

Genes and Training for Athletic Performance Revisited

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Sportscience 5(2), sportsci.org/jour/0102/jb.htm, 2001 (2032 words)

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There is evidence that genetic factors account for around 50% of variability in human physical performance. However, data supporting this position are not definitive. Research from studies of sport expertise indicates that differences between experts and non-experts in cognitive sports are found only in domain-specific, information-processing abilities that are primarily the result of training. Future research should examine an interactionist perspective to consider the relative contribution of genes and training to performance.

KEYWORDS: cognitive sports, environment, nature, nurture, skill

[Research Supporting the Training Perspective Concerns with the "Nature" Position](#)

Recently, I presented on the Sportscience list the notion that "sport performance and sport expertise are entirely the result of hours spent in focused, effortful training rather than innate, inheritable traits". Will Hopkins summarized the responses to this topic in a [recent issue](#) of Sportscience (Hopkins, 2001). He suggested that the empirical evidence presented by geneticists Claude Bouchard and Thomas J. Bouchard allows for an end to the passionate nature/nurture debate, at least for some measures of physical performance. Current research from the Bouchard labs indicates that up to 50% of the variance in these measures can be accounted for by genetic variation. While Hopkins' paper serves as a general summary of the biological evidence available to date, his description of the nurture position does not fully express the complexity of current research examining the contribution of environmental factors to the development of expert performance in highly skilled athletes.

Research Supporting the Training Perspective

Currently, the most radical viewpoint representing the primacy of training and environmental factors is the Theory of Deliberate Practice, a general theory of expertise presented by K. Anders Ericsson and his colleagues (see Ericsson, Krampe & Tesch-Römer, 1993). This theory finds its basis in the pioneering work completed by Simon and Chase in 1973. The Simon and Chase research identified domain-specific, information-processing characteristics that differentiated the expert chess player from the non-expert player. Moreover, they suggested that these differences were the result of almost full-time commitment to chess training rather than the result of innate abilities. Ericsson et al. have furthered this work by suggesting that it was not simply training of any type, but the engagement in "deliberate practice" that was necessary for the attainment of expertise. Deliberate practice is made up of activities done to develop required abilities that were not intrinsically motivating, required effort and attention, and did not lead to immediate social or financial rewards. Central to the notion of deliberate practice is the monotonic benefits assumption, postulating a direct relationship between

the number of hours of deliberate practice and the performance level achieved. To date, research examining the application of the theory of deliberate practice to the domain of sport has been limited but has typically provided support for the basic tenets of the theory (e.g., Helsen et al., 1998, 2000; Starkes, 2000).

The research is primarily studies of differences between experts and non-experts or novices. Specifically, no studies have found consistent, reliable differences between experts and non-experts or novices on static physical capacities such as visual acuity, reaction time, and/or memory (often referred to as hardware). However, consistent differences are reported for domain-specific information processing strategies (referred to as software). Singer and Janelle (1999), in a recent overview of the last 30 years of expertise research in sport, summarized the characteristics that distinguish the expert as follows:

- Experts have greater task-specific knowledge: Researchers McPherson (e.g., McPherson, 1993) and French (e.g., McPherson & French, 1991) have provided substantial evidence that sport experts have greater domain-specific knowledge than novices/non-experts. However, this increased knowledge is restricted to their sporting domain.
- Experts interpret greater meaning from available information: Abernethy's (e.g., Abernethy, 1987, 1990, 1991) research on visual search strategies and anticipation indicates that experts are more efficient at interpreting available visual information within their area of expertise.
- Experts store and access information more effectively: McPherson's (e.g., McPherson, 1993) research on information structure in decision-making sports suggests that experts have a more complex and structured network of information that they can access more efficiently than novices/non-experts.
- Experts can better detect and recognize structured patterns of play: Pattern recognition paradigms such as those employed by Chase and Simon (1973) and Allard and Starkes (1980) have provided robust findings regarding the superior ability of experts to store and access domain-specific information in more structured and complex "chunks".
- Experts use situational probability data better: Abernethy's research with squash, tennis and badminton players has indicated that experts are better able to anticipate the actions of their opponent (e.g., Abernethy & Russell 1987a, 1987b).
- Experts make decisions that are more rapid and more appropriate: The characteristics identified in the above points collectively provide an information processing system that is highly effective and markedly more efficient than those of the novice/non-expert.

In domains where the distinguishing characteristics between experts and non-experts are domain-specific, information-processing abilities there is evidence to suggest that these differences are the result of training rather than innate abilities. While certain gross, general traits have been linked to genetic endowment (e.g., intelligence), the refinement of these traits into domain specific abilities (e.g., pattern recognition, strategic thinking) is likely due to specific training undertaken during critical periods of development. The notion that there would be a gene that predisposed an athlete to superior information processing that is only manifested in a single domain (e.g., a gene for soccer processing) is not supported by empirical data.

Another interesting issue supporting the predominant role of training deals with studies examining the relative age effect (e.g., Helsen et al., 2000). Studies of the birth months of skilled athletes in numerous sports (e.g., soccer, ice hockey, baseball, cricket) have consistently indicated elite performers are more likely (up to 4 times more likely) to be

born in the first quartile of the selection year than in the last quartile. Further, dropouts from a particular sport are typically born in the latter parts of the selection year. In some cases, athletes can have up to a 12-month advantage in physical maturation over their peers born late in the selection year. In light of the characteristics usually sought by those identifying "talent", these findings imply that physical maturation characteristics determine who receives access to improved training resources and coaching. As a result, this system becomes self-perpetuating, promoting the further development of these athletes.

Concerns with the "Nature" Position

While I applaud Dr. Hopkins for attempting to summarize this complex issue in such a short space, the picture presented may not capture the actual complexity of this issue. Specifically, there are several areas that require further attention.

- *Lack of associations between DNA sequence and athletic performance.* This lack of association between genetic markers and performance may be "because performance is determined by many genes and/or they haven't struck gold yet" (Hopkins, 2001) or conversely, it may be because environmental effects have a larger contribution than considered. Scientific rigor compels us to consider all possible perspectives in the face of conflicting results (such as those examining the ACE allele).
- *Concerns with twins research.* There are methodological concerns regarding research using twins to examine the relative roles of genes and environment on human behavior. Twin studies typically examine participants from a specific subsection of the population (e.g., those middle to upper class); further, "heritability estimate[s] should not be extrapolated to the extremes of environmental disadvantages still encountered in society" (pp 137-138; Bouchard, 1997). By not including participants from the extremes, researchers may remove inter-individual variance that is associated with environmental factors and thereby inflate the contribution of genes.
- *Lack of elite athlete research.* Studies of genetic predisposition normally examine participants from the general population and then generalize these results to elite athletes. Hopkins identified the lack of research examining genetic predisposition in elite athletes. Elite athletes have performed large amounts of structured, specific training designed to make physiological adaptations necessary for high performance. The long-term (>10 years) effects that this type of training on the body are not clearly understood. Research examining the body's physiological and cognitive limits to adapt to training stress would provide useful data to address this topic.

In view of the strong evidence regarding the genetic contribution to performance on key variables, it seems clear that a certain portion of performance variance has to be attributed to heredity. However, the relative contribution of genes to sport performance is likely more varied than the 50% contribution indicated by Hopkins (2001). For example, the genetic contribution to inter-individual variance in height is around 80%. Therefore, it seems likely that the contribution of genetically transmitted characteristics to key performance variables will vary as well. Indeed, there may well be characteristics where heredity accounts for little variance among individuals. This hypothesis has yet to be proved or disproved empirically.

Future research should also consider an approach to sport expertise that investigates the inter-dependent role of genetic and environmental factors. For example, does possessing specific genes for general intelligence (*g*) influence the development of information-processing skills? Moreover, is this relationship moderated or mediated by early

cognitive stimulation during the first years of life? Interactionist models will likely be better able to capture the complexity of sport performance and expertise. More research is clearly needed before the nature vs nurture debate is resolved.

Acknowledgments

The author would like to acknowledge the responders to this original posting on the SportsScience list and Will Hopkins specifically for his helpful comments. Thanks also to graduate students and faculty at Queen's University for their constructive criticism.

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Edited and webmastered by Will Hopkins.

Published Aug 2001.

editor@sportsci.org

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