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'Keeping the eye on the ball': the legacy of John Whiting (1929–2001) in sport science

'Keep your eye on the ball' is the statement that made John Whiting famous in the world of physical education during the 1960s and early 1970s. It reflects very sound advice for any academic interested in teaching and research in the areas of movement coordination and control, skill acquisition and motor development. John Whiting passed away on 7 October 2001. Although his achievements in physical education, psychology and human movement science are well known and well documented, it is important to recognize his legacy in sport science; we feel that the *Journal of Sport Sciences* is an appropriate outlet to do so.

Perhaps his most significant contribution to higher education in the UK was to put physical education onto a more scientific footing through the establishment of the first postgraduate empirical research programme on motor behaviour, including specialist taught Masters provision. The innovative nature of his thinking becomes clear when one considers that this programme was a precursor to the development of undergraduate sports science provision in the UK almost a decade later. Between the early 1960s and the late 1970s, his research group at the Department of Physical Education at Leeds University produced eight doctorates (including his own), four books and 25 peer-reviewed scientific research articles. These achievements were outstanding in an age before desktop computers and laptops. They were achieved against a backdrop of low financial and technical support as well as a lack of understanding of the nature of experimental work in physical education by the university authorities at that time (for an interesting personal account, see Whiting, 1991). His seminal book *Acquiring Ball Skill*, which appeared in 1969, contains a detailed theoretical and empirical account of the performance and acquisition of ball skills; it was a bestseller in English and has been translated into French and Japanese.

In this tribute to his legacy, we will comment on John Whiting's impact and contribution to the sport sciences, which can be divided into two main areas of research: dynamic interceptive actions and learning studies.

Dynamic interceptive actions: the case of one-handed catching

To John Whiting, dynamic interceptive actions such as one-handed ball catching, as well as being of great practical significance, represented a task vehicle for the experimental analysis of the processes of perception and action. His earliest experiments on catching behaviour were based on the rigorous platform of experimental psychology and were conducted within an information-processing framework. The objective was to determine the importance of selected input variables on task performance (Whiting, 1968, 1970; Alderson *et al.*, 1974; Sharp and Whiting, 1974, 1975; Whiting and Sharp, 1974). Questions reflected concern about the amount of information necessary for making decisions. Although it is true that information about ball flight trajectory is necessary for successful catching performance, it became clear from Whiting's work that it is unnecessary to view the entire trajectory (e.g. Whiting, 1968). He argued that information occurring at one stage of the trajectory could be used in a predictive way to anticipate the future time and position of the ball. That successful one-handed catching demands conformity to highly constrained spatio-temporal requirements was shown time and again in many classic papers from his laboratory at Leeds. For example, using the then innovative technique of high-speed ciné filming, he showed that only 60 ms are available for catchers to close the fingers around the ball at the appropriate moment in time, when a ball is approaching at a velocity of 10 $m \cdot s^{-1}$ (Alderson *et al.*, 1974). In addition, he showed that the fingers started to close before the ball actually touched the hand. Thus, his work prompted early questions about what kind of nervous system would enable the catcher to adequately comply with the very narrow spatial and temporal tolerance bands that accompany success in such behaviour. It is interesting to note that these very questions are at the forefront of motor behaviour research in this new millennium.

What was less clear at that time was how much visual information was necessary for successful catching and at what stage in the flight path of the ball such information has to be acquired. Typical of his approach to this issue was the experiment of Whiting *et al.* (1970), which, in the spirit of the perceptual-moment hypothesis, explored whether there are critical time intervals for taking in information about ball flight. The authors' findings showed that performance improved (an increment in the number of successful catches) with increasing duration of viewing time, thereby questioning the prevailing assumption of the adequacy

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of information assimilated during a single restricted 'perceptual moment'.

In subsequent studies, Whiting and Sharp (e.g. Sharp and Whiting, 1974; Whiting and Sharp, 1974) searched for the optimal section of oncoming ball flight trajectory that provided most information for the catcher. Their results suggested that viewing the ball too early or too late in its trajectory led to decreased catching performance. This finding drew attention to the importance of the period for which the ball is not seen, as well as the period for which it is seen. Whiting and Sharp showed that catchers experienced increasing difficulty when they had to predict ball flight over successively longer intervals of time. Again, hindsight shows us that these findings raised the earliest questions about the dominant assumption of predictive visual timing as the control mechanism for catching behaviour. These concerns are reflected more recently in attempts to model interceptive actions from a continuous perception–action coupling perspective in the required velocity model (for a review, see Montagne and Laurent, in press).

These catching experiments from Whiting's 'Leeds Period' demonstrated the importance of the combination of the occluded period (when one does not see the ball) and the viewing period in providing explanations for catching behaviour. They also highlighted the importance of the spatial location in the trajectory of the ball at which such information is available for catchers. Whiting and students showed themselves to be ahead of the times by successfully taking a complex dynamic interceptive action (during the 1960s and 1970s, most research was done with single degree-of-freedom linear positioning and reaction time tasks) and using it as a task vehicle in a physical education research programme with a serious scientific foundation.

In his 'Amsterdam Period', Whiting studied dynamic interceptive actions within the framework of ecological psychology (e.g. Whiting, 1986; Savelsbergh and Whiting, 1988; Whiting *et al.*, 1988). One of the most influential and oft-cited research studies in that programme of work was known as the 'deflating ball experiment' (Savelsbergh *et al.*, 1991, 1993). In this experiment, one of the balls changed in size during approach, using an ingenious method involving balloons and vacuum pumps. The changing size provided non-veridical information, in the sense that the time-to-contact information specified by the optical expansion of the approaching ball was experimentally manipulated, with concomitant effects on movement kinematics of the grasp phase of the catch.

His work on the dynamic interceptive action of catching was published in many distinguished journals, including *Ergonomics*, the *Journal of Motor Behavior*, the *Journal of Experimental Psychology: Human Perception and Performance*, *Experimental Brain Research* and the *International Journal of Sport Psychology*. Whiting did not limit himself to studying one-handed catching all the time. In fact, one of his most cited ideas in interceptive actions is the 'Operational timing hypothesis' stemming from table tennis research carried out with Dave Tyldesley (Tyldesley and Whiting, 1975). The impact of this work clearly extended beyond the field of physical education and catalysed the emergence of a new scientific field, namely that of human movement sciences.

Learning: the second avenue of research

During his Dutch years, John Whiting's second major research interest crystallized in the area of motor learning. His most famous learning experiments were conducted on a ski-simulator. Again, his innovative thinking led him to eschew the use of ubiquitous single degree-of-freedom laboratory tasks in favour of sport-related actions. In the key studies, participants had to make slalom, ski-type movements on a ski-simulator. In a first series of experiments, he and his co-workers showed themselves to be ahead of the times by studying how the process of learning could be manipulated by manipulating different task constraints during practice. For instance, participants practised skiing movements at different movement frequencies (van Emmerik *et al.*, 1989), under different feedback conditions (den Brinker *et al.*, 1986) and with or without the availability of a video model (Whiting *et al.*, 1987). In the 1990s, in a second series of experiments, the innovative ideas of Bernstein (1967), the eminent Russian physiologist, were evaluated and supported. The nature of the process in which participants discovered and exploited the mechanical constraints of the ski-simulator apparatus during practice (Vereijken *et al.*, 1992a) was responsible for a resurgence of interest in discovery learning in sport. This important theoretical work of an applied nature was underpinned by rigorous modelling of the characteristics of the simulator in dynamic terms, like stiffness and damping as a function of displacement, angular velocity and mass (Vereijken *et al.*, 1992b). Major theoretical developments stemming from later work included the examination of the key ideas of Bernstein in combination with the concepts of dynamical systems theory (stimulated by the work of Peter Kugler on non-linear thermodynamics) and ecological psychology (as developed by the Gibsonian advocate, Michael Turvey). These visionary ideas are still at the forefront of developments in human movement science and sport science. Publications from this research programme on learning, like his earlier work on interceptive actions, found their way into many of the most important journals, such as the *Quarterly Journal* *of Experimental Psychology* and the *Journal of Motor Behavior*.

In addition to experimental work, John Whiting found time to edit or author around 20 books. The most important for the field of sport sciences are: *Readings in Sport Psychology* (published in 1972 and 1975), *Readings in Human Performance* (published in 1975), *Sportpsychologie* (published in 1984; a Dutch book about sport psychology penned with Frank Bakker and translated into English in 1990) and *Motor Development in Children: Aspects of Co-ordination and Control* (published in 1986 and co-edited with Michael Wade). Among these texts is the seminal bestseller *Human Motor Actions: Bernstein Reassessed* (1984), which adopted the innovative idea of publishing original chapters by Bernstein, accompanied by critical commentaries by leading experts in the field of human movement science. He also founded and acted as editor of key journals, such as the *Journal of Human Movement Studies* (1975–1982) and *Human Movement Science* (1982–1998). The publication of more than 100 journal articles and 50 book chapters, as well as the attainment of 20 PhD completions and two honorary doctorates (one in Canada and one in France), at a time when the RAE exercise was nowhere to be seen on the horizon, underline his legacy not only to UK sport science, but also to human movement science in the Netherlands and around the world. Undoubtedly, as indexed by the vibrant, healthy state of current research on movement coordination, control and skill acquisition and motor development, his influence and contributions to scientific work and academic life will be measurable beyond these outputs for many years to come.

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