Intelligence xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

Intelligence

Introduction to the intelligence special issue on the development of expertise: is ability necessary?

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ARTICLE INFO

Available online xxxx

ABSTRACT

The question asked in this special issue is if abilities are necessary to explain the development of expert performance. The issue consists of eight papers written by experts on expertise. A brief but incomplete summary of these papers is presented in this introduction. Ericsson presents his rebuttal to these eight papers. He argues that much of what has been presented is not relevant to expertise when it is defined as repeatable, high level performance by an adult. The eight authors then briefly respond to Ericsson's rebuttal. This issue is of major importance to intelligence researchers since it was Binet's original goal to find interventions that would undo the correlation between IQ and educational outcome. An example of height and National Basketball Association (NBA) players is used to demonstrate some of the methodological difficulties of expertise research when study samples are selected from experts. Height is largely uncorrelated with either points scored or salary of NBA players nonsensically suggesting that height is not important in basketball. The evidence presented here suggests that intelligence is important in the development of expertise and the lack of correlation with IQ sometimes found is probably due to methodological problems. Despite these problems, research on expertise has the potential of identifying factors that could be important in achieving Binet's goal of undoing the correlation between IQ and educational outcomes in the future.

This special issue presents a series of papers focused on a single question: Is ability necessary to explain the development of expertise? This is an odd topic for *Intelligence* since nearly every article published here shows how intelligence, a measured ability, influences some aspect of human behavior. This question arose from issues raised by the work of Anders Ericsson. Ericsson, Chase, and Faloon (1980) reported a single participant who, with extended practice, increased his digit span to exceptional lengths. Later it was shown that he did this by using a cognitive strategy employing running times that were familiar to him. Ericsson, Krampe, and Tesch-Römer (1993) studied the development of musical talent among various groups of differently skilled musicians and the development of their expertise. From this and much other work, Ericsson derived at least two general conclusions: (1) The development of expertise requires deliberate practice, a particular kind of motivated, focused practice; and, (2) With few exceptions, there is no evidence that ability is required to develop expertise.

Ericsson's development of the concept of deliberate practice is generally applauded as a substantial contribution to our understanding of the environmental conditions most helpful in developing expertise and is not the subject of this issue. The idea that anyone can do anything with 10,000 h of deliberate practice has become nearly institutionalized in parts of the popular press to a degree probably exceeding what Ericsson would support.

However, those who study individual differences in cognition are in general disagreement with the suggestion that abilities do not influence the development of expertise. To put this in the simplest terms, Ericsson argues that anybody can be good at anything. Those who study individual differences counter that, though there are wide ranges of what any person can accomplish, not everyone can do everything to the same

http://dx.doi.org/10.1016/j.intell.2014.02.004
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high level of proficiency. People are limited by their abilities. It is unfair to the less able to claim that with sufficient hard work they can accomplish what those more gifted achieve.

Nonetheless, it seemed appropriate to examine the evidence on each side of the issue. Eight papers from outstanding contributors to the field offer evidence that Ericsson is wrong in his conclusion that ability has no demonstrable relation to expertise. All of the papers in this issue focus on cognitive behaviors though much of what is said here applies to other domains of ability. The eight papers are presented in alphabetical order by first author. These papers are followed by a response from Ericsson. Each of the eight original authors then provides a brief response to Ericsson's comments.

In order to provide an overview of the special issue, the following is a synopsis of each of the papers by alphabetical order of the first author. This is not meant to be a fully inclusive summary of each paper but simply a sampling.

Ackerman (2014, this issue) argues that extreme hereditary or environmental views are "silly" and should be avoided since behavior is always a mix of the two, a position held at least as early as Galton. He argues that there are many situations where equal practice will still result in differences among people though Ericsson would argue that differences should be eliminated with sufficient deliberate practice. Much of Ackerman's paper focuses on methodological problems with expertise research in which experts are self-selected. He discusses in some detail how the development of talent is a complex mixture of abilities, environment, practice, and motivation.

He points to a number of factors that could constrain expertise development including physical limitations, injuries, poor early experience, and aging. He also details methodological problems like restriction in range, poor predictor measures, or psychometric issues like a low base rate that can hinder the study of expertise and lead to unwarranted conclusions. These considerations lead Ackerman to suggest that a multiple hurdle approach is most likely to successfully predict and classify elite performers over time. Interestingly, this is the approach frequently used in the development of elite performance.

de Bruin, Kok, and Leppink (2014, this issue) report data from a prospective study of children learning to play chess. In previous research using more advanced players, some studies have failed to find a relationship between chess skill and intelligence even though the average IQ of advanced chess players is generally higher than that of the population. In addition to IQ and chess skill, the authors also measured motivation, enjoyment, and amount practiced. Though the sample was small, the results are impressive and confirm common sense intuitions. The brief measure of intelligence correlated 0.47 with chess test performance. Though practice correlated negatively with IQ, it correlated 0.19 with chess test performance. Amount of practice was most highly correlated with enjoyment, 0.51. The correlations among variables in this study confirm the path analysis.

The path diagram suggests a reciprocal relationship among motivation, enjoyment, and practice. Both intelligence and practice contributed to chess test performance scores but intelligence was the larger contributor. At least in beginning chess players, intelligence appears to be the more important factor studied. What this study adds is an understanding of the contribution of motivation and enjoyment to the practice of chess skills and this provides a much more detailed model of what leads to expertise and the contribution made by intelligence.

Grabner (2014, this issue) reviews the evidence for the role of intelligence in developing chess expertise. Studies of players just learning to play chess are uniform in showing a correlation of chess playing ability and IQ. Studies that look at skilled players sometimes find a correlation between chess skill and IQ and sometimes do not. Studies that fail to find a relationship between IQ and chess skill are often attributed to methodological problems such as range restriction. It is almost always the case that skilled chess players show a mean IQ substantially higher than the population mean.

Besides surveying the literature, Grabner presents some new analyses of data from a previously published paper which included the largest sample of skilled chess players (90) so far tested. In brief, these results indicated that intelligence measures account for about 30% of the variance in ELO ratings (ratings of chess players based on a standardized point system).

Hambrick et al. (2014) took a different approach to the issue of what causes expertise. They reanalyzed six studies of chess performance and eight studies of music performance to determine what proportion of the variance could be accounted for by deliberate practice. They did this assuming a range of potential reliabilities from 0.60 to 0.90. If deliberate practice is the only thing that produces skilled performance, then it should account for a very high proportion of the variance if not all of it.

For chess performance, about 30% to 45% of the variance was accounted for by deliberate practice depending on the reliability of the deliberate practice measure. For music, from 26% to 40% of the variance was accounted for by deliberate practice, again depending on the reliability of the measure. In both domains, it was clear that a substantial proportion of the variance in outcomes was not accounted for by deliberate practice. If deliberate practice was the only factor determining expertise, as Ericsson argues, the authors of this paper conclude that it should account for a much higher portion of the variance in outcome than it does.

Plomin, Shakeshaft, McMillan, and Trzaskowski (2014, this issue) also took a different approach to the issue of expertise. The majority of the research on expertise has been done in the domains of exceptional memory, chess, music, and similar domains. They argue that such research is designed to answer the question of "what could be" but does not answer the question or even necessarily bear on "what is." As an example, they point to obesity. Though the study of diets and other interventions indicate what could be, they tell us nothing about "what is" the origin of obesity. Further, they propose that the most important questions about the development of expertise are at the intersection of what is and what could be. Knowing what is would be important in determining what could be.

The domain selected for investigation was reading. Expertise was defined as the top 5% on a number of reading tests in a study of 10,000 twins. The top 5% was selected to provide sufficient power for genetic analysis. Results were replicated on the top 1%. Extensive genetic analysis indicated that there was substantial genetic influence on reading in both the expert group (top 5%) and in the remaining group and that the effect of common environment was modest to negligible for both groups. The authors conclude that genetic influences account for more than half the difference between the expert group and the remaining members of the distribution. The similarity of results for the experts and those not designated as experts suggests that the same genetic and environmental factors are responsible for both groups' performance. In other words, expertise is an artificial designation of a portion of a continuous distribution and not a special or abnormal condition. The authors conclude by describing genetically informative designs that might be helpful in studying the origins of expertise.

Ruthsatz, Ruthsatz, and Ruthsatz-Stephens (2014, this issue) summarize ongoing work with prodigies. Prodigies are defined as children who develop expertise before adolescence. Because it is very unlikely that they could have engaged in 10,000 h of deliberate practice, they bear on the issue of the development of expertise. Ruthsatz has collected probably the largest sample of prodigies ever tested. Her sample includes prodigies primarily in art, music, and math. Three prodigies in her sample have excelled in two different areas.

Psychometric tests have revealed some interesting findings. While the prodigies' global IQ scores are high (M = 128, Range: 108–147), this is not the most impressive part of their psychometric profile. What is impressive is that all of them were in the top 1% on the Stanford–Binet working memory score (M = 146, Range: 138–152). Further, each prodigy showed an elevated attention to detail score on that subscale of the Autism Spectrum Quotient test. The talents of the prodigies seem to appear very early in life and some of the prodigies have no member of the family who could provide instruction. It seems very likely that there is a genetic basis for prodigies and unlikely that they have had 10,000 h of deliberate practice.

Simonton (2014, this issue) introduces another area of expertise: creative achievement. He points out that both expertise and performance must be carefully defined. This is complex because creativity shows immense variation in expression. Simonton then suggests that the way to approach research in this area is with a comprehensive, integrative model. Such a model would include deliberate practice, cognitive abilities, and dispositional traits. Each of these would be potentially influenced by genetic and environmental factors.

One of the problems with expertise in creative achievement is that creative achievement is often nebulous. For example, Galileo's astronomical observations did not and could not exist until he devised a telescope capable of observing the objects in the night sky. Simonton points out that these accomplishments had "no basis in any existing scientific expertise" but were accomplished through trial and error. He concludes that the expertise that eventually proved most useful in convincing others of the fantastic things he was seeing was his art training.

Simonton also points out that there is substantial variability in the acquisition of skill and production of creative performance. Some exceptional performers "get better faster". On average, composers required a decade before publishing their first major work, but some took much longer with a few taking much less than ten years. Some "get more bang for the buck" meaning there are substantial differences in productivity and the quality of what is produced. He points out that Bach, Beethoven, and Mozart account for nearly 20% of standard classical music repertoire.

Wai (2014, this issue) uses both prospective and retrospective data to make the single point that ability is important in becoming expert. The first data set will be familiar to readers of this journal. It includes longitudinal data from the Study of Mathematically Precocious Youth and Project Talent. Studies of these data, including the one by Wai, have repeatedly shown that the accomplishments of high ability students identified early in life are highly predictive of their expertise later in life based on highly objective criteria. Even among these highly selected youth it is possible later in life to discriminate, based on their accomplishments, when participants are sorted by ability level. The outcome measure used here was how many obtained higher degrees.

The retrospective data consisted of persons selected from lists of America's elite including Fortune 500 CEOs, federal judges, billionaires, and the United States Senators and Representatives. Their ability level was estimated by determining the proportion in each category that went to colleges or universities that would require SAT or ACT admission tests in the top 1% of ability. The results showed that somewhere between 39% and 45% of these elites were of high ability when assessed at 17 years of age. Two interesting facts: Billionaires had the highest probability of attending an elite university and the major exception was that members of the House of Representatives attended elite universities, only about 21% of the time, but had the second highest number going to graduate school, 47.5%.

In sum, the papers included here present data or logical arguments that heritable ability, and particularly intelligence, is a necessary component to acquiring expertise in nearly any domain. The evidence presented comes from diverse sources and seems nearly overwhelming in both its depth and breadth.

Ericsson (2014, this issue) responded to each of these papers. It appears that he dismisses much of the evidence presented here as not bearing on the issue. Part of his rejection is based on how he defines expertise: high levels of adult performance that can be repeatedly reproduced. But it appears that expertise in reading is not expertise as defined by Ericsson. For Ericsson, expertise seems to be much different than just high levels of competence. It is these exceptional individuals that he is trying to understand. I can neither do full justice to his arguments here nor will I summarize the rebuttals to his arguments by each of the original authors. I will, however, provide my views regarding the relation between ability and expertise.

My interest in the topic of expertise dates back to a paper by Ceci and Liker (1986). They investigated racetrack handicappers and found no correlation with intelligence. In fact, my fascination with the study of experts is that there are repeated claims of finding no correlation of expertise with intelligence as the research of Ericsson and others claim to show. These studies interest me because they appear to be a fulfillment of the hopes of the early IQ test makers. Binet's goal was to find a test that would identify children who would not do well in school and then to provide them with extra help that would allow them to succeed. Binet essentially wanted to find treatments that would invalidate his own IQ test. That is, if the right treatments could be found that would allow all children to achieve at the same high level, the correlation between IQ and educational outcome would be zero. If the claims made by Ceci and Liker and Ericsson are true, they could provide important information about how Binet's goal could be achieved. The search for such treatments that could invalidate IQ could be considered the holy grail of intelligence research. (Note that these treatments have to be more effective for the less able. If they were more effective for the more able, there is a possibility that they would increase the correlation with IQ. This is sometimes called the Matthew effect.)

Unfortunately, showing a methodologically sound zero correlation between expertise and intelligence is not such an easy task as Detterman and Spry (1988) pointed out in response to the original Ceci and Liker article. On the other hand, it is very easy to obtain a zero correlation between expertise and intelligence without regard to methodology. The major concern in much of the research that has shown a zero correlation between intelligence and expertise is that it results from one of many possible methodological problems nearly all of which have been pointed out by the eight contributors to this issue.

Instead of focusing on intelligence and expertise it may be clearer to talk about a domain where expertise and the factors related to it are more directly observable. As an example illustrating methodological difficulties, take the players of the National Basketball Association, generally regarded as among the best basketball players in the world (data for 2013 NBA players can be found at http://www.besttickets.com/blog/unofficial-2013-nba-census/). Some years ago, I correlated the height of NBA players with points scored and that correlation was about zero. In the data set for 2013, the correlation of height and salary is 0.09. Based on these near-zero correlations one would be forced to conclude that height had nothing to do with success in basketball.

This conclusion is patently ridiculous. Anyone who has ever seen an NBA game knows the importance of height to the game. Perhaps it is the case that the correlations are obscured by restriction in range. But, based on the standard test for restriction of range, there is no restriction of range. Typically, to assess restriction of range, the population standard deviation is compared to the sample standard deviation. Males in the United States have a standard deviation of 2.9 in. but players in the NBA have a standard deviation of 3.43 in. Since the standard deviation of the sample is greater than that of the population, one can conclude that there is no range restriction though this difference signals distributional issues. While height is approximately normally distributed in the population, it is probably not for NBA players.

The giveaway that height is involved in success in the NBA is that the mean height of NBA players is 79 in. while the average for the United States adult males is 70 in. There are two players in the NBA that are 69 in. tall. All others are above the mean of the United States male population. The median of NBA players is 80 in. or 3.4 standard deviations above the population mean. The tallest player is 87 in. tall or nearly 6 standard deviation units above the population mean! It is quite clear that NBA players have been, at least partially, selected for their height. It defies common sense that height is not important in basketball. But if mean height differences are ignored and only the correlations between performance or salary and height are considered, the data would suggest that height is not important in professional basketball. The results for NBA players mirror the findings from studies of expertise and intelligence.

This is a good example for understanding the potential methodological problems that can occur in the study of expertise. In most cases, the study of experts concentrates on areas of expertise where there is no uniform, universal instruction. These areas include music, chess, art, gambling, memory, and other domains in which not everyone is instructed in a rigorous and systematic way. (This issue has been confined to cognitive abilities though other domains could have been included.) There is very often increasingly rigorous progressive selection. For NBA players there is a tiered system beginning before adolescence and continuing through junior high school, high school, college, and, finally, NBA selection. Very talented players may skip some of these steps.

Practice is undoubtedly an important part of developing expertise. It is not clear whether 10,000 h of practice is essential. A good example of where 10,000 h is not an absolute necessity is poker. When playing poker in a casino or a typical home game, each player is dealt about 25 hands per hour. If a player engaged in 10,000 h of practice under these conditions, that player would play 250,000 hands. When online poker was introduced, the number of hands increased to 50 hands per hour because a computer shuffles and deals faster than a human dealer. Further, professional online players could play in up to 8 different games simultaneously on one or more computer screen meaning that they were playing 400 hands per hour. (YouTube videos can be found with players simultaneously playing 20 or more tables on multiple computer screens.) Given this increased speed of play, an online player could accumulate 250,000 hands in just 625 h. Recently, many exceptional young players developed exceptional skills as internet players. Doyle Brunson, now in his 80s and who was for many years considered among the best of all poker players, was once playing with a young player who remarked that young players like him had played more hands of poker on the internet than Doyle Brunson had played in standard poker games in his whole life. It would seem that 10,000 h is not a necessity when the skill level attained can be accelerated by more intense practice.

A major problem with much expertise research in identifying links to ability is that they begin by selecting people who are already experts. Conditioning sample selection on expert performance for NBA players might lead to erroneous conclusions about the importance of height. However, it could also be argued that not all tall people become NBA players so there must be factors aside from height that differentiate NBA players from those who are not NBA players. This is a much different question than what abilities are associated with becoming an expert in the first place. Identifying abilities important to becoming an NBA player would require a longitudinal study beginning with a randomly selected, representative sample of the population. Given that expertise is, by definition, a very low probability event, such studies would be very difficult to carry out since it would require a huge number of initial subjects to be sure you ended up with a sufficient number of experts.

This is not to say that nothing can be learned by studying experts retrospectively. There are reasons beyond intelligence that cause some people to become experts while others with the same level of intelligence do not. Things like deliberate practice, motivation, energy, personality, and enjoyment of the field are some of the things that are beginning to be identified. It would be even better if all of these factors could be combined in a single intervention that would negate the correlation of IQ with subsequent expertise thereby realizing Binet's dream. It would also be nice if short people could play in the NBA if they

Please cite this article as: Detterman, D.K., Introduction to the intelligence special issue on the development of expertise: is ability necessary?, *Intelligence* (2014), http://dx.doi.org/10.1016/j.intell.2014.02.004

desired. Unfortunately, given the evidence presented in the papers here contradicting these possibilities, neither of these things is likely to happen in the near future.

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