

Uncovering the secrets of The Don

Bradman reassessed

By Paul Glazier, Keith Davids, Ian Renshaw and & Chris Button

Across the world, sport science support programmes have been set up to help world-class sportsmen and women develop their skills and surpass the performances of their peers. But how did athletes of bygone generations cope without this support? What can modern-day athletes, and their coaches, learn from the early experiences and activities of past greats? In this article, we consider whether or not sport science can provide some answers to these questions by examining the factors underpinning the unique batting ability of one of the truly great performers of relatively modern times, Sir Donald Bradman. We also consider some of the training equipment and practice strategies used by today's leading cricketers, and question whether they are more advantageous than those of Bradman's era. In attempting to piece together understanding of the iconic Australian's cricketing development, we blend a mix of theoretical principles, experimental data and anecdotal evidence from the sport science and coaching literatures.

Contextualising Bradman's record-breaking career

Bradman finished his international career with a batting average of 99.94 runs per innings, a record that is still at least 40-50% better than any other batsman in the history of the game. Comparing player performances across eras, however, is fraught with difficulty and answering questions like: 'How do current Test batsmen measure up to the legends of yesteryear?' and 'Can there ever be another Don Bradman?' provides science with a complex challenge.

Recently, statisticians have attempted cross-generational performance comparisons of legendary sportsmen and women and, in cricket, Dickson et al(1) undertook a statistical analysis of all Test batsmen over a 120-year period between 1877-1997. By plotting the coefficient of variation of batting averages across eras (eg, pre-World War I, pre-World War II, 1946-65, 1965-1979, the 1980s and the 1990s), Dickson et al¹ showed that variability had decreased over time and that a modern player would need to average approximately 77 runs per innings to match Bradman's career batting average statistically. An analysis of modern players, however, shows that no current Test batsman is able to boast this figure, with the highest averages currently belonging to Matthew Hayden (Australia) 58.14, Rahul Dravid (India) 58.09 and Sachin Tendulkar (India) 57.39.

Dickson et al(1) invoked the ideas of the eminent evolutionary biologist, Stephen Jay Gould, for interpreting their modelling work. Gould(2) developed the evolutionary theory of punctuated equilibrium to describe how long periods of evolutionary stability for biological organisms are broken by sudden, shorter spurts of dramatic evolutionary change, the latter resulting from external perturbing forces. Gould's² theory contrasts with Darwin's traditional perspective that portrays evolution as a slow, steady process occurring at a relatively constant rate and, as we note below, is precisely the sort of framework that may be able to explain sudden jumps of 40-50% in cricket batting performance. Indeed, Gould(2) alluded to the baseball hitting average of 0.400 to exemplify these theoretical ideas and sport is

littered with examples of punctuated equilibrium from Fosbury's flop technique in the high jump, to Bjorn Borg's heavy top-spin forehand drive and the double-hitch kick long jump.

In the context of this article, these ideas lead to key questions such as: Why was Bradman so much more successful than anyone else? What was his secret? Was he simply a 'one-off genius' or is it possible that a cricketer of a future generation could emulate his amazing achievements?

The modelling of Dickson et al¹ raises the question whether or not another Bradman will ever emerge in the modern era, but reference to the theory of punctuated equilibrium suggests that this possibility is likely to occur as a result of sudden technical innovations produced by an individual performer. For this reason, it may be useful to gain an insight into Bradman's own technical development and practice strategies to ascertain what innovative, perturbing forces were at work.

What made Bradman great?

Since his retirement from the game, many explanations for the Don's expert batting and vast statistical superiority have been posited in the 'popular' press, media and coaching literature, but science is revealing that many of these claims are erroneous or unsubstantiated. For example, it has often been suggested that Bradman had better eyesight and faster reactions than his nearest rivals. However, he was discharged prematurely from the Australian Army during World War II for having defective eyesight – according to

Hutchins³, his release was due to fibrositis – and when he submitted himself for psychophysical tests at the University of Adelaide, it was found that he had a slightly slower reaction time than the average University student⁴. These facts are unsurprising given the well-documented findings that top-class athletes do not have exceptional perceptual systems and visual reaction times compared to their less accomplished counterparts⁵. Moreover, it has been reported that high-calibre athletes have the same incidence of visual defects as the normal population; about 10% suffer from problems of short- and long-sightedness and other weaknesses⁶. Other psychological factors have been implicated in Bradman's success, such as his supreme powers of concentration and mental toughness, but, although clearly important, these factors alone are unlikely to explain the large gulf between him and other batsmen.

Bradman's 'rotary' technique

Perhaps a more likely explanation for Bradman's success, gaining favour with top coaches, resides in his 'unorthodox' batting technique – a possible disequilibrating perturbation in the sport. Indeed, on the basis of the insights of Bradman himself and eyewitness accounts of keen observers, combined with original film and video footage, and a study conducted by sport scientists at Liverpool John Moores University in the UK, Shillinglaw⁷ concluded that the single most important factor underlying Bradman's outstanding run scoring record was his unique 'rotary' technique.

Most coaches emphasise the importance of grip, stance and back-lift as being the foundations for successful batting. Traditional coaching emphasises that the standard grip is one where the bat handle is held with the hands together, with the firmer top hand about 25 mm from the top of the handle. The hands are positioned so that the 'vees'

formed by the thumb and forefinger of each hand are in line with each other, pointing between the splice and the outside edge of the bat. During the stance, the bat should be placed just behind the back foot. The conventional back-lift should enable the bat to be taken back in a line from wicket to wicket with the top hand taking control. The front arm should be extended backwards to give a wide sweep with minimum flex of the elbow⁸.

Bradman adopted a grip that was not consistent with the coaching manual, having the 'vee' of his left hand in line with the splice of the bat.

In comparison, the key differences between these basics and Bradman's batting technique are highlighted by Bradman in his coaching book, *The Art of Cricket*(4). Bradman adopted a grip that was not consistent with the coaching manual, having the 'vee' of his left hand in line with the splice of the bat. Bradman's stance was also unconventional, involving closure of the face of the bat and positioning it between his feet. Similar differences were observed in his back-lift as he levered the bat up by pushing down with the top hand, whilst using the bottom hand as a fulcrum. As it neared the top of the back-lift, Bradman manoeuvred the bat through a continuous arc and back towards the plane of the ball during the downswing in preparation for impact.

According to Shillinglaw(7), this technique, which was putatively developed through long hours practicing his childhood game of striking a fast-moving golf ball with a cricket stump, afforded Bradman superior balance, shorter movement times and enhanced bat speed through the striking zone than more conventional batting techniques.

It is also interesting to note that Sir Jack Hobbs, arguably the greatest English batsman ever, extensively

practiced a similar game during his formative years⁷. Thus, although the old adage 'practice makes perfect' carries some weight in the quest to acquire skill, it seems that what you do during practice counts for far more than merely time serving the long hours needed.

Why did this type of unorthodox practice regime lead to such outstanding success and can talent development programs across the world learn anything from these experiences in developing the future world-class stars of sports? It seems that creating the right type of practice environment is important for developing the Bradmans of the future. What does the scientific sub-discipline of motor learning tell us about how to structure and organise practice environments for efficient and effective learning?

It seems that dynamical systems theory, allied to the insights of the Russian physiologist and biomechanist, Nicolai Bernstein, whose research accounts and stimulating ideas were translated into English in 1967, are proving invaluable⁹. His ideas, combined with powerful theoretical paradigms in science such as chaos theory and the sciences of complexity, have been integrated with concepts and tools from dynamical systems theory to re-shape our understanding of movement behaviour¹⁰.

Dynamical systems are examples of nonlinear systems operating in regions of state space far from equilibrium, providing them with an appropriate amount of metastability. Dynamical systems theory has been successfully applied to the study of coordination in nervous systems and movement control^{11,12}, movement development^{13,14} and skill acquisition¹⁵. In particular, the dynamical systems framework has influenced the way that movement scientists view inter- and intra-individual variability in motor performance, as a function of learning and development across the lifespan. Bernstein⁹ focused attention on processes of movement coordination and also noted the incredible

amount of variability exhibited over performance repetitions as individuals engaged in even the most repetitive of tasks such as hammering a nail.

The role of constraints in structuring technique variability

Traditionally, the study of motor behaviour has seen a tendency to operationalise variability with measures of variance in motor output (eg, standard deviation around the distribution mean of a dependent variable measured over repeated trials). From a cognitive science perspective, scientists seeking support for the concept of motor invariance provided a narrow interpretation of variability in movement as evidence of noise or random fluctuations at different levels of the movement system (eg, anatomical, mechanical, physiological).

This traditional emphasis led to the idealising of the notion of 'common optimal movement patterns' towards which all athletes should aspire, typically a performance model provided by a leading performer of the day. For example, the search for motor invariance implies that all cricketers should adopt a single optimal batting stance and technique, with the distinct possibility that the precious individualised practice solution of Bradman would have been 'coached out' of his repertoire at an early age.

Rather than being undesirable, variability of technique can be viewed as exemplifying functional adaptive behaviours of athletes, since a consistent outcome can be achieved by different patterns of joint relations owing to the dynamics of the joint biomechanical degrees of freedom.

Ideas from chaos theory indicate that a defining feature of a chaotic system is that deterministic processes can drive fluctuations in system output that apparently seems random. With such a view, noise may have a positive role in preventing a system from becoming too stable in complex

environments so that functional movement solutions may be found.

For example, Bradman has reported adapting his technique when playing defensive strokes from outside the line of ball flight to lessen the chances of edging the ball to the slips against swing and seam bowlers⁴. Furthermore, there is growing evidence that the nature of movement variability is driven by the interaction of the various sources of constraint on action, and this leads to the uniqueness of system dynamics for a particular performer under a specific set of task constraints. This task-specific view may provide a better framework for understanding the role of inter- and intra-individual variability in the provision of feedback, diagnoses and treatment interventions in human movement by sport medicine specialists¹⁶.

Both Bradman and Tendulkar shared two important commonalities that may account for their tremendous achievements.

Movement scientists have also revealed the important role of perception in shaping and guiding sports techniques. In achieving successful coordination solutions, it is clear that various sources of perceptual information can act as degrees of constraint on the many motor system degrees of freedom. Obviously, the relationship between perceptual degrees of constraint and the motor system degrees of freedom can change quite dramatically in dynamic sports environments, emphasising how the coupling of information and movement needs to vary functionally during performance.

Owing to the mutually dependent relationship between the perceptual and motor sub-systems, unambiguous task-specific perceptual variables such as time-to-contact and place-of-contact can act as degrees of constraint and can be used to make fine-grained

adjustments; for example, as required during cricket batting strokes¹⁷. Even under the most severe spatio-temporal constraints, the formation of perception-movement couplings enables batsmen to get the bat in the right place at the right time to intercept the flight path of the ball. Acquiring these functional perception-movement couplings also enables grip forces to be modulated right up to the point of bat-ball impact, thus ensuring that the ball is struck at the right speed into gaps in the field¹⁸.

Past vs. present: Bradman v. Tendulkar

From this theoretical backdrop, it becomes clear that the specific constraints of his childhood game encouraged Bradman to adopt a technique that enabled the bat to remain highly manoeuvrable, therefore minimising lags in the way that his perceptual-motor system dealt with rapid environmental changes and ensuring that the ball could be played as late as possible.

With this in mind, it may be more useful to compare the technique and style of Bradman with those of modern players. Bradman himself identified Tendulkar as the batsman who resembled him most in technique (ie, his compactness, technique, stroke production). Bradman was renowned for his efficiency of play and was said to pay particular attention to the balance of risk and reward in his shot selection. Given the perceived similarities in the play of Bradman and Tendulkar, it would be of interest to examine the cricketing development of these two so-called 'child prodigies'.

Despite the generally-held view that both players were great players due to 'natural talent', a common feature of both players' development is their extraordinary emphasis on practice. Although great store is given to the fact that Bradman developed his hand-eye coordination by famously practising with a golf ball and cricket stump against a water tank, he also undertook much realistic cricket practice.

Although he is said to have received no 'formal' coaching, Bradman was brought up in a family and community that loved cricket. For example, his parents, particularly his mother, bowled at him from about the age of 9 or 10. Bradman also engaged in other makeshift games as a child, such as playing tennis or soccer against the garage door. He scored his first 100 in a school match aged 12. Interestingly, from age 15 to 17 Bradman played almost no cricket, concentrating on tennis¹⁹. At 17, he became a regular player in the local Bowral Cricket Club, and his first full season was notable for the 300 he scored in the last game of the season. At 18, the final stage and perhaps the most critical(3) of Bradman's initial development was completed when he joined St. Georges Cricket Club in Sydney and began to play in a high standard of cricket on turf pitches.

Similar to Bradman, Tendulkar was steeped in cricket from a very early age. At two-and-a-half years of age, he insisted that his nanny throw a plastic ball at him, which he attempted to strike with a dhoka or washing stick²⁰. Interestingly, during these early years Tendulkar only played cricket with a hard rubber ball.

At age 11, probably the most notable difference in the development of Bradman and Tendulkar took place: Tendulkar was provided with quality coaching from a well-respected coach. The great strength of his coach was that equal emphasis was placed on net practice and match play. Under his guidance Tendulkar was exposed to a quite remarkable level of intensity in his cricketing activities. On a daily basis Tendulkar undertook net practice between 7.30 am and 10 am. The rest of the day was spent in playing up to 13 different games across Mumbai, as the coach shifted him to the adjacent pitch as soon as he got out in one game³. Even this was not enough and on the occasions when Tendulkar was not playing in an organised match, he could often be seen practicing his strokes inside his house with a ball hung from a small net.

This level of commitment could explain why Tendulkar's relative development was much faster than that of Bradman. Although they both scored their first centuries at 12 years, Tendulkar scored his initial first-class century at 14²¹ and his first Test century at 17. By the age of 21, Tendulkar had scored seven Test centuries, compared with two from Bradman at the same age.

Chappell expressed little enthusiasm for the contribution of sport science to the development of the next generation of Australian cricketers and suggested that a "mafia" of academics and sport scientists with little playing experience had over-complicated training, creating regimented coaching structures, leading to the development of cricketers with little understanding of the game.

Both Bradman and Tendulkar shared two important commonalities that may account for their tremendous achievements. First, both players gripped their bat in an unorthodox manner. In Bradman's case, there was no coach to interfere or change his preferred style. In Tendulkar's case, his coach was sensible enough to follow the old adage: "If it ain't broke, don't try to fix it!" The very low grip of Tendulkar enabled him to select as his first bat one that his coach considered far too heavy (he still uses a 3lb 2 oz bat when most players use approximately 2lb 8oz-2lb 10oz). Second, and possibly the most important common factor, is the importance attached to demanding practice by both men. They both support the view that natural talent alone is not enough, but that you need to work incredibly hard to fulfil any inherent potential^{4,22}.

Implications for practice a nonlinear pedagogical approach

The qualitative data on personal experiences of skill acquisition and development in world-class cricketers, allied to recent theoretical developments in science, have strong implications for sports pedagogists and coaches, providing a new approach steeped in 'nonlinear pedagogy'.

Nonlinear pedagogy advocates that a key aim is to provide practice environments that enable individual athletes to couple together key sub-systems of the movement system (perceptual and motor sub-systems) during functional, goal-directed practice. Nonlinear pedagogical approaches encourage discovery learning, a more positive view of movement variability, and an emphasis on varying the task constraints of practice.

Such an approach may signal bad news for any strategy that attempts to focus on the practice and acquisition of a 'common optimal movement pattern'. For example, ball projection machines or bowling machines are often used to perfect an ideal batting technique in highly replicable conditions since coaches can control the speed, trajectory and direction of deliveries projected at batsmen. However, the use of bowling machines prevents learners from picking up relevant information during the bowler's run-up, bound and delivery stride, and therefore the timing of their introduction needs to be carefully considered.

A recent study²³ showed that using a bowling machine results in batsmen adopting different timing and coordination patterns for deliveries bowled by a real bowler of comparative speed.

Against a bowling machine projecting cricket balls at 26.76 m.s-1, batsmen attempted to couple the backswing to the moment the ball emerged from

the projection mechanism (0.02 ± 0.10 s) whereas, against the real bowler, the backswing started later (0.12 ± 0.04 s). Even though the timing of backswing initiation was different, results from other research on bi-phasic striking activities²⁴ suggests that the batsmen may have attempted to standardize the initiation of the downswing effectively to control the temporal duration of this phase of technique. However, the downswing commenced earlier when facing the bowling machine (0.32 ± 0.04 s) compared to the bowler (0.41 ± 0.03 s) showing that bat speed differed in the two conditions.

These differences led to a different ratio of time spent during the backswing and downswing when batting against the bowling machine (47:53 %) compared to the real bowler (54:46 %). Moreover, initiation of the front foot movement occurred 0.16 ± 0.04 s after ball release from the bowling machine and 0.14 ± 0.03 s after ball release by the bowler. Finally, the timing of the placement of

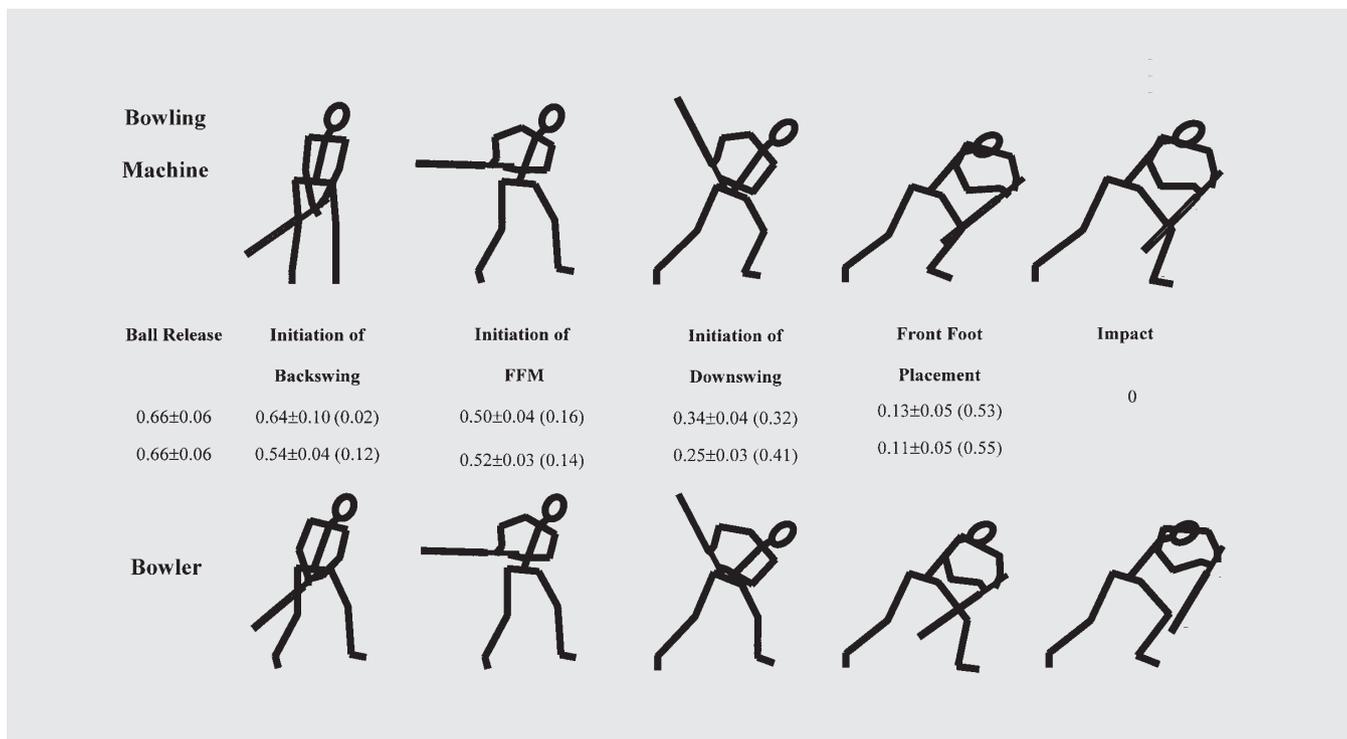
the front foot for the bowling machine (0.53 ± 0.05 s) was similar to the real bowler (0.55 ± 0.05 s).

When these differences are combined to the finding that the stride length was longer when facing the bowler (0.59 ± 0.06 m vs. 0.55 ± 0.07 m), it is clear that speed of foot movement is also affected by batting against bowling machines. It is important for batters to co-ordinate the bat swing movements to their footwork and coaching advice for batters suggests that backswing should be coupled to the movement of the front foot. However, these data revealed a greater correlation between initiation of backswing and front foot movement when batting against the bowler ($r = 0.88$) than the bowling machine ($r = 0.65$). In summary, these results suggest that coaches should think very carefully before using bowling machines in practice with expert players who gain a perceptual advantage from being able to utilise important information from bowling actions.

Interestingly, these ideas are being promoted from within high-level sport, too. Greg Chappell, one of the greatest cricketers of all time and now a highly respected coach, has criticised the use of bowling machines during practice. When interviewed by the Trinidad & Tobago Express and subsequently reported on cricinfo.com (22 June 2004), Chappell expressed little enthusiasm for the contribution of sport science to the development of the next generation of Australian cricketers and suggested that a “mafia” of academics and sport scientists with little playing experience had over-complicated training, creating regimented coaching structures,

Bradman showed that the best players are those who can overcome problems by coming up with specific solutions, often “breaking” conventional, technical rules.

Figure 1: Differences in timing and coordination of the phases of the forward defensive shot when batting against a bowler and bowling machine from the point of ball release to bat-ball impact. When batting against the bowling machine, the backswing was initiated virtually at ball release, with the front foot movement being initiated later. Against the bowler, the initiation of backswing and front foot movement occurred synchronously. Initiation of the downswing against the bowling machine was earlier and the downswing was slower than against the bowler. Front foot placement was temporally similar in the two conditions, but the stride was shorter and faster for the bowling machine condition. Smaller elbow angles when batting against the bowling machine led to different bat angles at impact. (NB. Figures are not to scale).



leading to the development of cricketers with little understanding of the game. He was particularly critical of the role of bowling machines during cricket batting practice, emphasising the importance of the batter adapting movements to key task information sources from bowlers. He argued that giving players too much technical information may only confuse them and cited a number of West Indian greats of the past, who could not explain “how” they played great shots, but were able to just “do” them.

On teaching players, he said: “To try to explain to them the biomechanics of it all would just confuse them. The more structure you get at an early age, the more it messes you up.” Chappell concluded thus: “We should not lose sight of the old fashioned methods of learning to play cricket by dismissing them out of hand, to replace them with unproven approaches like biomechanics that are not yet proven to be workable and that, in other sports like swimming and athletics, have been tried and discarded”.

Over-structured coaching to provide off-the-shelf coordination solutions may have limited value, since Bradman showed that the best players are those who can overcome problems by coming up with specific solutions, often “breaking” conventional, technical rules. In developing practice programs, sport scientists need to understand that variability is not error or noise to be eradicated but can be functional to successful performance.

The underlying science suggests that the feats of the Don are likely to be approximated, perhaps by an individual like Tendulkar, as long as coaches learn to respect individual differences by providing plenty of opportunities for young learners to discover their own fitting coordination solutions. Inter-individual variability needs to be better understood and player development programs should focus on manipulating the key constraints on each athlete, since each athlete should be considered as a unique individual.

In sport, it seems that the saying ‘nothing is more practical than a good theory’ warrants greater attention from scientists attempting to understand how to support the development of the highly skilled performers of the future. The sciences of chaos, complexity and dynamical systems theory may well hold the key to understanding the secrets of the Don in providing the theoretical rationale for structuring sports practice programs and using artificial aids such as ball projection machines to good effect.

Paul Glazier is at the School of Sport, Physical Education & Recreation at the, University of Wales Institute, Cardiff; Keith Davids and Chris Button at the School of Physical Education at the University of Otago; and Ian Renshaw at the Division of Sport & Recreation at Auckland University of Technology.

References

- Dickson G, Mummery K, Arnold T et al. Legends at the crease: changes to the performance variation of Test cricket batting performances 1877-1997. Sport Management Association of Australia and New Zealand Conference. Gold Coast. Griffith University. 1998.
- Gould SJ. The Structure of Evolutionary Theory. Cambridge, MA. Harvard University Press. 2002.
- Hutchins B. Don Bradman: Challenging the Myth. Cambridge. Cambridge University Press. 2002.
- Bradman D. The Art of Cricket. London. Hodder & Stoughton. 1958.
- Williams AM, Davids K & Williams JG. Visual Perception and Action in Sport. London. E & FN Spon. 1999.
- Beckerman SA & Hitzeman S. The ocular and visual characteristics of an athletic population. Optometry 2001;72:498-509.
- Shillinglaw AL. Bradman Revisited: The Legacy of Sir Donald Bradman. Manchester: The Parris Wood Press. 2003.
- Andrew K. The Skills of Cricket. Marlborough. The Crowood Press. 1992.
- Bernstein NA. The Coordination and Regulation of Movements. Oxford. Pergamon Press. 1967.
- Beek PJ & Meijer OG. On the nature of ‘the’ motor-action controversy. In Complex Movement Behaviour: The Motor-Action Controversy (Ed: Meijer OG & Roth K, pp. 157-185). Amsterdam. Elsevier. 1988.
- Kelso JAS. Dynamic Patterns: The Self-Organization of Brain and Behavior. Cambridge, MA. MIT Press. 1995.
- Davids K, Williams AM, Button C et al. An integrative modelling approach to the study of intentional movement behaviour. In Handbook of Sport Psychology, 2nd Edition (Ed: Singer RN, Hausenblas H & Janelle C, pp. 144-173). New York. John Wiley. 2001.
- Thelen E & Smith LB. A Dynamic Systems Approach to the Development of Cognition and Action. Cambridge, MA. MIT Press. 1994.
- Newell KM, Liu Y-T & Mayer-Kress G. Time scales in motor learning and development. Psychol Rev, 2002;108:57-82.
- Newell KM. Change in movement and skill: learning, retention and transfer. In Dexterity and its Development (Ed: Latash ML & Turvey MT, pp. 393-430). Mahwah, NJ. Erlbaum. 1996.
- Davids K, Glazier P, Araújo D et al. Movement systems as dynamical systems: The functional role of variability and its implications for sports medicine. Sports Med 2003;33:245-260.
- Savelsbergh GJP & Bootsma RJ. Perception-action coupling in hitting and catching. Int J Sport Psychol 1994;25:331-343.
- Glazier P, Davids K & Bartlett RM. Grip force dynamics in cricket batting. In Interceptive Actions in Sport: Information and Movement (Ed: Davids K, Savelsbergh G, Bennett SJ et al, pp. 311-325). London. Routledge. 2002.