interpret and apply these principles. We do this for two reasons. First, we hope our efforts go some way towards fulfilling Ericsson's wish to help apply his work effectively. Second, we hope to provide an example for others of how to present Ericsson's work in an accessible way.

The Seven Principles of Deliberate Practice and an Example of Their Application

Table 1 displays the seven key principles of deliberate practice as outlined by Ericsson and Pool (2016). We use an EXPERTS acronym, adapted from Eccles, Leone, et al. (2020), to help capture the principles in the table.

Table 1. Seven Key Principles for Applying Deliberate Practice

EXPERTS principles of deliberate practice	Brief description of principle
Established training techniques	Deliberate practice develops skills for which established and effective training techniques have been developed
e**X**isting skills as building blocks	Deliberate practice involves building step-by-step on, and modifying prior skills
Pushing the envelope	Deliberate practice involves constant attempts at skills just beyond current ability level
Enhancing mental representations	Improved performance depends on more sophisticated mental representations
Responding to feedback	Getting better requires obtaining and responding to feedback from informed instructors
Total application and focus	Deliberate practice requires full attention and conscious actions
Specific goals	Deliberate practice involves setting and focusing on specific goals for improvement

We now provide an example of applying all the principles of deliberate practice to show how employing deliberate practice is different from one common approach to improving, which is to simply "up the hours" on the target task. Our example involves the sport domain but could just as easily have involved other domains: medicine, military, airplane piloting, first responding, music, math, and so on.

Recreational golfers Jen and Bob currently meet one day per week to play 18 holes with friends. Jen and Bob each want to improve their game. To this end, Jen decides to "up" her golf hours and thus meets her friends for an additional 18 holes per week. However, after six months, Jen has seen no change in her handicap.

Bob does not "up the hours" but engages in deliberate practice. He books one hour per month with a golf coach, Zach. Zach analyses Bob's game and identifies putting as a weakness (i.e., **R**esponding to feedback, the letter R from the EXPERTS acronym, above). Zach prescribes established techniques aimed at getting the fundamentals of putting right (**E**stablished training techniques). These techniques require Bob to read putts more carefully and make step-by-step adjustments to his current putting stance and movement (e**X**isting skills as building blocks).

Bob also books one hour per month with a sport psychologist, Kesha, who helps him set a goal of spending every other week's golf session not with friends but practicing his prescribed techniques for one hour on a practice green (**S**pecific goals). Kesha suggests Bob practices alone to help him fully concentrate and remind himself before each session of his specific practice goals for the session (**T**otal application and focus & **S**pecific goals).

Each monthly visit to Coach Zach involves further feedback and attempts by Bob to put this guidance into action (**R**esponding to feedback). As Bob begins to master the fundamentals of putting, Zach prescribes new practice techniques so that he can attempt more difficult putts (**P**ushing the envelope). Gradually, Bob gets better at reading greens, judging the weight of putt needed, and sensing when his putting is "off" and needs adjusting (**E**nhancing mental representations). After six months, Bob's handicap has improved.

Finally, consider the time commitment for these different approaches. Jen added 18 holes per week to her original weekly 18-holes. 18 holes takes 4 hours to play, so her total time spent in golf per month is 32 hours. Bob replaced every other week's 18 holes with one hour per week of putting practice, and he met his coach and sport psychologist for one hour per month each. Thus, Bob's time commitment per month is 12 hours, which is 20 hours less than for the "upping the hours" approach. Consequently, in line with the deliberate practice framework, the deliberate practice approach is more effective *and* efficient than the upping the hours approach.

Pitfalls to Avoid When Interpreting and Applying These Principles of Deliberate Practice

Having provided some guidance about key principles of deliberate practice, we now turn our attention to common pitfalls in interpreting and applying the principles of deliberate practice, several of which are adapted from Eccles, Leone, et al. (2020). Outlining this information here should help those interested in learning more about using deliberate practice avoid these pitfalls.

Pitfall 1: Forgetting That Deliberate Practice is Not Simply Practice. Deliberate practice is not just about showing up to practice sessions; it is about the quality of practice at those sessions. Learners must avoid the mental trap of simply undertaking practice sessions but forgetting that these sessions will be effective only if they are goal-led, feedback-informed, and so on, in line with the principles of deliberate practice outlined above. Practice sessions should not be planned if learners are not able to apply the principles of deliberate practice during the sessions.

Pitfall 2: Overlooking Areas of Performance That Could Be Improved Via Deliberate Practice. Some areas of performance are often considered fuzzy, soft, and difficult to describe, such as the ability of an appointed team leader to inspire their team. These soft skills are often claimed to involve more art than science. The

danger of this thinking is that these areas of performance can be overlooked. Learners and their instructors must consider all areas of performance when planning to improve via engagement in deliberate practice. For example, Harris et al. (2017) identified a social barrier to effective team functioning in medicine. Individuals new to a team or more junior on a team often will not voice information or ideas critical to team decision-making to their team members due to perceptions of having a lower status in the team. Harris et al. (2017) recommended targeting this problem by deliberately practicing being assertive, which might include role playing the interruption of a team of more senior medics during ongoing performance such as a challenging intubation. It is not difficult to appreciate how the skill of interrupting in teams might be overlooked within curricula design in favor of deliberately practicing more easily defined technical skills such as the behavioral steps involved in an intubation.

Pitfall 3: Thinking That Deliberate Practice is About Out-Practicing or Out-Working Others. For us, this has been one of the largest pitfalls in interpretations of deliberate practice (Eccles, Balk, et al., 2020). Becoming an expert requires engagement in deliberate practice over an extended period such as tens of years. However, learners must limit their *daily* engagement in deliberate practice because such practice requires total application and focus and thus is demanding. If learners do not limit their daily engagement in deliberate practice, they will not recover mentally and physically for next day's practice session and in turn will not sustain their daily engagement in deliberate practice over the years required to reach the expert level. Based on Ericsson et al.'s (1993) original research with musicians, deliberate practice must be limited to 4 hours per day and this practice time must be broken in multiple sessions, each lasting no more than 80 minutes. The remainder of the day must be spent in comparatively restful activities; for insights into the nature of these resting activities, see Eccles and Kazmier (2019). Thus, social pressures to out-practice or out-work others should be avoided given the limits on daily deliberate practice.

Pitfall 4: Avoiding Attempts to Improve a Skill Because All the Principles of Deliberate Practice Cannot Be Applied to That Skill. For some skills, it is difficult to apply all the principles of deliberate practice. If this is case, then simply strive to get as close as you can to applying these principles, as Ericsson and Pool (2016) propose. For example, there might not appear to be established techniques available to train a given skill. However, for most skills, some training knowledge usually exists, even if it is informal in nature; for example, it might be described in an internet video uploaded by a skilled hobbyist rather than carefully prepared by recognized experts. Also, applying the principle of responding to feedback is challenging when top instructors are expensive and scarce. Again, the next best option might be the internet, which often has tutorials on how to perform skills that can be compared against the learner's attempts and forums allowing learners to upload videos of their performances to receive feedback from more knowledgeable performers.

Conclusions

Considering how we can push the envelope in relation to research and application in the area of expertise and expert performance was the mission of this concluding paper of the special issue on the impact of the work of K. Anders Ericsson. We hope that our efforts here will help the researcher and practitioner to push the envelope, take them outside of their normal comfort zones, and encourage them to move their work beyond current limits. We would like to thank the contributors to this special issue again for their contributions. We would also like to make one final nod of respect to our friend and colleague Ericsson, who to us was simply "Anders." We will miss our conversations with Anders, especially when we made some bold assertion, which often prompted him to smile slightly and say, in his distinctive Swedish American accent, "So, how confident are you that [X or Y] is actually the case?" We knew that Anders was about to challenge us with his famous quarter-dollar wager. Now, without those opportunities to engage with him, our lives are much less rich—although we may have more pocket change, because Anders invariably won those bets!

Author's Declarations

The authors declare there are no personal or financial conflicts of interest regarding the research reviewed in this article.

The authors declare that they conducted the research review reported in this article in accordance with the Ethical Principles of the *Journal of Expertise.*

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