How Experts Attain and Maintain Superior Performance: Implications for the Enhancement of Skilled Performance in Older Individuals

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Traditional theories of aging claim that basic processing speed and memory capacities show inevitable decline with increasing age. Recent research, however, has shown that older experts in some domains are able to maintain their superior performance into old age, but even they display the typical age-related decline in performance on psychometric tests of fluid intelligence. The study of expert performance shows that adults retain the capacity to acquire and maintain performance with the appropriate type of training and practice, even speeded actions and many physiological adaptations. In fact, experts' performance keeps improving for several decades into adulthood and typically reaches its peak between 30 and 50 years of age. The experts can then maintain their attained performance level into old age by regular deliberate practice. Much of the observed decline in older adults' performance can be attributed to age-related reductions in engagement in domain-related activities—in particular, regular deliberate practice.

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Recent reviews have documented how experts attain superior performance after an extended period of preparation (Ericsson & Lehmann, 1996) and how they can maintain a much higher than average level of achievement into old age (Ericsson, 1990; Hagberg, 1994; Krampe & Ericsson, 1996).

The evidence for exceptional expert performance and older experts' maintained superior performance has been difficult to integrate into contemporary theories in general psychology, with their traditional emphasis on typical developmental trends for representative samples of adults, rather than atypical individual performance. Consistent with the long tradition of psychological testing, psychological theorists have been primarily interested in identifying general abilities that mediate virtually all forms of cognitive processing, such as general basic memory capacity, basic perceptual–motor activity, and intelligence. To accurately measure basic capacities during the tests, test items have been designed to minimize effects of

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prior experience and knowledge by using arbitrary materials such as letters and digits, with a particular focus on factors that generalize across several tasks and materials.

When adults are tested on a wide range of general abilities, a very consistent pattern is observed across the life span: an age-related decline in performance that is often observed first in the 30s, with a roughly linear decrease with age, until more dramatic nonlinear decreases emerge during late adulthood. Although older adults can improve performance with short-term training, the increases are usually modest. Even the maximal performance attainable after training is believed to exhibit the typical age-related decline (Denney, 1982).

If the general abilities of older experts undergo the same type of age-controlled decline, how can their superior performance in their domain of expertise be explained? One possibility is that older experts are a very select group with very high levels of general ability. Although their relevant general abilities would exhibit the same age-related decline, their level of general ability would be much higher throughout their life span compared with age-matched representative adults. Second, older experts might be able to maintain their superior performance by acquiring mechanisms during late adulthood to compensate for the inevitable age-controlled declines in processing efficiency and capacity.

In contrast to the interest in the life-span development of general abilities, research on exceptional performance has focused on the conditions under which particular individuals are able to exhibit vastly superior performance and how this type of superior performance develops. Contrary to the limited modifiability of general abilities, the research on exceptional performance shows that adults can increase their performance dramatically, even by as much as 1,000%, on tests used to measure stable general characteristics, such as capacity of short-term memory, after relatively limited practice (Chase & Ericsson, 1982). These improvements in performance, however, were quite specific to the training conditions and did not generally transfer to other tasks and materials. The observed increases in performance revealed remarkable plasticity in adult performance in specific task domains, even among older adults.

The mechanisms mediating improved performance were not constrained by individual differences in general capacities and processes. Bodily and neurological mechanisms mediating the targeted physical or cognitive performance appeared susceptible to change through training and practice. Individuals improved performance on cognitive tasks by acquiring skills and building new mental representations that were unconstrained by capacities measured using traditional psychometric tests. To improve physical performance, individuals engaged in training that resulted in physiological adaptations involving changes to bodily organs at the cellular level.

According to this theoretical framework, traditional conceptions of learning based on short-term laboratory testing have underestimated the potential of change through training. Current analogies between humans and computers have tended to overemphasize the distinction between modifiable computer programs (software) and unmodifiable computer components (hardware). In fact, humans are quite different as biological systems, and they, unlike computers, can recover from physical injuries, such as broken bones and cuts, and show clear adaptations to the current level of physical and cognitive activity.
Development of Expert Performance

Research on expert performance has attempted to assess the degree to which general basic capacities or acquired mechanisms and adaptations determine the experts’ superior level of achievement. The first step has been to search for any reproducible superior performance on tasks that capture the essence of expertise in a given domain. It has been surprisingly difficult to document a performance advantage for experts in several domains such as accounting, clinical psychology, and fields requiring forecasting and decision making. In many other domains, experts exhibit reliably superior performance, and their performance has been successfully reproduced under laboratory conditions. Experimental analyses and process tracing have shown that the experts’ superior performance is not primarily mediated by general basic capacities but by complex cognitive mechanisms and physiological adaptations (Ericsson & Lehmann, 1996).

There are several lines of evidence supporting the acquisition of expert performance through extended domain-related experience. First, longitudinal studies of expert development show no abrupt performance increases, only gradual improvements in performance, when adult standards of measurement are consistently used. Second, individuals tend to attain their highest level of performance in their late 20s, 30s, or 40s in most domains—more than a decade past the age of full physical maturation of the body and nervous system. Finally, Simon and Chase (1973) found that even the most talented chess players had to prepare for over a decade to reach an international level of performance. There is extensive empirical evidence for the “10-year rule” in a wide range of domains of expertise (Ericsson, Krampe, & Tesch-Römer, 1993).

Many investigators have proposed that expertise in a domain would be attained virtually automatically after 10 years of experience, because the benefits of extended experience seemed so obvious. Surprisingly, scientific reviews have shown that the length and amount of domain–related experience were relatively weak predictors of performance level in a domain (Ericsson & Lehmann, 1996). Only some types of experience appear to improve performance. Ericsson et al. (1993) identified activities that met the necessary requirements for effective training and were designed by a teacher to improve a specific individual’s performance. They termed these activities “deliberate practice.” The amount of deliberate practice during musical development was found to be closely related to individual differences in performance among expert musicians. The most accomplished expert musicians started early (around 6–7 years of age) and increased their weekly amount of practice until they reached a practice schedule of 3–4 hr every day. By the time they reached age 20, they had engaged in more than 10,000 hours of practice—an average that is around 2,500–5,000 hr more than the group of less accomplished expert musicians and 7,000–8,000 hr more than amateur musicians of the same age. Cumulative deliberate practice is closely related to the attained level of performance in many other domains of expertise, such as chess (Charness, Krampe, & Mayr, 1996) and sports (Starkes, Deakin, Allard, Hodges, & Hayes, 1996).

It is not possible to infer from the observed correlations between deliberate practice and improved performance that practice causes improvement. It is conceivable that more talented and able individuals practice more because they enjoy deliberate practice (Sternberg, 1996). Nonetheless, Ericsson et al. (1993) found that
expert musicians did not rate deliberate practice as the most inherently enjoyable activity related to music. If the expert musicians had been guided primarily by inherent enjoyment rather than by their desire to improve their performance, they would have spent more time on other, more enjoyable music-related activities than deliberate practice. Ericsson et al. found instead that the best musicians searched for the maximum amount of deliberate practice that they would be able to sustain daily for months and years. The primary limiting factor seemed to be the length of time that expert musicians could sustain daily deliberate practice with full concentration without reaching exhaustion and burning out. To maximize the duration of intense practice, the best musicians slept and rested more than the least accomplished expert musicians, often by napping in the afternoon after the morning’s practice sessions.

Some of the best evidence against the inherent enjoyment of deliberate practice is its implicit requirement that students continually set new and higher goals to exceed their current level of mastery. This type of practice leads to repeated failures, which can hardly be considered enjoyable (Ericsson, 1998). For example, Janet Starkes and her colleagues (1996) recently reported that sub-elite figure skaters fell less often during practice on the ice than did elite-level skaters because the less skilled performers tended to perform jumps that they had already mastered. In comparison, the elite skaters made more attempts at jumps they had not yet mastered, leading to more failures but, most important, better opportunities for further improvement.

The best evidence for a causal role of practice in attaining expert performance comes from an analysis that relates particular forms of deliberate practice to specific changes in physiological and cognitive systems (Ericsson, 1998, 1999). A large body of experimental research on exercise has shown how a repeated overload of specific physiological systems leads to predictable cellular changes such as growth of capillaries supplying blood to the muscles. Even most anatomical characteristics distinguishing elite athletes, such as larger hearts and lungs, can be explained as physiological adaptations to intense practice over extended periods of time. Most of these adaptive changes are reversible. When the physiological challenge from exercise and practice is reduced as elite athletes stop or reduce practice, the physiological adaptations that helped support their superior performance disappear as their bodies revert back to normal levels. For a more extended discussion of the complex development of physiological and anatomical adaptations during the career of elite performers, see Ericsson (1999).

Laboratory research has identified several factors that increase effectiveness of learning, such as well-defined goals of appropriate difficulty, informative feedback, and opportunities for repetition and gradual improvement. Deliberate practice was originally proposed (Ericsson et al., 1993) as an application of these effective learning principles to the individualized practice activities suitable for the development of skilled, complex performance. As the complexity of the acquired skill increases, students assume greater control of their own learning, and they start to acquire cognitive representations for imaging, monitoring, evaluating, and correcting their performance (Ericsson, 1998). Studies measuring these cognitive representations and mechanisms have validated their role in mediating experts’ superior performance, as well as their ability to continue improving performance through deliberate practice. Unlike the reversible physiological adaptations to performance demands, cognitive skills and representations are much more
stable, and reduced levels of practice lead to less pronounced reductions in expert performance.

Implications for Age-Related Declines in Older Expert Performers

The theoretical framework for deliberate practice attributes the acquisition of expert performance primarily to regular training and practice with concurrent maximal levels of deliberate practice, which culminate in peak levels of achievement in a domain. This implies that performance in domains of expertise can be dramatically increased through training and practice during all developmental stages during the life span. Older expert performers (age 60–75) are often found to be able to perform at levels vastly superior to those of young untrained adults. It is also clear, however, that older expert performers are rarely able to match the performance of young expert performers (Ericsson, 1990), especially in activities demanding maximal speed and power. An even more important implication is that successfully maintaining expert levels of performance requires sustained levels of deliberate practice for both younger and older performers. Much of the decline in performance attributed to aging results from reduced levels of deliberate practice among older individuals. For example, older master athletes have been found to train less often and with less intensity than young elite athletes do. When older and younger athletes are matched on their level of training, very few differences in physiological adaptation and performance remain (Hagberg, 1994)—individuals’ maximal heart rate appears to decrease as a function of age, independent of level of training.

Experimental studies have shown that designed physical activities can improve the functionality of virtually any physiological system, even in older individuals (Spirduso, 1995). Consequently, most of the age-related decline in physical performance for otherwise healthy adults appears to be an automatic adaptation to lower levels of training and demanding physical activity rather than some inherent, unmodifiable consequence of increased age.

A similar pattern of involvement in deliberate practice across the life span is observed among professional musicians. Expert pianists and violinists gradually reduce their weekly amount of deliberate practice once they leave the music academy and start their professional careers as orchestra musicians or music teachers. Expert pianists who continue to give public solo performances maintain a level of deliberate practice (typically over 10 hr/week) sufficient to allow 60-year-old expert pianists to maintain speeded performance on piano-related tasks that matches that of younger expert pianists (Krampe & Ericsson, 1996). The older expert musicians’ maintained level of perceptual-motor performance, however, is quite domain-specific, and they show normal age-related decline in studies of speeded reactions in unfamiliar laboratory tasks.

Krampe and Ericsson (1996) proposed that reduced levels of maintained practice by older experts also appear to explain differences in the structure of skill between young and old experts in chess and typing. In support of this explanation, Charness et al. (1996) found that the recent level of deliberate practice was particularly influential in enhancing chess skill in older chess players. In sum, most of the age-related decline in maximal performance observed in older healthy ex-
perts does not appear to reflect inevitable age-controlled decline but, rather, reduced levels of practice.

**Conclusions**

Research on expert performance shows the remarkable plasticity of adult performance, which depends on a maintained level of deliberate practice. Most of the decreases in expert performance of older adults do not reflect inevitable age-controlled decline of general capacities but are a consequence of older individuals’ decisions to reduce the frequency of engagement in challenging activities and decrease the intensity of maintained deliberate practice. The generality of mechanisms mediating the acquisition and maintenance of expert performance strongly suggests that older, otherwise healthy adults can attain high levels of performance in specific task domains by regularly engaging in deliberate practice with suitably designed training activities.

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**References**


