

# Discovering deliberate practice activities that overcome plateaus and limits on improvement of performance

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Since Sir Francis Galton's book on *Hereditary Genius*, many scientists have argued that heritable factors set limits of performance and only allow a select few individuals to attain exceptional levels. However, recent research rejects the associated learning theory and its implied performance plateaus and shows that expert performance is mediated by acquired complex cognitive mechanisms. It describes different types of deliberate practice activities that develop and refine mental representations, which in turn permit attained performance to exceed performance resulting from extensive experience only. Empirical investigations are reviewed to show that expert performance and outstanding achievements will be primarily constrained by individuals' engagement in deliberate practice and the quality of the available training resources.

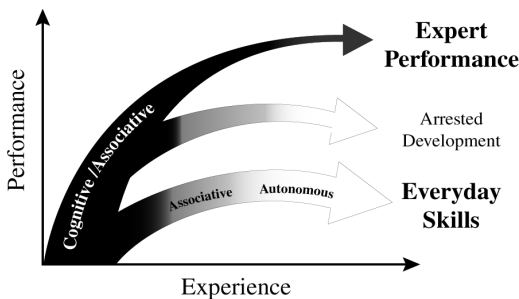
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Everyone has experienced the excitement associated with being introduced to a new activity and rapidly reaching an acceptable level of performance. In the beginning there are often dramatic improvements within the first few hours of introductory engagement in popular games, such as darts, volleyball, and shuffle board. Sir Francis Galton (1869/1979) summarized the popular view that performance improvements are rapid only in the start of initial training and that subsequent increases become increasingly smaller, until the performance reaches a plateau and "[M]aximal performance becomes a rigidly determinate quantity" (p. 15). According to this view, heritable capacities and innate talents set the upper bounds for an individual's physical and mental achievements. Once the performance has become immediate (automatic), then it does not seem possible that any additional amount of practice can

increase the performance further. This assumed inability to influence performance through any type of practice or training provided the foundation for Galton's compelling arguments that individual differences in performance must be determined by stable unmodifiable factors, such as individual differences in innate endowment.

In the nineteenth and early-twentieth centuries, most scientists assumed an important boundary between mind and body. Consequently, when a person's performance was reported to be automatic, it no longer would reflect conscious thinking, and therefore, the speed of the execution had to be limited by physical and biological characteristics of one's body and nervous system. In his pioneering book, *Hereditary Genius* (1869/1979), Galton presented evidence that height and body size were genetically determined and, thus, could not be altered by practice. In direct analogy he proposed that similar genetic mechanisms must determine all other aspects of one's physiology, such as size of brain and speed of neurons and, therefore by inference, all mental capacities.

The most important contemporary theories of skill acquisition (Anderson 1982, Fitts and Posner 1967) are consistent with Galton's general assumptions and fit with casual observations on the development of everyday activities. After being introduced to activities such as driving a car, typing, or playing golf, an individual's primary goal is to reach an acceptable level of performance. During the first phase of learning (Fitts and Posner 1967), novices try to understand the activity and concentrate on completing their attempts successfully, as is illustrated by the cognitive phase (black segment) of the lower arm of Figure 1.



*Figure 1.* An illustration of the qualitative difference between the course of improvement of expert performance and of everyday activities. (Adapted from Ericsson 1998, p. 90. © European Council for High Ability, used by permission.)

With more experience in the associative phase (grey segment in Figure 1), large mistakes become increasingly rare, performance appears smoother, and learners no longer need to concentrate as hard to perform the task. After a limited period of training and experience—frequently less than 50 hours for most recreational activities—an acceptable standard of performance is attained. Once performance is autonomous (white segment in Figure 1), individuals no longer attempt further modifications and improvements, and this typically leads to a stable plateau of performance, which is consistent with Galton's (1869/1979) description. Galton, however, would argue that these stable plateaus exist not only for the acquisition of acceptable performance in casual, recreational activities, but also for the acquisition of exceptional ability in most domains.

This view of acquisition of skill is consistent with findings for amateurs' performance in tennis and golf, where they improve initially but then stay at a stable of performance level for decades of regular engagement. Performance in everyday skills, such as driving and typing (Keith and Ericsson 2007), also are remarkably stable across decades of regular activity. Finally, professional performance does not improve with experience beyond the first few years of initial experience (Ericsson 2004, Ericsson and Lehmann 1996, Ericsson *et al.* 2007). In fact, sometimes job performance decreases as function of job experience since graduation (Choudhry *et al.* 2005).

### MAIN CONTRIBUTION

In most domains of professional and leisure activity, the majority of people reach stable levels of performance (plateaus) that are maintained for years and decades. These attained levels of performance are not rigidly limited by some upper bound. In their review, Ericsson *et al.* (1993) found many documented examples of individuals who, for requirements for promotion in the job, dramatically increased their performance by training—such as typing speed. In leisure activities, it is not uncommon that an adult starts taking lessons with a golf or tennis coach and, after a period of training, improves their performance. In the same review, Ericsson *et al.* (1993) proposed that for many different activities there existed deliberate practice activities that could change aspects of performance and over time increase the overall performance on tasks representative of the activity, such as time to type an unfamiliar paragraph, run 100 meters, or win chess games.

Deliberate practice differs from the mere experience of doing the task in many different ways. Perhaps the most striking way concerns the mental attitude of the individual. During deliberate practice the individual has the goal

of improving some measurable aspect of their performance. For example, a recreational golfer aims their putt toward the hole on the green and either misses or drops the ball in the hole. Every time the golfer putts the ball, it is a different situation and the golfer would not know whether the mistake was caused by their putting technique, the slope of the green, the resistance of the grass, or whatever. During deliberate practice on a practice green, the golfer has the opportunity to make the same putt many times (Ericsson 2001). If the golfer closes her eyes and strokes 10 putts without seeing the results, the balls will not have the exact same trajectory and will not stop at the exact same spot on the green. In fact, the balls will form a cluster and the diameter of this cluster will be a very good predictor of golf putting performance. Elite golf players will have a tighter cluster than less skilled recreational players, but every player will show considerable variability. Hence, even world-class players can never be certain that they would sink putts over 10 feet. In fact, all that they can control is that the putt will stop within a circle near the hole. Several of the best golf players in twentieth century reported that realizing that they could not control whether a given putt would drop in the hole and therefore should not be upset with themselves as long as the putt stopped near the hole in the circle (defined by their reproducible accuracy). Based on this analysis, it is clear that training one's putting stroke, so it can be controlled to give the same/similar result for putts of different lengths is an aspect that can be much better developed on the practice green by repeated shots and systematically varied putts. Similarly, learning to read the varied shape of the green with "hills" and "valleys" so one can image the path of one's putt is also a skill that can be improved more effectively by immediate feedback and opportunities for repeated shots to explore the consequences of differences in speed over inclined planes and slopes. In a similar manner, golfers learn to better plan the ball trajectories of drives and other longer shots by getting repeated opportunities with immediate feedback.

Deliberate practice can be focused on those aspects of the game that are weakest and have the most room for improvement. During typical everyday experience in the domain, the probability that a golfer would encounter a sequence of sand trap shots in a given round of golf is small, but during practice the coach could work on sand trap shots for a full hour. Likewise, a deliberate practice session can be designed to focus on any particular aspect of someone's performance.

Identifying the aspects that should be the focus of deliberate practice requires some assessment, typically by coach or teacher. It is possible to design tasks that the individual performs several times that allow the teacher to better assess current problems or anticipated future issues with some parts of

performance. In everyday life, beginners are searching for quick fixes that allow them to rapidly reach an acceptable performance. In contrast, teachers are focused on future performance and on the student acquiring the appropriate fundamentals, so that the student can master more complex techniques and reach higher levels of performance. In many domains, such as music, ballet, and gymnastics, teachers over time have developed a curriculum where there is consensus on the best ordering of techniques to be mastered in order to reach the highest levels of performance (Bloom 1985). For many domains of expertise, such as scientific research, writing, and art, there is currently less consensus on the preferred curriculum and even if a curriculum would benefit the development of creative performance.

Deliberate practice should be scheduled when the performers are rested and maximally alert, and the duration of training must be adapted so they avoid fatigue and thus are able to maintain their highest level of concentration and performance during the entire training session.

Deliberate practice requires a close connection between the actual performance and the training tasks. It is essential that some aspect of current performance is taken as the focus and that training tasks are intermittently exchanged for the real-world context so that transfer of improvements during training is successfully incorporated in the corresponding real-world performance. It is possible that the training tasks lead to performance improvements that depend on the crutches and the scaffolding during training and thus cannot be connected to the aspects of the real-world performance that were the original stimuli for the design of the practice activities.

In the rest of the paper I will discuss how these ideas have allowed researchers to identify the deliberate practice activities that have a high correlation with attained performance in numerous domains (Ericsson 2006).

### **Overcoming plateaus in chess**

If you were a chess player in a chess club in the 1950's and were able to beat all the other players, could you, and if so how would you be able to improve your performance? At that time there were no chess computers that played chess at a world class level, and it was not that common that people travelled to tournaments to play the best players in the state, country, or around the world. Based on some informal interviews and analyses, Ericsson *et al.* (1993) proposed that it was essential for effective learning that one encountered challenging situations, where the probability of making mistakes and failure was relatively high. We proposed that one method for doing this in chess would be to buy books and chess magazines with published games between

international level and world-class chess players. The aspiring chess expert would then simulate playing against these players by analyzing each position in the chess game and by trying to find the best move for every position in the game. If the chess player selected a move that matched the one picked by chess master then the chess player did as well as the master. More importantly, if the chess players picked a different move from the master then there is an opportunity for learning and improvement. Through further analysis, the chess player could attempt to figure out why the chess master's move was superior. The next step would be to think through how the chess players' processes involving search and move selection should be changed to be able to find this move as well as similar moves in other chess positions. A few aspiring chess experts reported spending 3-5 hours every day engaging in this type of solitary analysis along with studies of variants of chess openings. Subsequent studies have found that serious chess players spend as much as four hours every day engaged in this type of solitary study (Charness *et al.* 2005). Most important, these studies show that the accumulated hours of solitary analysis of chess playing is the best predictor of someone's chess skill. Somewhat surprisingly the amount chess playing with friends is not associated with increased chess-playing skill. Furthermore, these studies show that the size of someone's chess library, that is the number of chess books and chess magazines, is correlated with better chess skill—perhaps because they were necessary for solitary chess study before the emergence of chess playing computer programs and internet data bases. By spending additional time analyzing the consequences of moves for a chess position, players can increase the quality of their selections of moves. With more study, individuals refine their representations and can access or generate the same information faster. As a result, chess masters can typically recognize a superior move virtually immediately, whereas a competent club player requires much longer to find the same move by successive planning and evaluation rather than recognition (de Groot 1966). With additional time the master can often generate even better moves.

In the classical model of skill acquisition (Fitts and Posner 1967), more experience allows the person to generate the same move faster through automation. In contrast, the nature of the improvement in chess concerns the ability to generate different and better moves based on refined acquired representations and associated analysis and search (de Groot 1946/1978). The same type of improvement, based on deliberate practice and the acquisition of complex representations supporting planning, evaluation, and online monitoring of performance (cf. Ericsson and Kintsch 1995) can explain grad-

ual and extended increases in performance in a wide range of domains, such as billiards, golf, music, Scrabble, darts, and surgery (Ericsson 2006).

### **Deliberate practice in typing**

Most adults are able to type, yet there are often large individual differences in their style and efficiency. Adults typically do not think about their typing and simply do it, thus typing would seem to meet the criterion of low effort or even autonomous performance. A recent review (Keith and Ericsson 2007) has found that estimates of how much someone has been typing appear to be a poor predictor of measurable typing speed under standardized conditions. How could someone improve their typing performance after having typed at a similar speed for decades? The answer is clearly supported by a number of training studies. The key to improved speed in typing is to find some time during the day (Dvorak *et al.* 1936) when one is able to fully concentrate for 15-25 minutes. During that time, one finds something to copy and increases one's comfortable typing speed to a speed 15-30% faster than normal. During this faster speed it becomes apparent that some key strokes or key-stroke combinations are slower and associated with hesitations. One then works on mastering these weaknesses by focused practice and then by interweaving them into speeded typing. In an interactive fashion, we speed up one's typing to find the problems causing slower typing and then practice until the speed of typing has increased and then repeat the process. The general approach of this type of deliberate practice is to find methods to push performance beyond its normal speed—even if that performance can be maintained only for a short time. This methodology offers the potential for identifying and correcting weaker components that will improve performance.

How is it possible to improve the speed of habitual and effortless behavior? Researchers have studied the individual differences in typing speed of skilled typists and unskilled participants by having them type passages from a collection of unfamiliar texts as fast as they can without making errors. High-speed films of finger movements show that the faster typists start moving their fingers toward their desired locations on the keyboard well before the keys are struck. The superior typists' speed advantage is linked to their perceptual processing of the text beyond the word that they are currently typing (Salthouse 1984). By looking ahead in the text to identify letters to be typed, they can prepare future keystrokes in advance. This evidence for anticipation has been confirmed by experimental studies where expert typists have been restricted from looking ahead. Under such conditions their typing speed is dramatically reduced and approaches the speed of less skilled typists.

In sum, the superior speed of reactions by expert performers, such as typists and athletes, appears to depend primarily on cognitive representations mediating skilled anticipation, rather than faster basic speed of their nervous system (Abernethy 1991). For instance, expert tennis players are able to anticipate where a tennis player's shots will land even before the player's racket has contacted the ball (Williams *et al.* 2002). Eye-movements of expert tennis players show that they are able to pick up predictive information from subtle, yet informative, motion cues, such as hip and shoulder rotation, compared to their novice counterparts. They can also use later occurring and more deterministic cues, such as racket swing, to confirm or reject their earlier anticipations.

### **Deliberate practice in other domains**

In many domains performers and teachers have accumulated knowledge about effective methods of training and deliberate practice. They have developed curricula in a wide range of domains of expertise, such as music, ballet, gymnastics, martial arts, and so on. This implies that at some point in history one or more individuals must have discovered one of these methods for the first time. There are many documented instances of such discoveries in sports. For example, the famous long distance runners during the middle of the twentieth century, such as Emil Zatopek, developed different variants of interval training, where the runners alternate periods of fast running speed—much faster than their regular speed for endurance races—and slower speeds or even just rest (Billat 2001). These runners were vastly superior to their contemporaries, and it is likely that their superiority could be attributed to their superior training, as more recent runners are able to clearly surpass these classic runners based on the current running techniques that rely on their training innovations. Similar training innovations are found in virtually every domain of expertise.

In my early work with Bill Chase (Ericsson *et al.* 1980) on the acquisition of exceptional memory, I was fortunate to observe how our first participant, SF, encountered a plateau of performance. We were convinced that he had reached his highest level of performance at digit span after not making any improvements beyond lists with around 50 digits for over 10 hours of continued training. To test if he had reached an unmodifiable limit we presented him much longer digits (around 60 digits), and he found that he could almost recall these much longer lists. We also presented the digits at a somewhat slower rate (at 1.5–2 s per digit instead of the standard 1 s per digit) to help him test out better methods for encoding the digits. These tests convinced Bill



and me, and most importantly SF, that he could still improve his performance. SF later reached a digit span of 82 digits.

For the last few decades, I have been searching for documented instances where motivated healthy individuals have reached unmodifiable plateaus that constrain their performance in a given domain of expertise. So far I have mostly encountered people who gave up their efforts because they did not think that they could reach the performance of other people, rather than that they had reached their own limits.

## **IMPLICATIONS**

For a long time, the belief that individuals' innate capacity limits their attainable level of performance has been accepted based on indirect and weak evidence. In contrast, the theoretical framework of deliberate practice asserts that improvement in performance of aspiring experts does not result from automation due to further experience. By increasing the challenge of training, individuals can remain in the cognitive phase (see the upper curve in Figure 1) and keep engaging in deliberate practice to acquire and refine complex cognitive mechanisms that mediate how the brain and nervous system control performance.

The time has come to seek out detailed information on performance plateaus encountered by individuals motivated to improve. Scientists should document their existence and examine their structure with experiments and analyze the past training and current performance. This evidence on performance limits will allow us to evaluate different theories of the determinants of expert level performance, as well as motivate the development of new training curricula and associated deliberate practice activities in order to assess whether these plateaus reflect unmodifiable limits to the development of performance.

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