Supplementary Methods

The Racer's Mind – How Core Perceptual-Cognitive Expertise is Reflected in Deliberate Practice Procedures in Professional Motorsport

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Compared to experimental and computational methods in quantitative research - which are more standardized - *qualitative* research frequently requires much more extensive and reflective explanation of methodological choices, their rationale, and exposition of the steps taken during the development of the study. This further detail is important for qualitative researcher who want to better understand and evaluate the trustworthiness of the approach, compare the methods and results to the body other qualitative research, or are interested in adopting the methods or replicating the research reported in the paper (Levitt et al., 2017).

However, this detail is less relevant to, for example, experimental psychologists (probably more interested in new experimental paradigms that could be inspired by the work), developers of computational driver models in cognitive science and vehicle systems engineering (probably more interested in how the phenomena fit within the theoretical ideas) or practitioners (probably more interested in the practice drills themselves). In order to maintain the flow of the manuscript, the material is placed in this appendix given as Supplementary Methods.

This Supplementary Methods document is organized into sections as follows:

> **Section 1** Explains briefly how the present work fits in the Grounded Theory (GT) methodological framework
>
> **Section 2** Gives a detailed account, with extensive examples, of the data collection and analysis decisions
>
> **Section 3** Gives a reflective summarization of the means to achieve rigor and sources of researcher bias
>
> **Section 4** Shows with text excerpts from the original Deliberate Practice (DP) literature how the conceptual framework used in the analysis itself is grounded in the standard exposition of DP theory.

1. Grounded theory (GT) framework

Methodologically, the present work may be considered a variant of Grounded Theory (GT) - although with some caveats, as explained below. Different forms of Grounded Theory approaches have been used extensively in sport psychology (reviewed in Weed, 2009), including work on coaching and training (e.g. Holt & Dunn, 2004) and even expert cognition (Eccles & Arsal, 2015).

Key features of GT (see Weed, 2009, 2010 and Holt & Tamminen, 2010 for discussion) that apply to the present work are:

- **Iterative and nonlinear data collection and analysis**. Rather than first collecting data according to a predefined data-collection plan and then analyzing it in light of a priori theoretical hypotheses that motivated the data collection, in GT the data collection and analysis proceed simultaneously in parallel - with *constant comparison* between data, researcher hypotheses and emerging insight, and existing theoretical literature. Specifically, meaning unit identification and coding inform further data collection; further sampling of material is done on the basis of emerging concepts and categories, which in turn leads to further refinement or the concepts and categories.
- **Data-driven coding and generation of hypotheses** Hypotheses are not derived from existing theoretical literature/researcher intuition (only), but are *grounded* in domain insight, guided by the unfolding analysis. This does not preclude a theoretical point of departure/theoretical aims; for transparency and assessment of *theoretical sensitivity* – i.e. the degree that the analysis is influenced by prior theoretical notions as opposed to informed by the data – these need to be disclosed.
  Caveat: In the present work the aim was to i. develop a classification that would directly relate to experimental psychology research on skill and expertise, and ii. hypotheses that would be relevant to computational driver modeling literature in cognitive science and engineering, thus possibly compromising theoretical sensitivity (see *Section 3.3.4. Perspective Management and disclosure*, below).
- **Development of classification schemes** to organize the data moves from description to conceptualization, i.e. from concrete meaning units to more abstract and general taxonomies and conceptual frameworks. *Constant comparison* of concrete instances to one another, instances to emerging concepts, emerging concepts to one another, and finally relations of concepts to relations and the theoretical literature are the heart of GT.
  Caveat: The aim of this study was more modest than would be typical of a large study aiming for a comprehensive "grounded theory" of a field. Thus, the analysis (see *Section 2. Detailed account of data collection and analysis*) may be considered work in progress, and the present results more like an interim report on the way to a more comprehensive GT.
- **Substantive theory** that summarizes and systematizes the emerging domain insight; may serve development of more formal, domain-general theory.

- **Search to saturation**. When a comprehensive substantive theory of a domain is sought, data collection and analysis proceeds until the new material no longer provides further domain insights, i.e. until *theoretical saturation*. *Caveat:* The aim of this study was more modest: to uncover *some* interesting patterns of training that can be fruitful for future experimental work, and the development of driver models. At the same time the theoretical interest was perhaps more general than typical qualitative inquiry: perceptual-cognitive expertise in high-speed visually guided locomotion, rather than the historically and culturally situated understanding of *motorsport* training *per se*. Theoretical saturation was probably not a viable aim. However, the aim was nevertheless to acquire a *comprehensive* corpus of the literature: once search criteria were set, new material was searched until no new publications appeared to surface. I.e. search was continued until (a reasonable level of) *material saturation.*

2. Detailed account of data collection and analysis

2.1. The theoretical point of departure

The author has done and continues to do work on quantitative measurement and modeling of driving behavior, in particular visual strategies. While reading for amusement and inspiration professional motor racing training manuals - and in-depth technical articles in motorsport publications such as *Autosport, Motor Sport* and high-performance driving publications such as *EVO* - a forceful impression was formed of the depth of analysis of the techniques and skill involved, and the systematic and mature vocabulary and underlying logic that has developed in the field. This complexity and detail seemed beyond what can be currently understood in formal theories, and so seemed worth analyzing more rigorously, as it might provide fertile pointers as to which direction to develop theory (and indeed suggest where the simplification required in formal modeling might have led to over-simplification and a perhaps distorted view of the phenomenon).

The idea formed that as these are basically expert self-reports and analytic peer observations (albeit highly edited and not collected systematically for academic purposes), they might be taken as an object of document analysis – often a useful step in producing domain insight for task analysis and theory development in psychological investigation of complex skills “in the wild”.

2.2. Data collection and organization

Based on prior familiarity with the genre, it was decided to include books published on both auto racing and motorcycle racing – as many of the task demands and techniques seemed highly similar, despite different controls and somewhat different dynamics of the vehicles.

2.2.1. Search

In order to keep the number of items manageable, the search was restricted to include only auto and motorcycle circuit racing, and to exclude other forms of motorsport (e.g. karting, rallying, autocross & motocross, drag racing…). (Auto)biographies, material in magazines, leaflets published in Kindle form, and material on websites discussion forums was not included in the search for the same reason. Also, as the theoretical interest was in professional-level expertise, books on non-professional "track day" circuit driving, as well as books on "performance driving" skills on public roads were excluded.

The literature is not indexed in academic publication databases or Google Scholar. Normal Google searches provide mostly hits to Amazon, eBay and other bookshops selling the product. Cross-references between the books (quite few) were used, and Amazon.com, Amazon.co.uk and Amazon.de "Also Bought" buying behavior links were used. This was done iteratively, so that when a new books came up in the search, this was used as the reference.

2.2.2. Inclusion/exclusion criteria

A general impression of reading through the material was that most of falls quite naturally into two types of books:

i. those written by ex-drivers, often elite drivers with a world-class track record working with a journalist or a ghost writer,

ii. those written by professional coaches as study materials for their customers taking part in a racing school course or individual coaching.

The ex-driver works generally seemed to contain a larger number of personal experiences, tips, ideas and ways of approaching different aspects of the profession (see *Section 2.2.3. Description of content not selected as potential meaning units*). In contrast, the coaching literature, additionally, contained precise descriptions of procedures termed *drills*, below (see *Section 2.2.4. Description of content selected as potential meaning units*). As the theoretical motivation was to gain a detailed insight into training procedures, it was decided to select for more detailed analysis those items that had been written by professional driving coaches, typically published in conjunction with a racing school operating at a racing track or purpose built facility.

2.2.3. Description of content <u>not</u> selected as potential meaning units

The aim was to find and analyze material pertaining to **perceptual-cognitive aspects of driving technique** at a level of detail sufficient to be in meaningful dialogue with the driver modeling in perceptual and cognitive psychology, cognitive science and vehicle system dynamics engineering (including motor sport engineering).

The training manuals, however, generally take a more **holistic approach** to the skills and expertise needed to develop a successful career in motorsport, with driving technique only a part of this. To give an idea of this material that was deemed *not* to

deal with perceptual-cognitive aspects of technique and performance, some illustrative examples are given here.

Motor racing is a hard performance environment, where fast and accurate performance in high-stress, occasionally life-threatening, situations need to be maintained for prolonged periods of time (sometimes several hours). While physically only a moderately demanding sport, the heat stress, isometric exercise from g-forces, and demand for sustained high levels of concentration require that endurance and stamina are built up during of-season, and maintained throughout a season lasting several months.

Advise on basic **fitness and diet** regimes are found, though not prominent, in motor sport training manuals.

This advice may come in the form of general descriptions of the physiology, symptoms and relevance on performance,

> (Fitness & diet)
> "*Typical symptoms of tiredness during a race are a decrease in the abiility to concentrate and a reduction [sic] in reaction times. Without being aware of physical exhaustion or discomfort, we begin to make small mistakes, like running wide or missing braking points. This stems directly from physical tiredness. If you do not then realize that you need to concentrate more to stay on the track safely, you will be prone to making a bigger mistake*." Krumm, 2015, p. 177

> (Fitness & diet)
> "*One thing that every sports medicine specialist does agree on is carbohydrate loading before an event, for endurance. Pasta and potatoes are the driver's best friends on the nights before work (including testing)*." – Smith, 1996, p. 1-21

or more personal experiences and anecdotes,

> (Fitness & diet)
> "*If you push things closer to the limit at any time you need to be in top physical condition. If you are not, you run out of concentration and you will run off the track. In the year that Freddie and I went at it together we were using our mental capacity so much that we were exhausted. That is why he ended up pushing us both off the track in Sweden. We had both been under so much mental pressure that in the end he just blew a fuse*." Roberts, 1988, p.17

> (Fitness & diet)
> "*As for diet, I eat meat only once a week, otherwise sticking to raw vegetables, fish, milk products and salads. I don't smoke and I only have a glass of wine occasionally. During my time with Renault, my heart rate was*

> *65 beats per minute. Today, it's down to 48 and my stamina equates that of a downhill skier in the heat of competition*." Prost & Rousselot, 1988, p. 172

Such material is not specific to motor sport, and not directly conducive to developing a substantive theory of the core perceptual-cognitive expertise in the domain.

An aspect of career planning and success in motor sport is **sponsorship & team leadership**. These aspects, also not domain specific to motor racing, are well illustrated by the following passages:

> (Sponsorship)
> *"Your job for the sponsor does not end when you leave the track. Your job is to both promote his product and to increase his enjoyment of motor racing. His racing involvement is a very real part of his business or his social life - or both. This means bringing your car - and yourself - to his place of business from time to time to meet the troops and press the flesh. It means going to trade shows if his company uses them. It means being available and articulate any time that he wants to show off his racing driver to employees, associates, clients or friends. It means visiting branches or associate firms when you are in their area and entertaining associates at the track. It means writing thank you letters, news letters and video tapes. Basically, it means paying your way."* - Smith, 1996, p. 6-18

> (Team leadership)
> "*One thing is certain, unless your crew is convinced that you want to win the motor race more than you want anything else on earth on that particular day, your chances of winning are slim. It is not enough that you know - they have to know it as well. I am not advocating a juvenile 'rah rah rah', 'pep talk', sort of attitude here. I am talking about walking tall and exuding confidence. It also helps to smile, be cheerful and act as if you truly enjoy driving racing cars. This sort of attitude is catching*." - Smith, 1996, p. 6-14

Also rather general aspects of performance development - but which sometimes deals with the motivational basis for motor sport specifically - may be termed **attitude and motivation**:

> (Attitude & motivation)
> *"There is only one thing sure about your ability to win any given motor race. If you are not absolutely certain that you can win it, you won't".* - Smith, 1996, p. 6-20

> (Attitude & motivation)
> *"Ask any first class sportsman, and I do not mean merely motor racing, and he will tell you that if you do not have great enthusiasm you will never do really well. Enthusiasm, or as we Italians say, 'passion', means believing utterly in what you are doing; it means self sacrifice, an ability to adapt oneself to circumstances, and the will to keep cheerful even in the blackest*

> *moments. The real enthusiast must be able to 'write off' in his own mind any successes that come his way, and concentrate on how to do even better in the future".* – Taruffi, 1959, p. 12

> (Attitude & motivation)
> *"Inspiration comes under the heading of mental condition. It is the area of breakthroughs in racing and it really is a tool. Adding a dash of inspiration to faster is an important part of racing. It takes that very ingredient to push past the* [survival reactions] *which fight you, tooth-and-nail, for every single additional increased 0.25 mph, for every half degree of lean angle, for every 1/100th second earlier on the gas, for every additional ounce of steering input pressure, for every foot of widened attention on the track. Pushing through survival reactions makes you feel good."* - Code, 1993, p. 114

The first of the above quotations deals with the beliefs and performance-expectations, and the latter two with emotional aspects of performance.

The reason they are considered here not indicative of core perceptual-cognitive expertise in racing is *not* a presumed sharp distinction between "low-level" processes and "emotional" processes on one hand, and "cognitive" processes on the other. Instead, it is excluded due to the lack of detail on specific driving or riding *technique* – content that one could analyze in sufficient *detail* to speak to issues in driver modeling.

The same is true of passages dealing with the management of **emotional reactions**:

> (Emotional reactions)
> "*You must control your emotional or mental state of mind if you want to be successful. If you are excited, nervous, depressed, stressed, distracted, angry, or whatever, you may not be mentally effective. Your decision making will be slowed, you mind will not be focused. You don't need to be psyched up. You need to be calm, relaxed, and focused. Psyching up usually makes you overly excited and, therefore, less effective. You want to drive with a clean mind, not one cluttered with useless thoughts*." – Bentley, 1998, p. 100

> (Emotional reactions)
> *"Every driver reacts differently. With some drivers you can drive wheel to wheel and know they are not going to do anything silly. There are other drivers you don't feel comfortable with, because you know the guy is going to change his line before the corner or in general lose his rhythm. A good driver or a champion under pressure will not change his line or his speed. They can take the pressure. But some drivers cannot take the pressure. You can tell when you are racing against a good driver. He continues to drive at the same speed, the same pace".* - Fittipaldi & Kirby, 1987, p. 36

We next have to consider the more domain-specific aspects of skill, knowledge and technique, where the delineation of what to include in the core perceptual-cognitive

aspects expertise becomes more interpretational, and judgments more reliant on domain insight.

To focus on *core* perceptual-cognitive expertise, it was deemed that the material should describe techniques for learning skills that allow highest possible performance for a particular driver in a particular vehicle on a given piece of racetrack – that is, excluding the higher level tactics of driver-to-driver competition and the changes in cornering technique that need to be made when competing with other contestants. This **racecraft and basic tactics** builds on core skill and understanding, applying them in the context of driver-to-driver competition on the same piece of track.

For example,

> (Racecraft and basic tactics)
> "*A successful overtaking move means you have studied your opponent and discovered his weaknesses. And in order to identify them, we have to stay behind him for a few laps before attacking him with determination. If, for example, he exits a corner badly, we may leave him some room in order to attack him better without being slowed down by his car. In this way we will have made the gap and will exit with more revs*" – Senna, 1993, p. 152
>
> (Racecraft and basic tactics)
> "*Watch enough races, and you'll see drivers successfully pass by taking a broad arc into the corner inside their competitor. It looks like an early apex coming, but if the driver can brake and turn all the way to the apex and get back on-line for the exit it works out*." – Lopez, 1997, pp. 150-151

Proper interpretation and application of this information presupposes that one already understands the dependencies among corner entry and exit, different lines (wide vs. early entry), the role of engine revolution gauge "revs") in assessing cornering performance and "carrying speed" on the following straight etc. Thus, in the initial phase this more complex material was excluded.

These dependencies mentioned in the previous paragraph are often explained at length, and the reader (racing driver) is guided to develop **mental models** - a kind normative *lay theory* - of why proper techniques work, improper techniques do not work. Examples include different **track geometries** a racing driver must be able to "read" and reason about, technical understanding of **vehicle components**, especially tyres (slip angles) and suspension geometry, the **dynamical dependencies** between different control actions and their outcomes (their interdependencies and basis in vehicle dynamics, especially dynamic **transfer of weight** during cornering and how this affects the limits of braking acceleration and cornering):

> (Mental models – track geometry)
> "*A turn that begins with a bank and end off-camber demands the most changes and adjustments in lean angles. In order to continue around it, the*

bike must be leaned over farther. The effect is much the same as going from a banked to a flat surface. Gravity is now working against you, pulling you and your bike to the outside. You lose ground clearance. Therefore, you set up off-camber turns so that you are in the off-camber situation as short a time as possible - just the opposite strategy as for a banked turn". - Code, 1983, pp. 4-5

(Mental models – vehicle systems & components: tyres)
"Since the rubber tries to 'snap back' with a force proportional to the amount of distortion and since the center of pressure of the footprint is behind its (the footprint's) geometric center, the self-aligning torque tries to return the tires to its straight ahead position ... self-aligning torque, reacted through the steering, is one of the factors which allows the driver to 'feel' what his (front) tires are doing. ... self-aligning torque generated by slip angle peaks slightly before the cornering force generated by the slip angle does. This allows the exceptionally sensitive driver to operate in the area where self-aligning torque is just staring to fall off - before 'it goes all light and funny'". - Smith, 1996, pp. 2-6 - 2-7

(Mental models – vehicle systems & components: drivertrain)
"Since a front wheel drive car has a tendency to understeer (due to all the weight on the front end), it's important to trail brake a little more on the entrance to conrers. Left-foot braking is used by many front wheel drive racers to help with this trail braking". – Bentley, 2011, p. 132

(Mental models – dynamic dependencies)
"The relationship between steering position and throttle position is interactive. Steering input must be reduced ('unwound') in order to apply acceleration. Since a tire has a limited amount of traction you cannot use all of it to turn the car and expect it to accelerate at the same time. You have to trade off steering input as you begin to accelerate, otherwise you 'pinch' the car into the inside of the corner on the exit, often causing the car to spin and always scrubbing off speed". – Bentley, 2011, p. 79

(Mental models – dynamic dependencies)
"We often hear the expression, 'we've got to tighten this baby down' [i.e reduce the car's tendency to generate excessive rear tyre slip angles during cornering as speed increases, called oversteer], or 'we've got to loosen the thing up' [i.e. increase rear slip angles, reduce understeer]. You can tighten it down either by adding download to the car or rebound control to the shocks. In the first case you pay your penalty in aerodynamic drag while in he second the car may jack itself down over surface irregularities." – Smith, 1996, p. 7-6

(Mental models – dynamic dependencies)
"*At the approach to a corner, if you turn the steering wheel toward the inside of the road too early, it may force you to turn the steering wheel even tighter as you reach the end of the corner. If you're going slowly, the car will respond*

> *to this second turning motion; but if you're going faster, you could get to the point where the car won't respond, and it will run wide coming out of the corner regardless of what you persuade it not to do.*" – Lopez, 1997, p. 14

This material is interesting from a cognitive point of view, particularly concept learning and **communication with engineers** & technical aspects of set-up and vehicle dynamics (see below).

> (Communication with engineers)
> "*To be a sensitive driver means analyzing the car's reactions through a bend, feeling the effect of different set-ups - in other words, understanding the car. … If a driver has a certain amount of sensitivity, he will become an invaluable asset to the team in setting up and developing a car. He will be able to describe the car's behavior in the most accurate and detailed manner. Then the engineers will decide what adjustments and modifications to make on the basis of the information he has provided*". – Senna, 1993, pp 103-104

> (Communication with engineers)
> "*One misconception that some drivers have is that they need to tell their engineer or crew what to do to fix the car. While that may be the case if you're really the engineer, if you have someone who is ultimately responsible for the actual tuning of the car, your job is simply to report what you feel. It's not to say 'stiffen the front shock's rebound two clicks'. In doing that, the engineer can only assume what you're feeling and will not learn anything while making that adjustment. ... Rather, if you said, 'The car understeers just after I release the brakes. If you can control the rate the car's front end unloads, I think it will have less understeer', you rengineer can determine what it needs. ... On the other end of the spectrum there are drivers who will say 'It understeers' or worse yet 'The car sucks'. If you used the second comment, I doubt you'll be much help at all*." – Bentley, 2011, p. 286

The information is not necessarily detailed, or even factually accurate from a physics and engineering standpoint. It is formulated in an intuitive and useable way. Yet the fact that these techniques are founded on, and their descriptions make use of a lay understanding of, *vehicle dynamics* appeared to be a useful connection to the academic literature.

However, it was not considered part of the description of *core* perceptual-cognitive skill, as it has more to do about effective reasoning and communication (especially developing vehicle set-up), than the pure act of racing driving itself.

2.2.4. Description of content selected for extraction and analysis

Below are some passages exemplifying the core **perceptual-cognitive skill** descriptions sought for extraction and analysis.

These passages contain descriptions of *concrete situated motor actions*, *perceptual observations*, *attention*, or *learning*, *memory*, *reasoning* or other higher cognitive processes which are *intimated to be directly relevant to performance on the race track.*

Here are some examples:

> (Core perceptual-cognitive: knowing the track)
> "*You need to control your desire to go fast until you know exactly where you want the car to be on every inch of the racetrack - you have to know 'the line' - before you can safely go fast*." – Lpez, 2011, p. 14
>
> (Core perceptual-cognitive: remembering performance details)
> "*Many riders have a bad habit of talking in negatives about their riding. 'I didn't go hard enough', 'i should have gotten a better drive off the corner', 'I don't use the brakes that well', 'I need to get a better line through this turn'. … The only way to make changes in your riding is to change what was done. To do that, you need to know exactly what was done, not what wasn't*".
> Code, 1983, p.10
>
> (Core perceptual-cognitive: mental imagery rehearsal)
> "*In your mind's eye, see yourself repeatedly driving exactly the way you want: driving the perfect line, balancing the car smoothly at the very limit, making a well-executed pass and so on. Mentally drive the race car. But do it successfully. It's amazing how often an error in a driver's mental visualization of a lap actually happens. So, visualize yourself doing the right thing! ... You can visualize in slow motion. This gives you time to be aware of each minute detail of the technique, perfecting it before heading out on the track*." – Bentley, 1998, p. 106
>
> (Core perceptual-cognitive: trial and error learning)
> "*Every now and then, go onto the track and experiment: try taking different lines, changing the balance of the car, braking earlier or later, turning the steering wheel slower or flicking the car into a corner. No, this isn't an excuse to be sloppy or for making mistakes. Think of it as a musician jamming or an artist just throwing paint on a canvas to see what happens. Learn what happens when you do something different. Discover what you can and cannot do, what works and what doesn't*." – Bentley, 2003, p. 20
>
> (Core perceptual-cognitive: learning by imitation)
> "*Learn by observation, appreciation and imitation. Imitation is the ultimate learning technique. Copying is the most instinctive, simple and natural way to learn. … If you want to learn a skill, find someone who is very good at it. Then watch this person carefully. As you watch, feel yourself moving in the same way; then practice by visually imitating*." – Bentley, 1998, p. 112
>
> (Core perceptual-cognitive: concentration and attentional focus)

"*A racing driver must make sure he is concentrating at all times, and I believe that the best way for a driver to maintain his concentration is to talk to himself. After a while you tend to relax so you must keep asking yourself, am I taking this corner fast enough? Am I braking late enough here? What is my lap time? Am I slowing down*?" – Fittipaldi & Kirby, 1987, p.

(Core perceptual-cognitive: conscious observation & use of feedback)
"*Have you ever gone through a turn while changing the throttle position to try to find the right speed? The process involves your back and forth sampling of the speed against your idea of what speed it should be, along with the other factors you notice, lean angle, tire adhesion, line, reference points, pavement condition and many more*." – Code, 1986, p. 17

(Core perceptual-cognitive: vehicle control skillls)
"*[L]et me explain what I mean by perfect car control. In general, this expression is applied to someone who is a master at 'catching' a car that is momentarily out of control. A car that started to oversteer significantly is brought back under control by rapid counter-steering action. When you have real car control, though, you will not allow your car to develop sufficient oversteer to make such counter-steering action necessary in the first place. With perfect car control, your backside is your connection to the car and allows you to feel what is happening. When this is combined with the feedback through the steering wheel, you will be able to make micro corrections to keep a car on its ideal line before a bigger slide or drift begins to develop*." – Krumm, 2015, p. 25

Also explanation of techniques that are not familiar from everyday driving, such as heel-and-toe double-declutch downshifting, would belong to this category:

(Core perceptual-cognitive: vehicle control technique)
"*The simple function of the right foot in heel-and-toe is to, with the ball of your foot, brake for any given corner. Now comes the tricky part. At the same time your braking is being accomplished in a straight line, it is necessary also to rev the engine a predetermined amount with the heel of your right foot so that the clutching and shifting procedure can be accomplished at the same time while still slowing the car. In simple terms, while braking with the ball of your foot, the heel pivots to the right, still maintaining full braking pressure, and squeezes the throttle the proper amount of revs, then pivots back below the brake pedal to finish the braking or trail-braking procedure. … To double-clutch by itself is a rather simple procedure. First you push in the clutch, move the gearshift lever out of gear and into the neutral gate, release the clutch about half-way, then depress it again instantly, then continue your shift to the next desired gear and let the clutch out*" - Bondurant & Blakemore, 1998, p. 57

(Core perceptual-cognitive: vehicle control technique)

> "*Proper down-shifting is not easy. It requires lots of coordination, concentration and practice. This is the time to get everything working together: both hands, both feet, and most importantly (and most difficult for some), your mind. Your left hand is steering, your right hand is shifting, your left foot is working the clutch, and your right foot is not only braking but also rolling on and off the throttle smoothly, and your mind is telling you to keep up the proper revs. That's not all-your ears are listening to the engine and gearbox sounds; your eyes are looking for your turn-in point for the corner, at your tach, and maybe at the car in your mirror*." - Bondurant & Blakemore, 1998, p54

2.2.5. Iterative development of the coding scheme

For analysis, such passages deemed to represent **core perceptual-cognitive skill** were collected in an excel file, where each passage was copied to a single row, and different labels could be written on adjacent columns, color coded, and the material sorted in different orders to get a feel for the different themes in the text material. This process was continued while search for new data sources was ongoing. Different ways to classify the excerpts were considered.

One idea was to group skills in terms of the individual controls (*steering wheel, brake, throttle, clutch & gear*). However, this was quickly found undoable (at least in a 1:1 mapping), as many of the motor actions require a *combination* of many or all controls, while purely cognitive techniques such as gaze strategies or mental imagery do not relate to any specific control at all.

Similar problems were found when trying to categorize the passages in terms lat*eral control* vs. *longitudinal control* (i.e. control of *lane position* vs. *speed*), or in terms of which phase in the sequence (*approaching* a bend on a straight, *braking*, *turning in* and *entering*, steady-state *cornering*, arriving at the curve *apex*, engaging power and accelerating out to the curve *exit*) the training pertained to. Namely, the same way that skilled technique depends on "blending" different controls together, so it seems skill is also exhibited in the way longitudinal and lateral control are *combined*, and different phases of a bend spliced together. Also, errors in one phase of a bend will propagate further in the sequence and be compounded, meaning the whole sequence needs to be assessed as a whole. For example:

> (Error + Consequence)
> *"(I)magine entering a corner 1 or 2 miles per hour slower than ideal. What happens then? One of two things. First, and probably the lesser of the two evils, is you have lost momentum, and momentum is always important. … The second and more damaging - and more difficult to recognize - effect of over-slowing your car for a corner is what I call the change of speed problem. ... (T)he basic idea is that if you over-slow the car on the entry, you will naturally want to accelerate hard to get back up to speed. This acceleration will often result in a form of power oversteer in rear-wheel drive cars, and power-understeer in front-wheel drive cars*." – Bentley, 2003, p. 85

Indeed, one theme that emerged as the material was added to the excel was the high frequency of description of typical **errors**. (These were preliminarily defined as *incorrect actions, procedures or ideas that, when executed or applied, reduce performance*). For example:

> (Error)
> "*A common error that many drivers make is 'crabbing' into the corner - easing the car away from the very edge of the track prior to turning in*."
> – Bentley, 2003, p132

Sometimes the error is given context in terms of its **causes**, i.e. thought processes or actions that lead to the error:

> (Error + Cause)
> "*I now never walk (a track) until I've driven it at least for one session. Often, I found that if I walked a track before having a little real experience, I would get false thoughts and ideas of how to drive it. What may have looked like a third-gear corner while walking may really have been a fourth-gear corner. Then, before I could start to learn the track properly, I first had to 'unlearn' the false thoughts and idea*s." – Bentley, 1998, p. 79

or its **consequences**, and/or the **correct technique** that would remedy the error:

> (Error + Consequence + Correct technique)
> "*An abrupt snap off the gas upsets this balance and can steal traction from the rear tires, causing a spin. … When a car is cornering fast, its behavior depends on keeping a nice balance between the grip of the front and rear tires.*" – Lopez, 1997, p. 15

(Here, lifting the foot off the throttle mid-corner - the error - transfers weight to the front axle unloads the rear tyres, reducing their grip and causing the vehicle to over-rotate out of control - the consequence) The correct technique is “keeping a nice balance”). Thus, one way to analyse the material could be to produce a network of errors and techniques. Indeed, analysis of error patterns in complex natural behaviour is an established research strategy in cognitive studies (Cooper & Shallice, 2000; Reason, 1990).

However, many descriptions of errors and correct technique were quite *succinct* and *lacking in detail* (“abrupt snap”; “nice balance”). Analyzing them would therefore require much contextualization (cross-referring to other material in the same book, across books, or source material, domain insight). It was deemed preferable to try to find content units that would have more *explicit grammatical structure* in themselves, requiring less interpretive combination and cross-referencing on the part of the analyser. Additionally, because of their succinctness, the number of potential errors to analyse – especially if they were to be analysed in relation to their causes, consequences and correct technique – appeared prohibitive.

On the other hand, while the number of descriptions of technique were many, the number of extended passages describing technique in explicit terms were few.

In ascending level of structural detail, the descriptions of correct technique were labeled:

Adages (def. *typically an instruction or a simple rule of thumb or a mnemonic aid expressed in racing jargon*), e.g.:

> (Technique: Adage)
> "*All other things being equal, he who gets the power down first, will get to the next corner first*." – Smith, 1996, p. 2-34
>
> (Technique: Adage)
> "[S]*mooth is quick.*" - Bondurant & Blakemore, 1998, p. 71
>
> (Technique: Adage)
> "*Many riders have said. ´You go where you look'. … Let's restate it so the rider is more in control: Look where you want to go*." – Code, 1983, p.23
>
> (Technique: Adage)
> "*The most important corners are always the fastest ones*." – Smith, 1996, p. 4-4

slightly more concrete **strategies** (def. *a more complex instruction that requires some explanation*, this is the most common level of detail), e.g.:

> (Technique: Strategy)
> "*As you enter a corner, before you even get to the turn-in point, you should be looking at and through the apex. You have to know where you're going before you can know how much to turn the steering wheel at the turn-in point*." – Bentley, 1998, p. 102
>
> (Technique: Strategy)
> "*Once the throttle is cracked on, it is rolled open evenly, smoothly, and constantly throughout the remainder of the turn*". – Code, 1993, p. 7

and, finally, step-by-step **drills** (def. *clear procedures that can be performed in practice, with clear identification of relevant situational factors and sources of information one should use in adjusting the action*.), e.g.:

> (Technique: Drill)
> "*1) Identify the level of threshold braking availble by braking harder and harder on successive laps. 2) Once you're in the vicinity of threshold braking move the brake point down toward the corner in small increments (three feet at a time is a good rule of thumb. 3) If entry speed gets so high that the car*

begins to be forced off-line or the throttle-application is delayed, you've taken the braking too deep. Move the brake point back where it allowed you to do the line and corner exit properly." – Lopez, 1997, p. 76

(Technique: Drill)
"*How do you really know when you are driving the car at a speed where all four tires are right at their limit of traction? Start by asking yourself some questions. Is the car sliding? If not, you can drive faster. Is the car sliding too much? If so, you are scrubbing off speed, and possibly overheating the tires. An excessive slide or drift may eel good, and look great, but it is usually not the quickest way around the track. So, if no sliding is not enough, and too much is really too much, just how much is enough? ... Most drivers, when they first begin racing, do not slide the car through the turns enough. It's like the car's on rails. Then, with experience, they begin to slide the car more and more, eventually learning to slide it too much - they are driving slightly beyond the limit. Finally, they learn to fine-tune the amount of sliding, homing in on the ideal slip angle*." – Bentley, 2003, p.109

(Technique: Drill)
"At the Superbike School we have devised a method to cheat the problems of fixed attention going into turns; we call it the two-step turn-entry- At the entrance of every corner we tape marks down on the pavement. (I suppose it seems like an odd idea to put giant marks on the pavement for the purpose of training riders to quit looking at other marks on the pavement, but it works). The first mark is a reminder to look into the turn because 99% of all rider leave this important job until far too late. The second mark is the turn-point itself. The two-step goes like this: 1. You spot your turn-point as early as possible. This could be before you brake, while braking, anywhere – as early as possible, (That's one step). 2. Just before arriving at your turn-point you look into the turn to se whre (exactly) the bike should go. (That's the second step). … The difficult part of this technique is allowing your bike to go straight until you have reached your turn-point. [Survival reactions] are begging you to turn the bike at the same time you look in. This is the 'go where you look' survival reaction. … The two-step technique helps you defeat it." – Code, 1993, p. 99

Passages describing such "drills" or "exercises" became the focus, as they appeared more self-contained, and having sufficient content and explicit structure to be meaningfully analyzed in terms of technique and even underlying cognitive processes.

A theoretical framework to analyze drills was needed. **ABC "toolbox" of heuristics** (Raab, 2012; deOliveira, Lobinger & Raab, 2014) and the **DP framework** (Ericsson, Krampe & Tesch-Römer, 1993) were considered. Other frameworks could have been considered as well, and one cannot assume that these frameworks would be the best or most natural ones for the data. No systematic search of different frameworks

was performed. The “drills and strategies” were perused to see if they could be more naturally fit to one of the frameworks in rigorously operationalizable terms.

An ABC heuristic analysis decomposes complex action into building blocks, typically:

i. search rules that specify where in the environment or memory the relevant information is

ii. stopping rules that specify when to end search, and

iii. decision rules that specify the final decision.

A prerequisite is identification of the relevant core capacities (e.g. object tracking, recognition memory, frequency estimation etc.) that are brought to bear on performance of a specific task.

However, as the *goal* of this research was, inter alia, to try to identify the relevant core capacities, and as it is very much an open question where in the visual scene or memory the relevant information for racing driving performance is (this paper is meant to contribute), the ABC framework seemed unsuitable for present analyses.

Unlike the ABC heuristics, DP literature did not provide a similar systematic set of criteria of applying the concept of DP to a particular form of practice. Indeed, there is theoretical tension and debate in the literature as to when training can be “properly” considered DP (Ericsson, 2016). Thus, developing such criteria for the present work appeared to promise a useful contribution to the DP literature more generally. DP was chosen as the theoretical approach and a coding scheme developed on the basis of seminal papers defining the DP framework (see *Section 4. Operationalizing DP*).

Going through the material page by page, passages were selected and extracted on the basis that they should contain sufficient structure and detail to allow a classification of meaning units within the meaning units into one of the DP characteristics (DP1-DP4). All the four DP characteristics should be identifiable in each selected complete meaning unit. Such meaning units were deemed to represent “Deliberate Practice Procedures”, and made up the final dataset.

Interpretation of the passages from a *theoretical* perspective was done on the basis of the McRuer framework, which the author has worked on previously. Note that this material is placed in the Discussion rather than the Results, as it cannot be considered emerging from or grounded in the source material in a similarly methodologically rigorous way that the DP procedures are.

3. Reflection on methodological choices for trustworthiness and rigor

This section reflects on the rigor of the methodology used in the search, unitization and coding, the trustworthiness of the original material and management of researcher perspective and disclosure of bias.

3.1. Search

The literature is not indexed in academic publication databases or Google Scholar, cross-references between the books, author and racing school websites, and Amazon buying behavior links were used iteratively.

Cross references between the works was not as helpful as one might hope, as the authors do not use academic referencing, but usually only present a brief list of recommended reading at the end of the book. Occasionally, they may mention a prior treatment of a topic in a previous book, but this is actually fairly rare (one reason may be a tendency to promote the material as "the" one-stop reference work, or a "new" or "up-to-date" exposition of technique, showing familiarity with previous literature, but insinuating that previous works or the "traditional" approach may be outdated). Author and racing school websites were searched and perused, but these turned out to be of little help. Normal Google searches tend to return seller book store links.

The search method may not be ideal, but with the present literature turned out to be the most effective search method for this particular genre. Establishment of reference data bases for projects such as this seems desirable.

3.2. Unitization & Coding – trustworthiness and reliability

When multiple coders analyze the data, inter-rater reliability and inter-rater agreement are frequently used "reliability measures" for in qualitative research. *Inter-rater reliability* refers to two or more knowledgeable coders independently classifying raw material according to a pre-defined coding scheme. With exploratory document analysis in general it is not possible to have a detailed *a priori* coding and analysis framework in place prior to data collection and analysis. In the Grounded Theory methodology, in particular, this is the case, as it is one of the aims of the research to develop such frameworks based on the data. Thus, inter-rater reliability was not a feasible means to assess rigor in the present study.

As soon as differences of opinion among coders as to which code should be assigned to a given text - or if changes in the coding scheme itself are called for - the eventual agreement measure should be considered *inter-rater agreement* (although commonly "inter-rater reliability" before and after negotiation is reported), as the criterion of independence is violated (Smith & McGannon, 2017).

Especially in cases where the analysis requires on substantial domain insight (as in the present case where much of the source material is quite technical and dense

racing jargon), this can severely compromise the inter-rater agreement. It is not logistically easy to discover peers with the appropriate domain knowledge, interest, and time to embark on an exhaustive qualitative analysis, and if a research assistant were to be recruited and trained, the combined effects of academic seniority and domain knowledge of the PI might severely compromise the trustworthiness of inter-rater agreement negotiations. Smith & McGannon (2017) advise against using intercoder agreement as an argument for trustworthiness in qualitative research.

Another point to consider is that *coding* decisions are contingent on prior *unitization*: identification of the boundaries of meaning units to classify. These judgments possibly bring a stronger subjective element (from which the present study is not free) – but note that this is *not* solved by reporting inter-rater reliability/agreement, which is only possible to assess once the boundaries of meaning units (what to extract for coding) have been made. This is to the best of the knowledge of the author an unresolved problem in the methodology of qualitative research. The best practice seems to be to document in sufficient detail the decisions leading to unitization, as done in the previous section.

When a single coder is used, the overall goal is to produce a coding scheme such that one can be confident that other knowledgeable coders (if available) would agree on and/or independently reproduce the classification (Campbell et al., 2013). Because the aim was to produce a highly compressed corpus of analysis (orders of magnitude down from the original material running to several thousand pages), and because the analysis is done on published (non sensitive or confidential) material, *it is possible to submit the entire meaning units, their analysis and the coding scheme for peer review and peer and practitioner evaluation*. *That is, with data disclosure instead of negotiation within the research team, the validity of he proposed classification can be directly judged by peer reviewers, the scientific community and domain experts.*

Because the entire source material is presented as a corpus in the *Supplementary Results* document, the claim that the procedures are all DP is directly open to peer review and anybody can assess whether the inferences and hypotheses are sensible against the primary source material.

This is closer to quantitative open data approach (where single author research is not issue precisely because of these advantages). This author feels that - whenever feasible - this is generally a more transparent and valid approach to establishing trustworthiness than the usual way of reporting inter-rater agreement based on discussions and negotiations whose details are not disclosed.

The *constant comparison* process (Section 2) is not at a level sufficient for presenting a GT of the origins of racing driving expertise. But that is not (yet) the aim of the project. Already from beginning the *a priori* aim was to connect the emerging material (through some coding framework, for which DP was chosen) to specific driver modeling literature (the McRuer framework), which the author has been working in. This approach is not in *contradiction* to GT but does not (yet) go all the

way towards building a *data-grounded* substantive theory. Such a larger process would indeed require more checks and balances - such as more systematic and rigorous constant comparison, a plan to implement inter-rater agreement and reliability, and member checking. Indeed, the present work can be taken as a first pass at analyzing the material, with a more basic approach, to gauge whether the source material truly is rich and comprehensive enough for a more sustained qualitative research effort.

3.3. Representativeness of the material of actual determinants of performance

The original material is not produced for the purposes of scientific knowledge elicitation, but for training. For instructional purposes, the material must be organized and presented in a way that is meaningful at the phenomenological level and makes immediate intuitive sense to the trainees, even if this sometimes requires recourse to metaphor or idiosyncratic models that might be qualitatively different from the (eventual) scientific model of performance. The experts' or coaches' (retrospective) attestations to cognitive processes need not and cannot likewise be taken at face value.

For example, looking "around a bend" clearly is not optically possible, but presumably gives the right impression to the trainee (and to the researcher perhaps a hint of the role of attention in visual strategies, not just optics).

Even the detail of the training procedures cannot be taken as 1:1 representative of actual training, as the 'textbook' and 'in practice' versions might differ in important details. Such facts can only be elucidated through direct observation, experiment, and theory development.

What the present Results strictly state is: *in the coaching literature in professional motor sport there are detailed descriptions of training activity that can be considered Deliberate Practice Procedures under a strict and systematic definition of DP grounded in the DP literature*.

The Discussion interprets the content of such procedures in terms of putative *core perceptual-cognitive mechanisms, within (an extension) of the modelling framework of McRuer et al.* (which is the conceptual basis of driver modelling in motorsport engineering).

DP procedures alone hardly give a comprehensive picture of core perceptual-cognitive motorsport expertise. But because they *codify in a precise way procedures that are relevant for development of perceptual- cognitive skills*, they can be used as starting point and *grounding for hypotheses and experimental designs* that probe the behaviour and physiology in more detail.

Also, much of the relevant perceptual-cognitive processing occurs outside awareness and the present material is limited to what can be brought into awareness and

communicated verbally/in pictorial form. Important factors may only be discoverable by more detailed and accurate methods.

3.4. Perspective management and disclosure

For transparency, this section reflects on how researcher perspective influenced and guided the data collection and analysis.

The author has a long standing personal interest – but no expertise or professional background – in auto racing. This stems, on one hand, from an interest in *expert performance* and its attainment generally, and on the other hand from an interest in the skill involved in *high-speed vehicle assisted locomotion*, especially car driving. The author has an interest in cars generally and would consider himself an enthusiast, or a "car guy". He owns three sports cars (the financial and time commitment indicating the interest is more than passing), and for insight has practiced some of the basic techniques such as heel-and-toe double de-clutching with them. He is widely read in driving technique (mainly books and magazines), and in his spare time follows motor sport (online, on TV, occasionally attending races). He has some experience in Sim racing and rental karting but cannot be considered proficient in the skills.

The philosophical stance of the author is post-positivistic (as seen from final paragraph): he sees the aim of research is seen as discovering pre-existing patterns (when successful, research codifies "facts"). The aim of the present study was to arrive at a coding scheme that would be generalizable to other domains, not dependent on technical concepts or deep domain insight. More widely, the aim is a theory of expert racing driving. Such a theory may be informed by a substantive grounded theory (if developed). But unlike in qualitative research, the author would not consider a taxonomy or conceptual model (perhaps expressed in a complex figure) a theory – as a scientific theory in the strict sense must be expressible in algebraic, geometrical or algorithmic terms. This perspective on science is in part behind the aim of the Results and Discussion establishing a dialogue with experimental psychology and driver modeling in cognitive science an (racing) vehicle systems engineering.

The coding of the material and methodological decisions were made with explicit methodological commitment to this view, and an interest in linking the information in driver training literature to driver modeling which the author has research expertise on.

Peer discussions with researchers from the driver modeling and experimental psychology traditions sounded the developing interpretations from the point of view of psychological and computational driver models and theory. These researchers had no particular interest or experience in racing driving, did not see the raw data, nor were they aware of the development to the coding scheme. These discussions were used to maintain meaningfulness of the ideas (in the Discussion) to research on the driver modeling.

4. Operationalizing Deliberate Practice

There are many definitions or characterizations of Deliberate Practice in the literature, but no hard-set list of criteria was found. To attain a higher level of rigor and reliability in the analysis of training documents, explicit coding criteria were developed for coding meaning units as instances of Deliberate Practice,. That is, *individually necessary and jointly sufficient criteria* that (a verbal description of) a training task design would need to fulfill in order to be considered as a Deliberate Practice Procedure.

For this purpose, the core features of Deliberate Practice - as discussed in seminal papers (Ericsson et al., 1993; Ericsson & Charness, 1994; and Ericsson & Lehmann, 1996) were identified. Supplementary Table M1 outilines the **four core features** of **Structure, Goals, Feedback** and **Repetition** that were abstracted from the theoretical papers. At the end of this document, text excepts from the original papers *color coded in the same scheme* as in Supplementary Table M1 and in the tables in Supplementary Results are given. This is meant to indicate the particular way the criteria for DP characteristics are themselves grounded in the literature on DP.

SUPPLEMENTARY TABLE M1

Four core features of Deliberate Practice

DP1 Structure	DP2 Goals	DP3 Feedback	DP4 Repetition
Clear task instruction, perhaps even a step-by-step walkthrough. Simplified, restricted or modified activities designed to isolate a specific subtask, facilitate the diagnosis errors or explicit monitoring. A progression of subtasks of increasing challenge may be involved. May not be fully representative of the conditions of maximal performance. (Not "spontaneous" trial and error or play either).	Ultimate goal (motivation) is self-improvement Proximate goal is to perform a specific subtask or isolated skill at a higher level than previously. "Pushing the envelope" of performance. Proximal goal is *not* enjoyment, winning etc., hence need not be as inherently motivating as competition or achieving maximal performance	Action outcome immediately and unambiguously informative of proximal goal attainment, or errors that need to be remedied. Instruction i. indicates what the relevant feedback is, and ii. specifies how to use to correct behavior. Full concentration on performance is typically required for effective error monitoring and use of feedback.	Sustained engagement in repetitive drills. High training volumes ("10 year / 10 000 hour rule"). Repetition relies on motivation and willingness to expend effort specifically on self-improvement, rather than inherent enjoyment.

"The central claim of our framework is that the level of performance an individual attains is directly related to the **amount** of deliberate practice."
- Ericsson, Krampe & Tesch-Romer (1993). The role of deliberate practice in the acquisition of expert performance

“[T]the most cited condition concerns the subjects’ motivation to **attend to the task** and exert effort to **improve their performance**. . . . The subjects should receive **immediate informative feedback** and knowledge of results of their performance. The subjects should **repeatedly** perform the same or similar tasks” (Ericsson et al., 1993; p. 367).

"Most contemporary domains of expertise have evolved over centuries from activities originally centered around playful interaction with learning through active participation. As the levels of performance in the domain increased in skill and complexity, methods to **explicitly instruct and train individuals** were developed. In all major domains there has been a steady accumulation of knowledge about the best **methods to attain a high level of performance** and the associated practice activities leading to this performance. Full-time teachers and coaches are available for hire and supervise the personalized training of individuals at different levels of performance starting with beginners. Throughout development toward expert performance, the teachers and coaches instruct the individuals to engage in **practice activities that maximize improvement.** Given the cost of individualized instruction, the teacher **designs practice activities** that the individual can engage in between meetings with the teacher**.** We call these practice activities deliberate practice and distinguish them from other activities, such as playful interaction, paid work, and observation of others, that individuals can pursue in the domain."
- Ericsson, Krampe & Tesch-Romer (1993).

"Although work activities offer some opportunities for learning, they are far from optimal. In contrast, deliberate practice would allow for **repeated** experiences in which the individual can **attend to the critical aspects of the situation** and **incrementally improve her or his performance** in response to **knowledge of results, feedback, or both** from a teacher."
- Ericsson, Krampe & Tesch-Romer (1993). The role of deliberate practice in the acquisition of expert performance

"Consider three general types of activities, namely, work, play, and deliberate practice. Work includes public performance, competitions, services rendered for pay, and other activities directly motivated by external rewards. Play includes activities that have no explicit goal and that are inherently enjoyable. Deliberate practice includes activities that have been **specially designed to improve the current level of performance**."

- Ericsson, Krampe & Tesch-Romer (1993). The role of deliberate practice in the acquisition of expert performance

"The goal of play is the activity itself, and the inherent enjoyment of it is evident in children who spontaneously play for extended periods of time. Recent analyses of inherent enjoyment in adults reveal an enjoyable state of "flow," in which individuals are completely immersed in an activity (Csikszentmihalyi, 1990). Similarly, analyses of reported "peak experiences" in sports reveal an enjoyable state of effortless mastery and execution of an activity (Ravizza, 1984). This state of diffused attention is almost antithetical to **focused attention** required by deliberate practice to **maximize feedback and information about corrective action**. In contrast to play, deliberate practice is a **highly structured activity**, the **explicit goal of which is to improve performance**. Specific **tasks are invented to overcome weaknesses**, and performance is carefully **monitored to provide cues for ways to improve** it further. We claim that deliberate practice requires effort and **is not inherently enjoyable**. Individuals are **motivated to practice because practice improves performance**".
- Ericsson, Krampe & Tesch-Romer (1993). The role of deliberate practice in the acquisition of expert performance

"[I]ndividualized training activities especially **designed** by a coach or teacher to **improve specific aspects of an individual's performance** through **repetition** and successive refinement. To receive maximal benefit from **feedback**, individuals have to **monitor** their training with **full concentration**, which is effortful and limits the duration of daily training." Ericsson & lehman 1996 p279

"[T]raining activities are **designed** to **improve specific aspects of performance** through **repetition** and **successive refinement**. To receive maximal benefit from **feedback**, individuals have to **monitor** their training with **full concentration**, which is effortful and limits the duration of daily training." (Ericsson & Charness, 1994)

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