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Vol. 18, No. 1, June 2007, pp. 57–58

COMMENTARY ON ERICSSON *ET AL.*

Nature and nurture interact to create expert performers

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Ericsson and colleagues have provided an exhaustive review of research on the role of training in the acquisition of expert performance and their framework continues to be invaluable for examining issues in this area. However, several researchers have noted limitations with the theoretical foundations of the deliberate practice approach (see Abernethy *et al*., 2003). Rather than reiterate these, I will focus on the authors' dismissal of the possibility of innate factors explaining expert performance—an issue relevant to my own work.

Several times in their review, the authors reject innate factors by noting that improvements in skill occur in small incremental steps rather than in 'abrupt' leaps, which we are to assume would reflect the profile of development if innate factors constrain skill acquisition. I believe this is a straw man. No recent evidence from the field of genetics indicates that expertise spontaneously appears and most researchers agree that a devoted apprenticeship to 'deliberate practice' is an absolute necessity for performance at an elite or expert level. In the language of logic, researchers generally agree that deliberate practice is *necessary*; disagreement exists regarding whether it is *sufficient*. In sports, for example, an athlete with a genotype allowing them to complete large amounts of high intensity training without suffering from injury would be at an advantage over an athlete with a less resilient makeup. However, upon examination it would appear that training was the distinguishing factor between the two athletes. Although I agree with the authors' position that the identification of individual genes that explain expert performance has been largely unsuccessful, research is beginning to mount supporting the role of specific genes as possible *contributors* to elite performance (e.g., ACE gene; Baker & Davids, in press).

Ericsson and colleagues contend that any 'healthy' individual has the potential for expertise. Healthy persons, in their perspective, do not include 'individuals who have identified and medically recognized deficits due to birth defects, accidents, diseases, and known chromosomal and other well-understood genetic disorders'. This

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010057-2

DOI: 10.1080/13598130701350635

definition of health suggests that individuals can be neatly classified as either healthy or not healthy, a position found to be seriously flawed by the World Health Organization (WHO, 1946). Furthermore, this definition is problematic for understanding the interplay between genes and practice because it allows anyone demonstrating a clear genetic advantage (cf. Schuelke *et al.*, 2004) to be easily dismissed.

Perhaps the most significant obstacle to the acceptance of Ericsson *et al.*'s position is their implication that everyone has the genes necessary for the acquisition of expertise provided they are able to put in appropriate deliberate practice. This notion of '*genotypic equivalency*' does not seem to fit with basic evolutionary or genetic theory grounded in the necessity of genetic variability for promoting natural selection over time (Baker & Davids, 2007). If current understanding of evolutionary theory is correct, random and non-random genetic variation in all areas of human performance and behaviour are critical for continued species evolution.

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Routledge
Taylor & Francis Group

COMMENTARY ON ERICSSON *ET AL.*

The genesis of creative greatness: mini-c and the expert performance approach

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Creativity scholarship generally focuses on one two forms of creative performance: eminent or everyday. Eminent forms of creative performance—often referred to as *Big-C* creativity—focus on clear examples of creative expression (e.g., Mozart's musical compositions, Einstein's theories, Dickenson's poetry, Coltrane' jazz, Gandhi's social justice). Everyday forms of creativity—referred to as *Little-c* creativity—focus more on the creativity of everyday life, accessible to most anyone (Runco & Richards, 1998). For instance, a jewelers' unique setting of stones in a pendant or an interior decorator's arrangement of furniture in an office building are examples of little-c creativity. Rarely are Big-C and little-c creativity conceptualized as existing on the same developmental continuum (for exceptions see Cohen, 1989; Beghetto & Kaufman, in press). Consequently, Big-C is often represented as genetically inspired—the creative genius; and little-c as more widely distributed (see Runco & Richards, 1998; Sternberg *et al.*, 2004; Kaufman & Baer, 2006, for reviews).

Our recent theoretical work (Beghetto & Kaufman, in press) has focused on developing the construct of mini-c creativity and illustrating how all levels of creative performance follow a trajectory that starts with novel and personally meaningful interpretations (mini-c), which can then progress to intrapersonally judged novel and meaningful contributions (little-c) and even develop into superior creative performance (Big-C). The mini-c construct highlights how all healthy individuals have the developmental capacity to produce creative contributions (even Big-C creativity). The work by Ericsson *et al.* provides compelling empirical evidence in support of this developmental perspective, demonstrating the important role that deliberate practice plays in superior creative performance.

The expert performance framework aligns well with our own (and others'—see Cohen, 1989; Sawyer *et al.*, 2003) more developmental views of creativity which posit that Big-C performance is more likely influenced by intense deliberate practice

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010059-3

DOI: 10.1080/13598130701350668

within a particular domain than some special, genetic endowment of a few individuals. Indeed, research on expert performance and creative eminence highlights the importance of sustained, deliberate practice (see Simonton, 1994; Ericsson, 1996). Genius-level creators typically require 10 years of preparation in a domain of expertise to reach world-class expert-level status. Studies by Bloom (1985) and Hayes (1989) indicated that a decade of intensive preparation is necessary to become an international performer in a broader range of domains including chess, sports and the arts and sciences.

Although we find ourselves in general agreement with much of what is presented in the Ericsson *et al.* article, we want to highlight an important area of divergence. Ericsson *et al.* argue that the criteria by which superior (or Big-C) creative performance is deemed acceptable must follow scientific, objective guidelines. Ericsson *et al.* are leery of 'subjective' expert evaluations of expert performance (and provide compelling reasons for their skepticism). Although we understand why their strict criteria is necessary for establishing their argument and setting the conditions under which their assertions can be empirically tested, we also find it important to point out (as systems theorists of creativity have argued, e.g., Csikszentmihalyi, 1999) that Big-C creativity, by definition, is a subjective judgment of the gatekeepers of particular domain. Big-C creativity typically reflects the type of creativity that radically shifts a field (see Sternberg *et al.*, 2002). It may take decades to truly ascertain the actual impact. Creativity that seems revolutionary may turn out to simply be a footnote to history. What this often-unspoken requirement means is that it is nearly impossible to conduct a study of living people in Big-C. The only hints that we can get at determining which creative persons or products will be accepted by future gatekeepers can sometimes be through the subject assessment of current gatekeepers.

Recognizing the subjective role of gatekeepers in determining Big-C creativity does not undermine the argument that deliberate practice trumps genetic endowment in superior creative performance (Big-C), but rather highlights the importance of carefully examining the role that deliberate performance plays (among the confluence of other factors, e.g., luck, circumstance, zeitgeist) in the developmental trajectory from mini-c to little-c and ultimately, Big-C creative expression.

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Vol. 18, No. 1, June 2007, pp. 63–64

COMMENTARY ON ERICSSON *ET AL.*

Parts do not make a whole. Lumping expertise into one whole

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I appreciate the opportunity to comment on a scholarly review that uses a theoretical perspective to link research. This has been a missing element in our field (Coleman, 2003). Ericsson and colleagues propose a framework for studying exceptional performance and evaluating the evidence on that basis. Their theory is narrower than it should be because it accepts only one research paradigm as its foundation. Alternate views of science and reality exist (Denzin & Lincoln, 2005). The theoretical map created by the authors is less than the territory. Adherence moves researchers to study limited notions of talent.

The authors present a powerful argument by staying true to the tenets of their theory, which assert that learning and deliberate practice is the most parsimonious explanation for development of expert performance in competitive domains. The paper proposes standards for judging research. These statements are exemplary of the attributes of a post-positivistic quantitative research paradigm, especially subject selection, control, observation, reproducibility and prediction.

Besides the theoretical proposal which I admire, many of the findings are particularly helpful for understanding exceptional talent. Significantly, the paper effectively challenges the innate ability position by proposing ways to prove that point; weakens the 'g' notion of general ability; provides persuasive evidence on deliberate practice; and underlines the roles of human choice and setting in talent development. Superior performance clearly does not happen by accident.

The authors in creating a map of the territory forget that multiple maps can be drawn of any territory. Their particular map, drawn from the post-positivistic paradigm, set parameters for inquiry that are too limiting for my understanding of science and interest in the phenomenon. Two aspects of the theory particularly trouble me.

Wringing out social judgment and subjectivity in the study of exceptional performance sets an absolute universal criterion which transcends time and place

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010063-2

DOI: 10.1080/13598130701350700

and ignores the reality I understand. It overlooks that development happens in domains as well as in individuals so that the description of exceptional performance and criteria change over time. The criterion for excellence is established by humans living in cultures. The preciseness of measurement does not make it less relative, only less visible that judgments were made. The objective view of exceptional performance is less interesting to me than the subjective experience of exceptional performers. After original performers set the new standard, others experts reproduce it.

Searching for standard elements of future exceptional performance is paradoxical. These markers are found by working backwards from the performance. Business and the military have long adopted this task analytic approach. The parts are reconstructed to be equal to the sum in training. The problem is that the sum of the parts does not equal the performance nor are the parts less complex than the final performance such as syllabication and reading. Even if we place persons in situations analogous to what the original exceptional performance occurred, as in the Kepler analogy, the place of that historical contribution cannot be removed from the culture. See Feldman and Fowler (1997) on this point. Researchers, given their criteria for research, can only work back from the ordinary experts. Exceptional talent provides the window into the process of unique performance.

Ericsson and colleagues' explanation seems appropriate for a theory of the development of domains that are bounded, less abstract and intellectual, have complex routines, and have a substantial physical component. Little evidence for domains that are open ended, such as poetry, theoretical physics, architecture, painting, is presented. Those domains most interest me.

The issues I have mentioned have the effect of limiting research by encouraging the study of narrow domains with substantial physical component. Ericsson is not studying those individuals who advance and redefine a domain. A science of exceptional performance should study them. The authors do not rule that out. Yet, it is unlikely that their theory would move researchers in that direction because original work is irreproducible. Their system lumps exceptional performers together in a domain. We study the central tendency of groups because the original experts cannot meet the theoretical standards of reproducibility. This is too limiting.

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Vol. 18, No. 1, June 2007, pp. 65–66

COMMENTARY ON ERICSSON *ET AL.*

If you can't measure it—it doesn't exist

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The field of gifted and talented research is in serious need of scientific work of this calibre, as distinct from theories, models and anecdotes. The authors state there is no evidence either that some individuals have an innate head start to reach an élite level, or that DNA limits achievement in healthy individuals. Ericsson's earlier work demonstrated the strong effects of deliberate solitary practice on high-level performance, quite differently from mindless drill (see Ericsson *et al.*, 1993). We need to move, they say, from measuring indefinable latent abilities to isolating reproducible stage transitions of superior performance. It is true that if (and it's a big if) we could isolate and reproduce the criteria for, e.g., high-level creativity we could teach it.

However, too many false leads are presented here (somewhat repetitively) as 'typical' approaches to giftedness: imaginary demons which the authors then verbally slay. A notable example is identification and educational provision on the basis of one criterion, such as IQ, with all its well-recognized faults: a crude approach dominant only in the US. The authors spend very many pages showing that gifts do not arise 'abruptly and naturally… without training'. But does a single professional today even claim that learning and environment have no part in gifted achievement? Again, they say that if one cuts out the obligation to look at innate abilities, there is no need for longitudinal studies. How shortsighted, because we know that gifts appear and disappear at different times in a life (Arnold & Subotnik, 1994; Freeman, 2006). And if we could all do relatively better, as they (and many a school teacher) have so rightly claimed, it does *not* prove that DNA is limiting (other than in height and body size), nor in how many directions and to what extent we could improve.

Worryingly, the authors say that experts are 'not necessarily' any better at their jobs than novices, including financial advisors and doctors. They also accept the benefits of being in the right place at the right time for the recognition of excellence, though without mentioning the subtle dynamic influences of the social context itself (see Freeman, 2005). As evidence, they have chosen simplistic research by Qin and

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010065-2

DOI: 10.1080/13598130701350726

Simon (1990) in which American university students came up with the same ideas as Kepler when presented with knowledge available in Germany circa 1600, failing to recognize that the students had already absorbed post-Kepler understanding. Nor do their calculations reflect Kepler's personal contribution, his courage under threat of heresy, and the terrible imprisonment of his mother as a witch.

The point about the human sciences is that they are concerned with humanity. Skills-training in a laboratory, typically in memory, moving up from the mastery of one learning stage to another, is not the kind of apprenticeship which Leonardo da Vinci had. In that kind of setting, so much of the precursors of genius are absorbed, consciously or not. Though genius may not be scientifically provable, neither is the proposal that any healthy individual can be a Mozart. The fact that nobody has never made an adult genius from a random healthy child does not deter the authors. Objective research can indeed demonstrate that superb concentration over a minimum of 10,000 hours can produce superb performance, but world-changing greatness is another matter (Freeman, 1998). Their purely scientific approach—if you can't measure it, it doesn't exist—may provide some reproducible structure of the dynamics, but it can neither accommodate Winner's (1996) 'rage to master', Subotnik and Jarvin's (2005) 'charisma, nor the vital leap of faith that changes life for millions of people'

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Vol. 18, No. 1, June 2007, pp. 67–69

Routledge
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COMMENTARY ON ERICSSON *ET AL.*

Predictably, an unconvincing second attempt

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Less than a decade ago, Howe *et al.* (1998) attempted to demonstrate the lack of scientific support for the concept of innate talent (IT). Most (≈75%) of the 30 commentators to that target article clearly disagreed with their core position. In spite of Ericsson's current efforts to counter or circumvent the major objections expressed then, most of them remain valid here. Here are some of the problems.

1. I noted a very selective presentation and interpretation of the scientific literature, especially with regard to cognitive abilities, their most common measure (IQ), and their heritability.
2. The author readily rejects information, especially of a retrospective nature, when it contradicts his positions, but as readily accepts it when it supports his thesis (e.g., Bloom's retrospective interviews).
3. The author describes the IT perspective in a biased, almost caricatured way (e.g., stating that IT defenders believe in the 'sudden' appearance of expert performance before any training).
4. The text accumulates 'evidence' that is in fact irrelevant to the core question, for instance a long description of the necessary role of deliberate practice (DP), a role no IT defender denies.
5. The author's discussion of physical abilities and their (lack of) heritability omits lots of strong favorable evidence (see Entine, 2000, for a fascinating and 'user friendly' overview).
6. Ericsson proposes deliberate practice (without IT of course) as a more 'parsimonious' explanation; it is advanced not only as a necessary 'ingredient' of expertise, but also as a construct almost sufficient to explain expert performance. Yet, nowhere in this article do we find statistical data on the explanatory power (e.g., effect sizes, percentages of explained variance) of that construct. He does offer statistically significant differences between group means; but, with sufficiently large samples, statistically significant differences can easily mask effects with limited *substantial* explanatory power.

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010067-3

DOI: 10.1080/13598130701350742

Lack of space does not allow a more detailed description of the above comments (see Gagné, in press). In the remaining space, because of the illustrative significance of prodigies, I will focus on Ericsson's treatment of information about these extremely precocious individuals. He brushes aside testimonies about prodigies, including one I had cited (Gagné, 1998) in my comments to Howe *et al*'s (1998) target article about violinist Sarah Chang. It was the extremely laudatory judgment of her master teacher at the Julliard School of Music when Ms Chang was only 5 years old. In Ericsson's view:

> … such evidence is not based on reproducible observable performance but on anecdotes that typically cannot be verified and in particular replicated under controlled test conditions. Such evidence is of little value to scientists and will not contribute to sound empirical foundations.

What a strange requirement to ask for controlled replication of publicly known achievements! Here is a short excerpt from Ms Chang's official biography (www.pittsburghsymphony.org/pghsymph.nsf/bios/Sarah+Chang):

> Born in Philadelphia to Korean parents, Sarah Chang began her violin studies at age 4 and promptly enrolled in the Juilliard School of Music, where she studied with the late Dorothy DeLay. Within a year she had already performed with several orchestras in the Philadelphia area. Her early auditions, at age 8, for Zubin Mehta and Riccardo Muti led to immediate engagements with the New York Philharmonic and the Philadelphia Orchestra.

Here are my questions to Ericsson.

1. Are these accomplishments 'verifiable' facts about her extremely rapid progress?
2. Do her performances at age 8 qualify as 'expert' performance?
3. Do her 8-year-old achievements compare favorably with those of most 'expert' *adult* violinists studied by Ericsson?
4. Is this a clear exception to the 10-year rule?
5. And, especially, does Ms Chang's early progress exceed by 'galactic' units the learning pace of those thousands of young violin learners who 'screech' their way through years of Suzuki classes? My own answer is predictably 'Yes' to all these questions.

Finally, let me add that Ericsson's introduction of prodigies' adolescent problems and (frequent? occasional?) lack of adult eminence is totally irrelevant in the discussion of the extremely rapid development of their early talent.

For now, the defense rests.

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High Ability Studies
Vol. 18, No. 1, June 2007, pp. 71–73

COMMENTARY ON ERICSSON *ET AL.*

Investigating the role of domain general mechanisms in the acquisition of domain specific expertise

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The expert performance approach championed by Ericsson *et al.* provides a scientific way forward for research on giftedness, and offers exciting new ways to further our understanding of the determinants of high ability within a particular domain of expertise. While the methods the authors use are commendable and are likely to further our understanding of the nature of expertise, I question whether they offer the most complete way to investigate the role of domain-general mechanisms (whether or not they are innate) in the acquisition of domain-specific expertise.

First of all, not all domains of expertise are alike. Domains differ to the extent which they rely on physical and mental abilities. Most of Ericsson *et al.*'s examples focus on domains where the main determinant of expertise-acquisition is the development of motor functions, not mental functions. It is an open question whether executive functions are just as malleable as motor functions.[1] One cannot collect data on the malleability of physical abilities, and claim that the same holds in equal measure to mental abilities. Whether anyone (regardless of general cognitive ability) can be trained to be an expert physicist to the same degree that they can be trained to be an expert dart thrower is an interesting and open question.

Secondly, Ericsson *et al.* are quite right in questioning the extent to which general cognitive ability constrains the ability to acquire expertise. It is true that a person's IQ score says very little as to their eventual capacity to learn a complex skill. The only way to assess an individual's capacity for intelligent functioning is to actively test that person's limits. This can be achieved through studies that further our understanding of learning processes, and sources of individual differences in these processes. Individual differences researchers have indeed attempted to understand the role of domain-general ability in skill acquisition. When humans with a wide range of general cognitive ability encounter a novel task, the critical components of performance in the initial stages are general reasoning ability and working memory

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010071-3

DOI: 10.1080/13598130701350767

capacity (Ackerman, 1988; Kyllonen & Christal, 1989; Anderson, 1993). It is only after this bottleneck is overcome that initial working memory resources play less of a role, and perceptual speed and psychomotor abilities take over in importance. Comparing world-class *experts* to novice *experts* to investigate the role of innate ability in expertise acquisition will not get at this important bottleneck, as only individuals who have already passed this important bottleneck will be studied.

Thirdly, Ericcson *et al.*'s methods don't allow for a complete understanding of the domain-general learning mechanisms that support skill acquisition. By focusing on a *specific* domain of expertise, important domain general learning mechanisms may not be identified simply because they aren't sought. To more fully understand the role of domain-general learning mechanisms, researchers must study individual differences in the ability to acquire knowledge that is independent of any particular domain of expertise. Recent research suggests interesting new avenues for the study of individual differences in domain-general learning mechanisms. The study of implicit learning, traditionally studied using experimental methods, is starting to be looked at from an individual differences perspective. Recent results suggest that individual differences in implicit learning may not be related to the central executive functions of working memory, or even fluid intelligence (Reber *et al.*, 1991; McGeorge *et al.*, 1997; Gebauer, 2002; Unsworth & Engle, 2005). If this research continues to replicate, it would suggest that humans may have multiple domain-general learning mechanisms (Mackintosh, 1998). Since implicit processes play a large role in skill acquisition, a further understanding of the source of individual differences in these domain-general learning mechanisms may be able to inform the expert performance approach.

Hopefully by investigating a wide range of domains of expertise (that differ in the constellation of mental and physical abilities they rely on), a wide range of individuals (with differing levels of general cognitive ability, personality traits, and domain-specific abilities), and a wide range of psychological approaches (experimental, individual differences) within every stage in the expertise acquisition process will we come to a deeper and more complete understanding of the mechanisms mediating expert performance and the role of domain-general cognitive abilities.

Acknowledgements

The author would like to thank Daniel Bor for providing valuable references, and James C. Kaufman for bringing his attention to this commentary opportunity.

Note

1. Fascinating recent research does indeed suggest that central executive functions are quite malleable, as are the brain structures underlying these functions. In one study (Klingberg *et al.*, 2002), children with ADHD received an intensive training program to increase their working memory capacity. Not only was working memory capacity increased through training, but so was their performance on a test of general fluid intelligence. As a result of training, the children also showed a reduction in symptoms traditionally associated with AHD. Similar

improvements were also found for those without ADHD. In another study (Olesen *et al.*, 2004), healthy adults received working memory training for 5 weeks. As a result of training, brain activity related to working memory increased.

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Vol. 18, No. 1, June 2007, pp. 75–77

COMMENTARY ON ERICSSON *ET AL.*

Achievement sometimes requires creativity

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Ericsson and his associates continue to produce impressive research on talent and exceptional performances. The objective of their featured article—'a general theoretical framework that establishes scientific criteria for acceptable evidence of superior reproducible performance, which any theory of exceptional performance must explain'—is certainly laudable and worthwhile. I do have several concerns.

First, I am unconvinced that there is, as Ericsson *et al.* claim, no evidence for constraints on the attainment of achievement. Everyone does have enormous potential for growth and improvement, but that potential is not unlimited—and it is not universal. There are individual differences in potential, though we each have some level of potential. Much depends on the concept of 'constraint'. Certainly there are constraints at the extremes of the range of reaction (i.e., the gene-environment collaboration), but the range between the extremes may be enormous-especially in the case of achievement.

Second, there is some genetic evidence for creative thinking (see Runco, 2007). There is also neuroanatomical evidence, though it is less direct. This is relevant because neuroanatomy is strongly tied to inheritance. I do not much care for the word 'innate', and will not use it, for it sometimes connotes inflexibility. It is as if genes lead directly to behavior or capacity, which of course is not the case. They merely provide potential.

I have other reasons for questioning the claim that 'remarkable achievements of eminent individuals have traditionally been explained by the concept of innate talent or giftedness'. Research on eminent creative persons shows clearly their persistence and immersion (Albert, 1990; Gruber, 1974, 1988; Csikszentmihalyi, 1996). Family experience is also extremely influential, and often studied (see Albert, 1980; Sulloway, 1990; Runco & Albert, 2005). Genetic conceptions of giftedness are not the norm.

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010075-3

DOI: 10.1080/13598130701350791

As a matter of fact Ericsson *et al.* largely ignore the role of creativity. This is unfortunately not uncommon in studies of achievement. There are numerous possible paths to achievement, some individuals attaining it by virtue of their creativity, but others by virtue of their traditional intelligence, charisma, or contrarian ways. Not all eminent persons are creative (Runco, 1995). Yet some are, which means that achievement cannot be fully understood without acknowledging the possible or occasional role of creativity.

The likelihood of varied paths also suggests a potential problem with the methodology and general expert performance approach. In Ericsson *et al.*'s own words, 'the expert performance approach starts by identifying reproducibly superior performance and then works backwards to explain the development of the mediating mechanisms'. The methodology is in some ways (e.g., experimental control) impressive, but again, just because one path leads somewhere (to expertise), this does not mean there are no other paths. What occurs in the controlled setting may or may not represent what is actually done in the natural environment. Then there is the question of the representativeness of the tasks. In fact, there is one component that is probably not reproducible: problem discovery. Creative achievement often depends on it (Jay & Perkins, 1997; see Runco, 1994 for a review), but it is, by definition, something which cannot be given to examinees, nor to anyone, and thus it is very difficult to examine in any objective matter. It is much like the intrinsic motivation that often characterizes creative performance in that it cannot be given to people. They must find it for themselves or it is not truly intrinsic.

Ericsson *et al.* are close to this perspective when they wrote, 'the production of a specific innovative idea cannot be reproduced at will'. They then added the dubious claim that 'it is unlikely that a single individual could generate and develop an original innovative idea more than once'. Why not? Gruber's (1986) studies of Darwin and Piaget found that they had good ideas with great regularity. On a smaller scale, Runco *et al.* (2000) have assessed the frequency with which ideas are produced in the natural environment. Then there is the view that generating good ideas is easy—but implementing them is difficult (West, 2004). Frankly, I see several points in Ericsson's work which would benefit from a reading of the extensive literature on creative ideation and divergent thinking. It would also be important for them to consider the most recent research. Older work on ideation and divergent thinking is easy to criticize; it has obvious flaws. Methodologies have changed dramatically in the past 10–15 years, however, and it is that more recent work that accurately informs us about creative cognition.

I fully agree with Ericsson *et al.* about the problems with social judgment, and indeed have been trying to make the same point (e.g., *Creativity need not be social*, Runco, 1999b; *Creativity is always personal and only sometimes social*, Runco, 2006). I have even published a list of notable 'misjudgments' about talented individuals and important discoveries and inventions. They are often overlooked or go unrecognized for surprising periods of time. Consider in this regard that Mendel's work on genetics was not cited for decades; the first Wright Flier (flown at Kitty Hawk, NC) was not placed in the Smithsonian for nearly 50 years; and Capitol and Decca Records initially decided to pass on marketing the Beatles in the US (Runco, 1999b). Even experts can misjudge creativity and talent.

These observations are intended to assist Ericsson *et al.* and complement their fine research. It certainly is useful research, and promises to be even more useful when the small gaps and questions I have identified are taken into account.

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High Ability Studies
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COMMENTARY ON ERICSSON *ET AL.*

On the advancement of the expert performance approach via a deep understanding of giftedness

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This paper presented well the achievements of the expert performance approach. The 10-year rule of expertise is one of them, a very practical rule. For example, when I meet a new physician, my first question always is: 'How many years of practical experience do you have?' 'Do not send me a bunch of non-experts to see my baby. Send me a paediatrician who has at least 10 years of experience', I demanded the administration of the Children's Hospital in Ottawa and forbade non-experts to enter my room. They promised to send me their best expert. The following morning Dr Johnson came, saying that he had five years of experience and he thought that he was an expert. You can imagine my disappointment.

However, the expert performance approach does not answer some important questions directly arising out of its main statements. For instance, after Professor Anders Ericsson's presentations to a professional audience working in the area of giftedness on 7 February 2006 in Germany, Professor Christoph Perleth raised an interesting point: 'Even if I deliberately practice extremely hard everyday, I know I will not become an Olympic champion'. The cognitive–developmental theory of giftedness can help in this regard (Shavinina, in press). According to the theory, everyone with Olympic or similar aspirations has to start from childhood or as early as possible. The first years of a child's life are characterized by a number of sensitive periods—periods of the child's heightened and very selective responsiveness to everything that is taking place in the world around him or her (Shavinina, 1997). During these periods:

> … certain influences have a big impact on all course of the individual development by provoking one or other deep changes. In other periods, the same influences can be neutral or even give an opposite impact on child development. Sensitive periods coincide fully with… the optimal terms of learning. (Vygotsky, 1956, p. 278)

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010079-4

DOI: 10.1080/13598130701350882

Gifted development is the uneven, asynchronous, or dyssynchronous, and, hence, unusual development, beyond which there are periods of heightened (cognitive, emotional and social) sensitivity (Shavinina, 1999).

However, this is not the whole story. Sensitive periods—which constitute the developmental foundation of giftedness—accelerate an individual's mental development through the actualization of his or her intellectual potential and the growth of the individual's cognitive resources, which leads to the appearance of a unique cognitive experience. This experience—which consists of conceptual structures, knowledge base and subjective mental space—is a cognitive basis for giftedness. The cognitive experience manifests itself in the specific type of mental representations (i.e., how an individual sees, understands and interprets everything what is happening in the surrounding reality; Shavinina & Kholodnaya, 1996). It means that gifted people have a unique individual 'intellectual picture of the world' (Shavinina, 1997), which is responsible for their exceptional performance and/or achievements. They see, understand, and interpret everything differently. This is true in the cases of child prodigies, Nobel laureates in science and great entrepreneurs (Shavinina, 2004, 2006).

The most important aspect of the uniqueness of the gifted's intellectual picture of the world is the objectivization of their cognition. It means that gifted individuals see everything in an objective manner. Their significance in society:

> … should be seen not only in that they solve problems well and create new knowledge, but mainly in the fact that they *have the ability to create an intellectually objective picture of the world*, i.e., they can see the world as it was, as it is, and as it will be in its reality. (Kholodnaya, 1990, p. 128; italics added)

The unique type of representations is the essence of giftedness.

The cognitive experience serves as a psychological basis for the three main levels of the manifestations of giftedness (i.e., its various characteristics, traits, properties and qualities): intellectually creative, metacognitive and extracognitive abilities, respectively (Shavinina & Kholodnaya, 1996). In other words, the gifted individuals' highly developed intellectually creative, metacognitive and extracognitive[1] abilities are the manifestations of their unique cognitive experience (Shavinina, 2004). Giftedness is a result of the protracted inner process of the construction and growth of the individual's cognitive resources leading to a unique cognitive experience beyond which there are periods of heightened cognitive sensitivity. The cognitive–developmental theory of giftedness therefore explains both the process, or dynamic, aspect of giftedness (i.e., gifted development) and its productive, or resulted, aspect (i.e., the gifted individual's exceptional achievements and/or performance).

This theory helps rectify a few important omissions in the expert performance approach. First, there are no doubts that extended training and deliberate practice improve performance. But it is not entirely correct to assert that starting practice anytime will lead to Olympic gold medals or similar achievements. *The beginning of the deliberate practice should coincide with the sensitive periods in an individual's development.* For example, the famous Canadian hockey player Wayne Gretzky began skating just before turning three, and soon after, his father built a skating rink in their backyard. Gretzky spent hours there, occasionally coming in to have his toes warmed between the hands of his father. Those early years of playing hockey were critical for his amazing success in hockey. Unfortunately, in this light, Professor Perleth will never become an Olympic champion, not even if he follows all prescriptions of Professor Ericsson and his colleagues.

Second, deliberate practice does not improve performance automatically. The deliberate practice leads to the development of a unique cognitive experience and thus eventually changes an individual's mental representations. As the boundaries of the subjective mental space change, the representations become more complex, differentiated and integrated, and, as a result, more unrepeatable (Shavinina & Kholodnaya, 1996). Professor Ericsson *et al.* say about cognitive representations and their modification during deliberate practice, but mainly in the context of metacognition, that is, 'representations that monitor and control the integration of complex behaviour during learning'. The cognitive–developmental theory of giftedness clearly explains why cognitive mechanisms become 'more complex and refined'. For example, based on the position of the expert performance approach I would have to say to my 7-year-old son, who has been playing piano for two years:

> You have to spend 100,000 hours composing symphonies (i.e., deliberate practice) in the years to come, and after that you will produce something like the Fifth Symphony, because your cognitive mechanisms will become more complex and refined.

But this is not the whole story. In light of the cognitive–developmental theory of giftedness I would say:

> You have to spend 100,000 hours composing symphonies in the years to come, and after that you will produce something like the Fifth Symphony, *because you will construct specific forms of the organization of your cognitive experience and, as a result, the unique structure of the mind—which makes the extraordinary (intellectual creative) achievements to be possible. That is, you will develop a unique type of mental representation.*

This is behind Beethoven's, Mozart's, Picasso's and Van Gogh's achievements, as well as the accomplishments of any top achievers in any field of human endeavour. 'Gretzky *sees a picture* out there that no one else *sees*', Boston Bruins General Manager Harry Sinden said (Sinden, 2007, italics added).

Third, the objectivization of the cognition of gifted individuals explains why they are able to accurately predict the future and thus be ahead of their time. *A lack of the objectivization of cognition explains why experts can know so much and predict so badly.* This is because they do not see everything in an objective manner.

Finally, the gifted's unique cognitive experience determines the advanced development of their *metacognitive and extracognitive abilities.* For instance, on many occasions Wayne Gretzky explained his unbelievable success in hockey by his ability to be not where a pack is at the moment, but to always be where it will be in the next moment. Why don't we have hundreds of Wayne Gretzkys? Many practice deliberately and extremely hard, in accordance with the expert performance approach. As Wayne Gretzky's and one of his manager's quotes indicate, he has a unique type of mental representations and, as a result, metacognitive abilities. We do not know for sure whether deliberate practice alone shaped these abilities or it only crystallized them. Anyway, I always repeat to my son before each of his hockey games: ‘Do you remember what Wayne Gretzky said?’

Note

1. *Extracognitive abilities* refer to four interrelated—and at the same time obviously different—components: (a) specific feelings: feelings of direction (in one’s own professional activity and in search of mentors), harmony, and style, including senses of destiny, good ideas, promising and elegant solutions, and feelings of being right, being wrong, or having come across something important; (b) specific beliefs and intentions (e.g., belief in elevated standards of performance and in hard work); (c) specific preferences and intellectual values (e.g., the ‘inevitable’ choice of the field of endeavour and internally developed standards of working); and (d) intuition (Shavinina, 2004).

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High Ability Studies
Vol. 18, No. 1, June 2007, pp. 83–84

COMMENTARY ON ERICSSON *ET AL.*

Talent *and* expertise: the empirical evidence for genetic endowment

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I will focus this comment on the claim summarized in the last sentence of the target article's abstract. To begin, the concept of talent does not require the existence of 'innate constraints to the attainment of elite achievement'. On the contrary, genetic endowment may merely influence the rate at which domain-specific expertise is acquired without imposing any upper or lower bounds on attainment. Thus, empirical research indicates that outstanding creative individuals require less time to master the requisite knowledge and skill than do less creative individuals (Simonton, 2000). In addition, talent may affect the magnitude of performance for individuals with the same acquired level of expertise. Talented persons may 'get more bang for the buck' out of a given quantity of declarative and procedural knowledge. But, again, this enhancement effect does not amount to the imposition of any 'innate constraints'.

An even more fundamental problem is that the authors completely ignore the strong evidence for genetic contributions to both creativity and leadership—two prominent types of distinguished accomplishment. This evidence emerges from a pair of well-established findings: (a) these attainments are associated with a distinctive profile of intellectual and dispositional traits; and (b) the latter traits almost invariably have sizable heritabilities. Given those facts, it logically follows that some portion of those achievements must have a genetic basis. The only issue is the magnitude of the genetic contribution. Is it trivial or substantial?

Fortunately, it is easy to derive a general formula that estimates the impact of innate talent, namely, $h_T^2 = \Sigma\, \beta_j\, r_j\, h_j^2$ (cf. Ilies *et al.*, 2004). Here h_T^2 is the proportion of variance in achievement that can be ascribed to genotypic variation, β_j is the standardized partial regression coefficient for predicting talent criterion T using trait j (controlling for the other traits), r_j is the zero-order correlation between criterion T and trait j, and h_j^2 is the heritability of trait j, where the traits may be defined as any inventory of individual-difference variables for which both β_j and h_j^2 are nonzero. Naturally, to obtain an accurate assessment of h_T^2, β_j, r_j, and h_j^2 should be corrected

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010083-2

DOI: 10.1080/13598130701350890

both for range restriction and for attenuation due to measurement error (see Kuncel *et al.*, 2004).

When this formula is applied to the statistics reported in a recent analysis of emergent leadership (Ilies *et al.*, 2004), I obtained $h_T^2 = .25$. Hence, one quarter of the variance in leader emergence in groups can be attributed to natural endowment. Currently I am applying the same estimation formula to a meta-analysis of the correlates of scientific and artistic creativity (Feist, 1998). Preliminary analyses indicate that between 22% and 36% of the variance in the achievement criteria may have a genetic foundation. Hence, undisputable empirical evidence exists for the impact of genotypic traits on exceptional achievement. Environmental variables, including deliberate practice, explain most but not all of the variance in extraordinary accomplishments. At least for creators and leaders, nature as well as nurture underlies their attainments.

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Vol. 18, No. 1, June 2007, pp. 85–87

COMMENTARY ON ERICSSON *ET AL.*

Exploring the implications of putting the expert performance framework into practice

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We can count on Anders Ericcson and his colleagues to give us well written and articulated arguments that challenge our thinking. Since it is difficult to address the many points and sub-points of their extensive and meaty manuscript, we will limit our comments to two key issues that emanate from the piece: (a) the audiences that the authors address; and (b) the implications of their work for policy.

Potential audience for Ericsson's work

Three audiences can greatly benefit from studying the target article carefully:

1. Researchers who are focused on giftedness in the form of 'g' or other abilities categorized as innate.
2. Practitioners who work with talented individuals in various domains.
3. Researchers who study the process conducted by the second group.

Ericsson *et al.* seem to focus more exclusively on the first group, which is a significant but limited representation of the gifted or talent development community.

Some scholars and practitioners argue that innate talents or gifts are necessary for eventual significant performances or ideas. But no serious scholar argues that innate abilities *are also sufficient* for greatness. We argue that it is just as difficult to isolate the contributions of disciplined practice as it is to isolate innate abilities. The research question that would put this argument to rest is to show how two groups, one with 'abilities' in that particular domain and another without, would perform with identical practice regimes, holding variances such as previous exposure, family values and psychosocial dimensions constant, especially in domains where creativity

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010085-3

DOI: 10.1080/13598130701350916

is the main criterion for renown. In other words, how does one account for people who practice as much as experts, but never achieve that stage of expertise?

The second audience that should be familiar with Ericsson *et al.*'s work is made up of the teachers and coaches who identify and prepare elite performers and scholars. Most members of this group are renowned for their skill in 'knowing talent when they see it'. Of course, by the time they 'see it', it's hard to distinguish how much a candidate's performance is due to practice, abilities, opportunities, personality or passion.

There is yet a third group of audience members, all of whom are familiar with Ericsson *et al.*'s work. This group of scholars draws from the work of the first two audiences. We include ourselves in this third group as those who have studied talent development first hand among concert performers, springboard and platform divers and science professionals. We agree that:

- Disciplined practice guided by an outstanding teacher/mentor is essential to developing exceptionally high quality performance.
- Commitment of years to instruction and practice is also essential.

However, the implications of the research conducted by Ericsson *et al.* have not been sufficiently fleshed out, to the regret of the latter two audiences listed above.

- In some areas where strength, speed and increasingly difficult physical feats of daring are the measures of greatness, money and effort are already going into analyzing training to maximize potential. Will financial support be invested in random assignment of individuals to such a regimen of training to see whether they are competitive? Without such studies, training efforts and practice cannot be isolated from other variables that contribute to the development of champions.
- What does disciplined practice look like when it comes to developing outstanding ideas rather than physically expressed strength, speed and daring routines?

Implications of Ericsson's work for policy

Ericsson *et al.*'s main concern is with the scientific study of giftedness, removed from social context and judgments. Yet the current reality of gifted identification and assessment forces researchers to think about the policy implications of their work. For example, no roadmap for definitive, scientifically-based paths to talent development yet exist. Shall we therefore drop efforts to find and develop talent until such paths are sufficiently scientific? Should we invest whatever money currently exists in talent development programs into ensuring that every person who wants to be a concert violinist, research scientist or sculptor gets the very best teachers? Although this is a cause that meets the criterion of ideas for a perfect world, would such initiatives lead to wise use of resources and human capital? How can we be inclusive enough to ensure that those that might otherwise fall through the cracks are served while excluding those who won't be a good investment or are likely to lose interest?

Most of Ericsson *et al.*'s emphasis lies on practice, yet the role of other variables in producing greatness needs to be addressed. Although practice is an essential component of becoming an expert, factors such as motivation, ambition, etc, are also essential, yet not sufficiently addressed in the target article. For example, according to Subotnik and Jarvin (2005), Juilliard teachers say that a student can be technically perfect, yet if he or she does not possess a 'feeling' for the music, the music can be a failure or not compelling. They acknowledge that there are tricks for mimicking emotion that can be taught to technically adept students, but that audiences respond to genuine interpretation.

We argue that in the imperfect world of limited resources, domain-specific abilities in combination with psychosocial characteristics and excellent teaching contribute to outstanding performance and the generation of great ideas. Domain-specific abilities, whether innate or developed through exposure, attract teachers seeking out protégés. In order to be great, however, an individual must go beyond his or her teachers. We contend that an individual's psychosocial and expressive dimensions are the variables that make the largest impact on a field or audience. For example, Laura Wilkinson, 2000 Sydney Olympic Gold medalist in the 10 meter platform diving event, fractured her foot six months before the Olympics, only began to practice two weeks before the event, yet dove perfectly and won. Because she and her coach did mental imagery instead of physical practice, other factors than practice and expert skill must have been involved in her success.

We look forward to the continuing evolution of the talent development field and welcome Ericsson *et al.*'s scientific examination.

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High Ability Studies
Vol. 18, No. 1, June 2007, pp. 89–92

COMMENTARY ON ERICSSON ET AL.

Cognitive functions of the cerebellum explain how Ericsson's deliberate practice produces giftedness

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A critical issue for Ericsson *et al.*'s proposal is the development of a fully adequate description of neurophysiological substrates for deliberate practice. Ericsson *et al.* do provide two substantial subsections on biological substrates—namely, their subsections, 'Acquisition of superior power, control, and speed of motor activities' and 'Improvement in the selection of actions in representative situations'. However, as it stands, these discussions do not adequately explain the remarkableness of giftedness.

To get at the details of the subtle effects of deliberate practice, Hesheng Liu[1] and I recently proposed a thoroughgoing neurophysiological explanation of the child prodigy (Vandervert & Liu, in press). Our explanation is based upon the *collaboration* of working memory and cognitive functions of the cerebellum (Ito, 1997, 2005; Vandervert, 2003a, b; Vandervert *et al.*, 2007). In our approach all *repetitive* working memory processes taking place in the cerebral cortex (e.g., in deliberate practice) are *adaptively modeled* in the cerebellum (see Ito, 1997, 2005; Chein *et al.*, 2003; Vandervert *et al.*, 2007). When the resulting cerebellar control models are fed back to working memory areas of the cortex, the thought processes of working memory become faster, higher in attentional control, and more appropriately and optimally timed (Akshoomoff *et al.*, 1997; Ito, 1997, 2005; Ivry, 1997).

The above newer role of the 'cognitive cerebellum' (see Schmahmann, 1997; Ramnani, 2006) offers needed detailed support for Ericsson *et al.*'s proposal. In addition to the cerebellum constructing adaptive models of mental activity occurring in working memory, it has been convincingly argued that the cerebellum does this in the form of multi-pairs of models that constitute complex *modular* architectures for mental processes that when fed to working memory functions in the cerebral cortex act to *facilitate the development of new, higher levels of performance* (Haruno *et al.*, 1999; Wolpert *et al.*, 2003). This process comes about through the combination of learned

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010089-4

DOI: 10.1080/13598130701350940

'forward' and 'controller' pairs of cerebellar models. *Forward* cerebellar models are anticipatory/exploratory controls for movement and thought, and *controller* models are automatic controllers that are learned through the repetition of successful forward models. The resulting cerebellar control architecture has been termed Hierarchical Modular Selection and Identification for Control (HMOSAIC) (see Imamizu *et al.*, 2003; Wolpert *et al.*, 2003; see also Leiner *et al.*, 1991; Leiner & Leiner, 1997, for modular specificity between the cerebellum and prefrontal areas of the cerebral cortex.) New, hierarchically-arranged *levels* of the cerebellar control architecture (HMOSAIC) develop *as practice is extended over time*. These levels are direct explanatory counterparts to the stages Ericsson *et al.* describe in their Figure 1.

Cerebellum-mediated stages of deliberate practice

Japan Prize laureate Masao Ito (1993, 1997, 2005) has long made the case that movement and thought are, in terms of cerebrocerebellar system neurology, 'identical' control objects. Thus, in terms of *neural control*, hands, feet, computer keyboards, for example, and all thoughts are equivalent 'control objects'. In describing how pairs of forward and controller cerebellar models work together, Ito (2005) commented on how advances in both motor and mental control would take place at an unconscious level:

> If the forward and inverse [controller] model controls are combined, an interesting possibility emerges [after much practice] that the cerebellum conducts the entire process of thinking … which will not come up to the level of consciousness. This may explain our daily experience that, after repeated trials of learning, a correct answer [or a correct movement] pops out readily without a conscious effort. (Ito, 2005, p. 102)

Because forward models may be uniquely combined with other forward models in HMOSAIC, or variant forward models may be composed from the possibilities of movement or thought spaces already learned (Haruno *et al.*, 1999, 2001; Wolpert *et al.*, 2003), the above process Ito describes would also advance behavioral and mental capabilities to higher, goal-directed levels.

Hesheng Liu and I believe that this process takes place countless times during a developmentally initiated version of deliberate practice as the individual transitions to the development of new, more accomplished levels of the HMOSAIC architecture (Vandervert & Liu, in press). In this regard, we argued how the development of HMOSAIC can be accelerated along modular lines through high attentional control starting in early infancy and thus account for the child prodigy. It is important to note here that the cerebellar modules of the deliberate practice architecture include thought, movement, attentional and emotional components (see Schmahmann, 2004).

In regard to Ito's above comment concerning 'cerebellum-mediated thinking', what 'pops out' due to cerebellar modeling is *either* the well-learned solution to a problem (as Ito suggests) or it is the next silently emerging instance, level or stage of gifted performance. If there is a 'silent' or 'mysterious' mechanism behind the remarkableness of giftedness, I believe it lies here in the 'quietude' of cerebellar modeling within HMOSAIC that occurs in small forward/controller modeling increments during Ericsson *et al.*'s deliberate practice.

Note

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High Ability Studies
Vol. 18, No. 1, June 2007, pp. 93–95

COMMENTARY ON ERICSSON *ET AL.*

Ericsson's three challenges of giftedness research

Albert Ziegler

My comments are split into two parts. In the first part I will try to compose succinct formulations of the three challenges with which Professor Ericsson has confronted us as giftedness researchers. In the second part of my commentary I will pose questions with three main points to Professor Ericsson.

I would first like to say, for the record, that I find it to be of true and noble scientific conduct when a researcher specifies the conditions under which he is prepared to abandon his theories. Professor Ericsson has named these in several passages of his article, albeit in slightly varied expressions. I would like to refer to this as *Ericsson's Challenge I*: Is there empirical evidence that reproducibly superior performance can be reliably predicted by innate talents after deliberate practice has been statistically controlled? Although in recent years Professor Ericsson's attitude towards giftedness researchers was, at times, distinguished by rather severe vehement attacks, I am afraid that the situation giftedness researchers now find themselves in is similar to the situation described in Genesis 18 which depicts the destruction of the city of Sodom: God informed Abraham that he intends to destroy Sodom because of its immorality. Abraham pleads with God to not destroy the city. God agrees that he would not destroy the city if there were 50 righteous people in it, then 45, then 30, then 20, or even 10 righteous people. The Lord's two angels only found one righteous person living in Sodom, Abraham's nephew Lot. I am afraid that out of the thousands of studies on giftedness, among which there are hundreds of longitudinal studies, not one single study has been found which commensurates with Professor Ericsson's absolutely fair testing criteria. We will have to wait and see if among the hundreds of giftedness researchers who have been challenged to compose a peer commentary, one single such study can be named. In fact, I consider Ericsson's Challenge I to be a wake-up call for giftedness research. We are in desperate need of meaningful, conclusive studies, since we, as the body of an empirical science, should no longer be content with continued theoretical argumentation. Also, since existential statements along the lines of

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ISSN 1359-8139 (print)/ISSN 1469-834X (online)/07/010093-3

DOI: 10.1080/13598130701350973

'There is an X' cannot be falsified for logical reasons (unless one is able to search through the entire universe), it is our obligation as giftedness researchers to convincingly verify X, that is innate talents, with methodologically sound investigations and studies.

Ericsson's Challenge II actually conveys an intensification of his first challenge. Recent years have been witness to the development of a trend in which innate talents have been legitimatized with the vague allusion that genetic influences play a part in almost all areas of human achievement. I agree with Professor Ericsson that this, by no means, implies that these genetic influences have been verified for the field of achievement excellence. The fact alone that correlations between variables which are considered to be operationalizations of talent (e.g., IQ) and achievement level, decreases with increases in the degree of expertise should provide enough warning. Therefore, it does not suffice to supply evidence of 'innate' when we are speaking of 'innate *talents*' and *achievement excellence*. Professor Ericsson is fully justified here in reminding us that we, as giftedness researchers, should not be content in relying on deliberations based on plausibility, and rather should take to heart the scientific standards found in every introductory textbook in the verification of genetic influences. I would like to formulate *Ericsson's Challenge II* as follows: Is there empirical evidence for genetic influences on superior performance which result from behavioral genetic studies which fulfil the fundamental standards accepted by the scientific community?

What holds for the prognostication of exceptional achievements should also be applied with a healthy dose of self-criticism to the educational techniques we develop as giftedness researchers. I can well remember an incident which occurred during the conference 'Beyond standards' in Bad Boll 2006 (Ziegler *et al.*, 2006). An Israeli school director directed a question towards an assembly of 50 keynote speakers, as to whether they were aware of a gifted program that demonstrably fosters *exceptional performances*. The half-hearted answers proved to be unsatisfactory to him, and he was fully justified in insisting on hearing, (a) what sorts of exceptional performances the past participants in the most popular programs had achieved precisely (not merely a specific percentage of absolvent with Ph.D. degrees, since gifted programs in most cases accept only a highly selected sample for enrolment anyway and, moreover, he was interested in exceptional achievements); and (b) whether the success of these programs was evaluated under clear scientific controls, which to him meant sound standards as, for example, the inclusion of a control group. In response to the embarrassed silence, the school director inquired with increasing desperation as to whether among the hundreds of thousands of children who had taken part in gifted programs, had not at least one gone on to later win a Nobel Prize or a Fields Medal or something along these lines? I would like to refer to the problem voiced by the school director as *Ericsson's Challenge III*: Is there sound empirical evidence that shows there are persons who exhibit reproducibly superior performance as the result of any gifted program?

I now come to some questions which I would like to direct towards Professor Ericsson. They are concerned with his approach to the acquisition of expertise which

I fundamentally agree with: performance changes as a transition from one state, S[i], to another state, S[i+1].

First, I am interested in the assumed logical and mathematical description of the transitions. In the target article it appears as though the transitions lead to monotone increases and linear achievement growth, in particular one gains the impression that only one single sequence is possible. When, however, a student decides to employ a new learning strategy, then this transition can have detrimental effects on achievement until the learning strategy has been perfected, and thereby might allow for a nonlinear increase in achievement. Also, it is commonly known and widely accepted that persons are capable of acquiring, for example, mathematical competencies in a variety of sequence orders.

The states S[i] to S[i+n] appear to be the states of an individual. However, in line with Csikszentmihalyi (1998), one could also argue that the mind is not the place where genius can be found and can be developed. The location of genius is rather a system which consists of an individual, a cultural domain, trainers and mentors, etc. The progression of states can also be seen as a co-evolution of interacting systems, whereby individuals with growing action repertoires in increasingly potent learning environments under the supervision of increasingly more capable trainers and mentors will be able to further develop their action repertoire (Ziegler, 2005). My question is then, does Professor Ericsson support the opinion that a comprehensive theory of the development of expertise necessitates the consideration of such system driven aspects?

In the target article, Professor Ericsson concedes the elementary scientific possibility that innate talents may possibly have an affect on exceptional achievement. I would like to know what sort of advice he would give to giftedness researchers, should this possibility prove to be founded. Let us for the moment assume that innate talents have been confirmed through behavioural genetic studies. Would he then actually use innate talents to rationalise state transitions, and would he declare the explanatory concepts of cognitive psychology for substandard and denounce their usage (e.g., memory processes, efficient problem solving strategies, knowledge representation)? To what extent does he consider the discussion on distal explanations, such as innate talents to be meaningful, as long as the proximal explanations for state transitions have not been revealed? Shouldn't one first—above all in gifted education—translate all innate talents into proximal psychological variables?

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