

Developmental Activities That Contribute to High or Low Performance by Elite Cricket Batters When Recognizing Type of Delivery From Bowlers' Advanced Postural Cues

Paul R. Ford, Jeffrey Low, Allistair P. McRobert,
and A. Mark Williams

Liverpool John Moores University

We examined the developmental activities that contribute to the development of superior anticipation skill among elite cricket batters. The batters viewed 36 video clips involving deliveries from bowlers that were occluded at ball release and were required to predict delivery type. Accuracy scores were used to create two subgroups: high-performing and low-performing anticipators. Questionnaires were used to record the participation history profiles of the groups. In the early stages of development, hours accumulated in cricket and other sports, as well as milestones achieved, did not differentiate groups. Significant between-group differences in activity profiles were found between 13 and 15 years of age, with high-performing anticipators accumulating more hours in structured cricket activity, and specifically in batting, compared with their low-performing counterparts.

Keywords: expert performance, skill acquisition, anticipation

Several researchers (e.g., Helsen, Starkes, & Hodges, 1998) have shown that performance is closely related to the amount and type of practice accumulated by individuals during their development. Ericsson, Krampe, and Tesch-Römer (1993) termed this activity *deliberate practice* (for reviews, see Ericsson, 2003, 2007a, 2007b). They defined deliberate practice as domain-specific, structured activity with the primary goal of improving an important aspect of current performance. In their original paper, Ericsson et al. (1993) explicitly differentiated deliberate practice activities from play, competition, and work. However, researchers (e.g., Soberlak, & Côté, 2003) have subsequently shown that expert performance in sport is also often related to the amount of *deliberate play* engaged in by individuals early in their development. Deliberate play is enjoyable and has rules adapted from adult norms that are monitored by the children themselves (Côté, Baker, & Abernethy,

The authors are with the Research Institute for Sport and Exercise Sciences, Liverpool John Moores University, Liverpool, U.K.

2007). In this study, we attempt to identify activities that contribute to the acquisition of superior anticipation skill by examining differences in the participation history profiles of batters who are classified as either high- or low-performing anticipators based on their performance on a film-based test of this skill.

The relationship between the amount of deliberate practice and attainment of expert performance was first shown by Ericsson et al. (1993). They used questionnaire and diary methods to record the developmental activities of expert musicians at the Berlin Music Academy. The best violinists reported that at the time of the study they were spending 24 hr per week engaging in solitary deliberate practice compared with 9 hr per week for music teachers. The total hours accumulated in individual, deliberate practice between commencing participation in the domain and 18 years of age for the best violinists were 7,410, whereas for the good violinists and music teachers it was 5,301 and 3,420, respectively. The accumulated practice hours for the best violinists were similar to those of expert pianists. Pianists reported that at the time of the study they were spending 27 hr per week in deliberate practice and had by 18 years of age accumulated a total of 7,606 hr in practice. The authors suggested that individual differences in attainment are monotonically related to the amount of deliberate practice accumulated.

Starkes, Deakin, Allard, Hodges, and Hayes (1996) were the first to examine the tenets of deliberate practice theory in individual sports. Adult wrestlers who performed at international level reported spending 39 hr per week in practice compared with 21 hr per week for club-level athletes. Wrestlers commenced participation in the sport at an older age than musicians (i.e., 13–14 years of age), which led to international (5,882 hr) and club level (3,571 hr) wrestlers accumulating significantly lower practice hours by 18 years of age when compared with the hours reported by Ericsson et al. (1993) for expert musicians. Although findings generally supported the work with musicians, Starkes et al. (1996) found that athletes reported that time spent practicing with others was more important compared with time spent alone. Subsequently, similar findings have been reported across a number of individual (Hodge & Deakin, 1998; Hodges & Starkes, 1996) and team sports (Helsen et al., 1998) (for a review, see Ward, Hodges, Williams, & Starkes, 2004).

Other researchers (e.g., Soberlak, & Côté, 2003; Baker, Côté, & Abernethy, 2003a, 2003b) have used structured interviews (e.g., Côté, Ericsson, & Law, 2005) to reveal another type of activity in which expert athletes engaged in early in their development, namely deliberate play (e.g., street soccer, backyard cricket). Côté et al. (2007) summarized the findings of these studies in their Developmental Model of Sport Participation (DMSP). In the DMSP, expert adult athletes pass through three consecutive stages of development. These stages are termed the *sampling* (6–12 years of age), *specializing* (13–15 years of age), and *investment years* (16+ years of age). During the sampling years, children who later became elite athletes participated in a large number of hours of deliberate play activity across a number of sports, but a low number of hours in deliberate practice. For example, expert ice hockey players reported engaging in 6.0 other sports during this period and relatively high amounts of deliberate play in hockey (Soberlak, & Côté, 2003), whereas experts from other team sports reported participating in 8.6 other sports (Baker et al., 2003a). In this model, children typically refrain from specializing in their primary sport until later in their development (Baker, 2003). During the specializing years, these same individuals participated in a comparable number of hours in deliberate play and deliberate

practice in one or two sports, including their primary sport. In the investment years, they participated in a large number of hours of deliberate practice in their primary sport, but a low amount of deliberate play and other sports.

The DMSP needs to be examined in other sports and countries to examine its generalizability. For example, Law, Côté, and Ericsson (2007) examined the participation history profiles of elite gymnasts in Canada. The Olympic gymnasts participated in fewer than two other sports between 6 and 12 years of age, whereas lower-skilled international gymnasts participated in three other sports. Although both the Olympic and international gymnasts started participating in the sport at around six years of age, by 16 years of age the Olympic gymnasts (18,835 hr) had accumulated almost three times the amount of deliberate practice compared with the international gymnasts. However, Olympic gymnasts reported reduced enjoyment, poorer physical health, and more injuries compared with the international gymnasts. In gymnastics, where expert performance is typically required before puberty, early specialization appears to be a prerequisite (Côté et al., 2007; see also, Ward, Hodges, Starkes, & Williams, 2007).

The findings from studies examining the amount of hours accumulated in practice activity and the level of attainment in a domain tell us very little about how the specific adaptations that characterize expert performance occur. Positive correlations between amount of time accumulated in deliberate practice activities and level of attainment does not imply causality for the skills acquired by athletes during their development (Sternberg, 1996). Ericsson (2003) called for research detailing causal accounts of specific adaptations that occur during the development of expert performers. For example, Hodges, Kerr, Starkes, and Weir (2004) demonstrated that the performance times of elite adult triathletes and swimmers were positively related to the amount of weekly and accumulated sport-specific practice aimed at improving performance, whereas non-sport-specific practice activities (e.g., active leisure, fitness) were not correlated to performance times. Further research is required to show which specific practice activities cause positive adaptations during athlete development.

Some researchers have started to identify activities that contribute to the development of certain skills in expert performers. Weissensteiner, Abernethy, Farrow, and Müller (2008) examined the link between the practice activities undertaken by cricket batters and their ability to anticipate bowling deliveries. Skilled and lesser skilled batters from three different age groups (i.e., U15, U20, and adult) completed a test of anticipation skill in which they were required to predict the type and length of delivery based on advance/prerelease information from bowlers (i.e., run-up and delivery action up to the point of ball-release). The batters also provided their participation activity histories in a semistructured interview (Côté et al., 2005).

The hours accumulated in organized cricket (deliberate practice and competition) accounted for a relatively low, yet significant, proportion of the variance (13.3%) in the ability of players to anticipate ball type. Participant age accounted for a further 6.9% of the variation in anticipation; the U20 and adult players had superior anticipation scores compared with the U15 players. The U15 group had accumulated significantly fewer hours in organized cricket compared with the older players. Weissensteiner et al. speculated that at junior levels of cricket the ball speeds from deliveries are much slower compared with at senior level, and consequently, at U15 level, the need to anticipate is greatly reduced compared with the older age

groups. They suggested that in cricket superior anticipation skill may only develop late in adolescence. The relatively weak ability to predict anticipation skill from hours accumulated in activity was attributed to the researchers examining only the *amount* of activity, whereas the *type* of activity engaged in may have more of an effect on skill development.

Berry, Abernethy, and Côté (2008) conducted a more fine grained analysis of the type of activity by examining the developmental histories of 32 players in the Australian Football League (AFL) who had been classified by their coaches as either expert or less-skilled in their decision-making skills. The accumulated hours in invasion-type activities differentiated expert and less-skilled decision makers. The expert decision makers accumulated more hours during their development in structured activities (deliberate practice and competition) of all types, in structured activities in invasion-type sports, in invasion-type deliberate play, and in invasion activities from sports other than Australian football compared with less-skilled decision makers. It appears that decision-making skill in Australian football is facilitated by engagement in invasion sports activity regardless of the intent of the activity or the degree of specificity to the sport.

The studies by Weissensteiner et al. (2008) and Berry et al. (2008) demonstrated the types of activities that contribute to the development of expert anticipation and decision-making skill in athletes. However, to create their expert and novice groups, these researchers relied on the subjective judgments of coaches, which may be susceptible to systematic biases, such as the coaches relationship with their athlete or the athlete's personality (for a review, see Ericsson, 2003). Systematic bias through the subjective selection of coaches is problematic since all experts have aspects of their performance that are stronger or weaker compared with performance aspects of other experts in their domain (Ericsson, 2003). Therefore, subjective selection may lead to individuals being selected into the expert group who are not expert at the task being examined. Ericsson (2003) states that researchers should seek to measure task performance using objective measures.

Researchers have developed a number of objective methods to measure the perceptual-cognitive skills used when making anticipation judgments (for a review, see Williams & Ericsson, 2005). The temporal occlusion paradigm has been used to objectively measure individual differences in the ability of expert athletes to anticipate the outcome of a situation based on the postural movements of their opponent/s in the moments before a key-event, such as ball-racket contact in badminton shots (for reviews, see Hodges, Huys, & Starkes, 2007; Williams & Ward, 2007). In fast ball sports, such as cricket, this ability enables athletes to prepare and execute their own response to counter the intentions of opponents. Video clips filmed from a first-person perspective of an opponent performing a given action (e.g., soccer penalty kick) are projected to participants life-size onto a large screen. The video clips are occluded at varying time periods relative to a critical event (e.g., foot-ball contact during the penalty kick). Participants are required to anticipate their opponent's action or the outcome of the situation by either responding verbally, using pen and paper, or by physically performing an action in response to the stimuli presented. This method has been used to show systematic differences between expert and novice athletes in anticipation skill in a range of sports tasks, such as soccer penalty kicks (Williams & Burwitz, 1993), squash (Abernethy, 1990), and tennis (Jones & Miles, 1978).

Expert cricket batters have been shown to outperform novices consistently when the temporal occlusion paradigm is used to evaluate their ability to anticipate the type and/or length of delivery from pace (Abernethy & Russell, 1984; Penrose & Roach, 1995) and spin bowlers (Renshaw & Fairweather, 2000). A number of other techniques have been used to assess what batters perceive when viewing bowler's deliveries (for a review, see Williams & Ericsson, 2005; Williams & McRobert, 2008). McRobert, Williams, Ward, and Eccles (2009) employed an eye movement registration system to record batters visual behaviors when making anticipation judgments. They found that skilled batters made more fixations and spent more time viewing the bowling arm and predicted ball release area, as well as more central areas of the body such as head-shoulder and trunk-hips compared with less-skilled batters. Müller, Abernethy, and Farrow (2006) used a spatial occlusion technique to show that the ability of skilled batters to predict the type of delivery was poorer when the hand of the spin bowler was occluded or only footage of that arm was provided, although this was not the case for pace bowlers. These two studies show that the extraction of information from a specific body area/cue can lead to superior anticipation judgments. However, others (e.g., Ward, Williams, & Bennett, 2002) have used point-light displays to show that tennis players anticipate the actions of an opponent based on their perception of the *relative motion* between these specific body areas/cues, which may also be the case for batters in cricket.

In this study, we examine the type and amount of developmental activities that contribute to the ability to use information arising from a bowler's postural movements before ball release to anticipate the type of delivery in expert youth cricket batters. The batters were required to view 36 video clips of bowler's deliveries occluded at ball release and to predict delivery type. Accuracy scores were used to create two groups from a larger sample of elite youth cricket batters: high-performing anticipators and low-performing anticipators. We used questionnaires to collect participation history data for both groups. We predicted that the participation histories of both groups of batters would follow the tenets of the DMSP (Côté et al., 2007), particularly in the early stages of development. Participants are expected to have accumulated more hours in unstructured cricket activities and other sports (possibly in related field sports to cricket, Berry et al., 2008) compared with structured practice between 6 and 12 years of age (i.e., the sampling years). However, based on the findings of Weissensteiner et al. (2008), differences in activity profiles between groups are only expected to emerge in later years when the increase in speed of deliveries necessitates that batters anticipate. Between 13 and 15 years of age (i.e., the specializing years), the high-performing anticipators are predicted to have accumulated more hours in structured cricket activity, especially batting activity in which they face these bowling deliveries, compared with the low-performing anticipators.

Method

Participants

A total of 45 elite, male cricket batters aged 16–22 years ($M = 17.32$ years, $SD = 0.65$) participated. All players were contracted to represent one of 19 County clubs, which compete at the highest level in English cricket. A group of novice

cricket players ($n = 14$) with a mean age of 20.3 years ($SD = 2.3$) participated in the anticipation test only. Participants provided informed consent and the research was conducted according to the ethical guidelines of the lead institution.

Apparatus

Anticipation Test. Video footage of cricket bowling deliveries was recorded at a standard cricket field with a conventional turf wicket. A video camera (Canon XM2, Tokyo, Japan) was positioned 2 m behind the batter's stumps, at an approximate height of 1.75 m, so that the camera view replicated a batter's view of the bowler, wicket, and field. A total of eight bowlers (five right-arm and three left-arm dominant) were recruited from an English County cricket club and were filmed bowling a series of different deliveries. The pace bowlers were instructed to bowl out-swing, in-swing, and straight deliveries. Spin bowlers were instructed to bowl off-spin, leg-spin, and "wrong-un" (i.e., "googly") deliveries. The video clips were digitally edited using Adobe Premier 7 software to construct the anticipation test. Thirty-six video clips were included in the test film.

The clips were presented in a random order that was consistent across participants so as to minimize the possibility of order or learning effects. The video clips showed the bowler's run-up and terminated at the moment when the bowler released the ball (see Figure 1). A trial commenced with a black screen showing a 3 s countdown before the video clip was shown for a duration of 6 s. The video clip ended at ball release when the screen went black for 1 s, which was followed by white text appearing on the back screen reading "Respond now" for 15 s. Six clips showing deliveries that were not used in the experimental trials were used for pretest familiarization.

Questionnaire. A questionnaire was used to elicit information on the developmental activities undertaken by players. The questionnaire was based on that used in previous research (e.g., Ward et al., 2007). It contained three sections. The first section was designed to elicit information on cricket-specific milestones. Participants were required to record the age at which they first took part in: cricket (not in an organized league); supervised training in cricket with an adult; junior County cricket; an elite Academy. The second section of the questionnaire was designed to elicit information on participants' engagement in cricket activities. Four cricket activities were listed: match-play, deliberate team practice, deliberate individual practice, and deliberate play. These activities were chosen based on previous research in which retrospective questionnaires were used (e.g., Ward et al., 2007) and to match the recommendations proposed by Côté et al. (2005).



Figure 1 — Final frame of video clip that had shown the pace bowler's run-up and that terminated when the bowler released the ball.

Match-play was organized competition in a group supervised by adults (e.g., league games). Deliberate team practice was organized group practice supervised by coaches or adults with the intent to improve performance (e.g., practice with team). For the purposes of clarity in this study and to match the definition of Ericsson et al. (1993), we defined deliberate individual practice as activity done alone with the intent to improve performance (e.g., practicing bowling alone), although we acknowledge there are situations where deliberate individual practice can also occur in the presence and with the assistance of others. Deliberate play was games with rules supervised by the participants themselves with the intent of gaining enjoyment from the activity (e.g., game of cricket with friends). Batting activity during match-play and individual practice was recorded. Batting activity during team practice was also recorded, which was further differentiated into time spent batting in the “nets” or time spent batting in match-like situations. “Nets” batting practice was that conducted in between standard cricket nets with either a bowling machine or bowler delivering the ball. Match-like batting practice was that conducted on a cricket pitch or similar with bowlers and at least some fielders. Participants provided the number of hours per week and weeks per year in each of the activities for each year. They were also required to provide the number of weeks from each year that they were injured and unable to take part in cricket activity. They completed this information starting from the current year and working backward to the first year they had played cricket.

The third section of the questionnaire was designed to elicit information on the participants’ engagement in other sport activities. Participants were provided with a comprehensive list of sports and were required to indicate those in which they had participated in regularly for a minimum period of three months in total. Sports that were not on the list could be added to the end of the list by participants. They were required to provide the age at which they started playing each sport, the number of hours per week and the number of months per year they had spent in each sport, and the age that they finished taking part in each sport (unless they were still participating in a sport). This procedure for collecting data on each participant’s engagement in other sports has been used previously by researchers using retrospective questionnaires (e.g., Ward et al., 2007).

Procedure

Two experimenters visited each club on one occasion to collect the data. Video clips were projected onto a large screen (Sahara, London, U.K; height, 3.0 m, width, 3.5 m) using an LCD projector (Hitachi, CPX 345, Tokyo, Japan). Participants sat in a room in a position that enabled them to view the full screen at an approximate distance of 5–10 m. Participants were required to watch each video clip and predict the type of each delivery by hand notating their response onto a designed response sheet. The types of bowling deliveries were: (i) for pace bowling, in-swing or out-swing; (ii) for off-spin bowling, off-spin or “wrong-un”; and (iii) for leg-spin bowling, leg-spin or “wrong-un.” Participants were instructed to respond to every trial even if they were uncertain. Participants first viewed the six video clips for pretest familiarization. They then viewed the 36 video clips in the experimental trials. The total duration of the test was approximately 30 min.

Following completion of the anticipation test, participants were given a short break. They were then required to complete the participation history questionnaire.

One experimenter provided verbal instructions about how to fill in the questionnaire. Participants were required to complete the first section of the questionnaire and then to wait for further instruction on the next section (the same occurred for the third section). At the start of the second section (which was designed to elicit information on participants' engagement in cricket activities) to aid memory recall for the number of hours engaged in, the participants were required to record the cricket teams and coaches that they played for in each year of participation. Both experimenters were available to answer any queries or questions related to the completion of the questionnaire, such as those related to interpretation and confirmation. Participants completed the questionnaire in one hour.

Reliability and Validity

The reliability of the participation history data were examined using the test–retest method. Five randomly selected participants completed the questionnaire on a second occasion three months after the first occasion. Two statistical methods were used to assess measurement error between the two tests. First, an intraclass correlation was used to assess the relative reliability, which is the level of association between the two tests (Atkinson & Nevill, 1998; Thomas, Nelson, & Silverman, 2005). Second, the limit of agreement method was used to assess the absolute reliability, which is the level of agreement between the two tests (Atkinson & Nevill, 1998; Bland & Altman, 2007). A large intraclass correlation coefficient was reported for the hours per week spent in cricket activity, $R(84) = .87$, demonstrating very good relative reliability. The limits of agreement were 1.01 ± 9.53 hr, $p > .05$, showing that there were no significant systematic errors between tests.

The validity of the participation history data were examined by having a parent for each of the five participants fill in the questionnaire using their perception of their son's activities. The parent's version of the questionnaire was then compared with the first version of their son's questionnaire. The same two statistical methods that were used to analyze reliability were also used to assess the measurement error between these two tests. A large intraclass correlation coefficient was also reported for the hours per week spent in cricket activity, $R(84) = .76$. The limits of agreement were 1.13 ± 10.97 hr, $p > .05$, showing that there were no significant systematic errors between tests.

Data Analysis

The dependent measure for the anticipation test was response accuracy for correctly predicting type of delivery, which was calculated for each participant based on all 36 trials. We used the response accuracy scores from the anticipation test as an objective method to differentiate the 45 elite cricket batters by using the score to create a rank order of participants. Two groups were created from this rank order. The top 15 ranked participants with the highest response accuracy scores were classified as "high-performing" on the test. The bottom 15 participants with the lowest response accuracy scores were classified as "low-performing." The participants ranked 16–30 were excluded from further analysis. Response accuracy scores from the anticipation tests were analyzed using independent t tests between the high- and low-performing groups, as well as between the low-performing and novice groups.

The participation history data for the high- and low-performing groups only were analyzed. Since the mean age of the players in both groups was only 17.3 years, the data were analyzed for two age periods: 6–12 years and 13–15 years, which represent the Sampling and Specializing stages respectively in the DMSP (Côté, 1999; Côté et al., 2007). Independent *t* tests were conducted on the mean chronological age, start age for cricket, start age in organized league, start age in junior County level, and start age in an elite Academy. The hours in cricket activity for each year between 6 and 15 years of age were calculated by multiplying hours per week by weeks per year minus weeks off injured per year. An independent *t* test was conducted on total hours accumulated in cricket activity between 6 and 15 years of age. To increase statistical power, we combined match-play, deliberate team practice, and deliberate individual practice into a single activity termed “structured activity” (Berry et al., 2008). Deliberate play became “unstructured activity.” Separate 2 Group (High-performing, Low-performing) \times 2 Activities (Structured, Unstructured) ANOVAs with repeated measures on the last factor were performed for (i) 6–12 years and (ii) 13–15 years of age. Any significant main effects were followed up with pairwise comparisons. The Bonferroni correction method was used to adjust the alpha level required for significance for post hoc pairwise comparisons only.

The hours accumulated specifically in batting activity during structured activity were calculated by summing the batting hours accumulated in each of the three structured activities: match-play, coach-led practice, and individual practice between (i) 6–12 years of age and (ii) 13–15 years of age. We calculated proportions for these data by dividing the number of hours in structured batting activity by the number of hours in structured activity. Independent *t* tests were performed for the proportion of total structured cricket hours accumulated in batting between (i) 6–12 years of age and (ii) 13–15 years of age. We also conducted independent *t* tests for the proportion of coach-led batting practice spent in “nets” practice, number of other sports, and hours accumulated in other sports for these two age ranges. Cohen’s *d* formula was used to calculate effect size for measures involving two means. This measure was calculated using pooled standard deviation. Cohen’s *f* formula was used to calculate effect size for measures involving more than two means (Cohen, 1988). The alpha level required for significance for all tests was set at $p < .05$.

Results

Anticipation Test

The high-performing group ($M = 26$ trials correct out of 36, $SD = 1$) scored significantly higher on the test of anticipation compared with the low-performing ($M = 19$ trials correct out of 36, $SD = 2$), $t(28) = 12.46$, $p < .05$, $d = 4.64$. The low-performing group scored significantly higher on the test of anticipation compared with the novice group ($M = 13$ trials correct out of 36, $SD = 4$), $t(27) = -5.30$, $d = -1.94$. Overall, response accuracy on trials that contained spin bowlers was 80% for the high-performing, 77% for the low-performing and only 22% for the novice group. Response accuracy on trials that contained pace bowlers was 61% for the high-performing, 41% for the low-performing, and 42% for the novice group.

Milestones

There were no differences in chronological age between the high-performing ($M = 17.4$ years, $SD = 0.5$) and low-performing groups ($M = 17.3$ years, $SD = 0.6$), $t(28) = 0.38$, $p > .05$, $d = 0.00$. The start age in cricket did not differentiate the high-performing ($M = 6.0$ years, $SD = 2.6$) from the low-performing group ($M = 5.7$ years, $SD = 1.5$), $t(28) = 0.77$, $p > .05$, $d = 0.15$. The age at which the participants started playing organized cricket in a league also did not differentiate the high-performing ($M = 8.8$ years, $SD = 2.0$) from the low-performing group ($M = 9.1$ years, $SD = 1.3$) (both groups started participating in an organized cricket league 3 years after starting cricket), $t(28) = 0.59$, $p > .05$, $d = -0.18$.

The age at which the participants started playing junior County cricket did not differentiate the high-performing ($M = 10.5$ years, $SD = 1.8$) from the low-performing group ($M = 10.3$ years, $SD = 1.5$) groups, $t(28) = 0.83$, $p > .05$, $d = 0.12$. The age at which players started representing an elite Academy also did not differentiate the high-performing ($M = 14.6$ years, $SD = 1.1$) from the low-performing group ($M = 14.4$ years, $SD = 0.8$), $t(23) = 0.62$, $p > .05$, $d = 0.21$. Two players from the high-performing group and three from the low-performing group had not played at elite Academy level.

Hours Accumulated in Cricket

Figure 2 presents the hours accumulated in cricket activity for the two groups. The total hours accumulated in cricket between 6 and 15 years of age differentiated the high- from the low-performing group, $t(28) = 2.48$, $p < .05$, $d = 0.95$. The high-performing group ($M = 5043.6$ hr, $SD = 2134.0$) accumulated more hours in cricket compared with the low-performing group ($M = 3510.2$ hr, $SD = 1090.5$).

Age 6 to 12 Years. The statistical results for hours accumulated in cricket activity between 6 and 12 years of age are displayed in Table 1. There were no significant group or interaction effects. A main effect for activity showed that hours accumulated in structured activity ($M = 1434.3$ hr, $SD = 766.1$) during this period were significantly greater than those accumulated in unstructured activity ($M = 830.3$ hr, $SD = 919.6$). The group means and statistical results for the proportion of structured activity hours spent in batting activity and the proportion of coach-led batting practice hours spent in “nets” are shown in Table 2.

Age 13 to 15 Years. The statistical results for hours accumulated in cricket activity between 13 and 15 years of age are displayed in Table 1. Hours accumulated in cricket activity between 13 and 15 years of age were greater for the high-performing ($M = 2479.1$ hr; $SD = 899.5$) compared with the low-performing group ($M = 1545.5$ hr, $SD = 453.8$). A significant main effect for activity showed that hours accumulated in structured activity ($M = 1767.6$ hr, $SD = 705.4$) during this period were greater than those accumulated in unstructured activity ($M = 244.7$, $SD = 380.9$). A significant Group \times Activity interaction showed the high-performing group ($M = 2140.4$ hr; $SD = 726.4$) accumulated more hours in structured cricket activity compared with the low-performing group ($M = 1394.8$ hr; $SD = 453.0$). Table 2 shows that the high-performing group ($M = 56\%$, $SD = 13$) spent a significantly greater proportion of structured cricket activity in batting activity

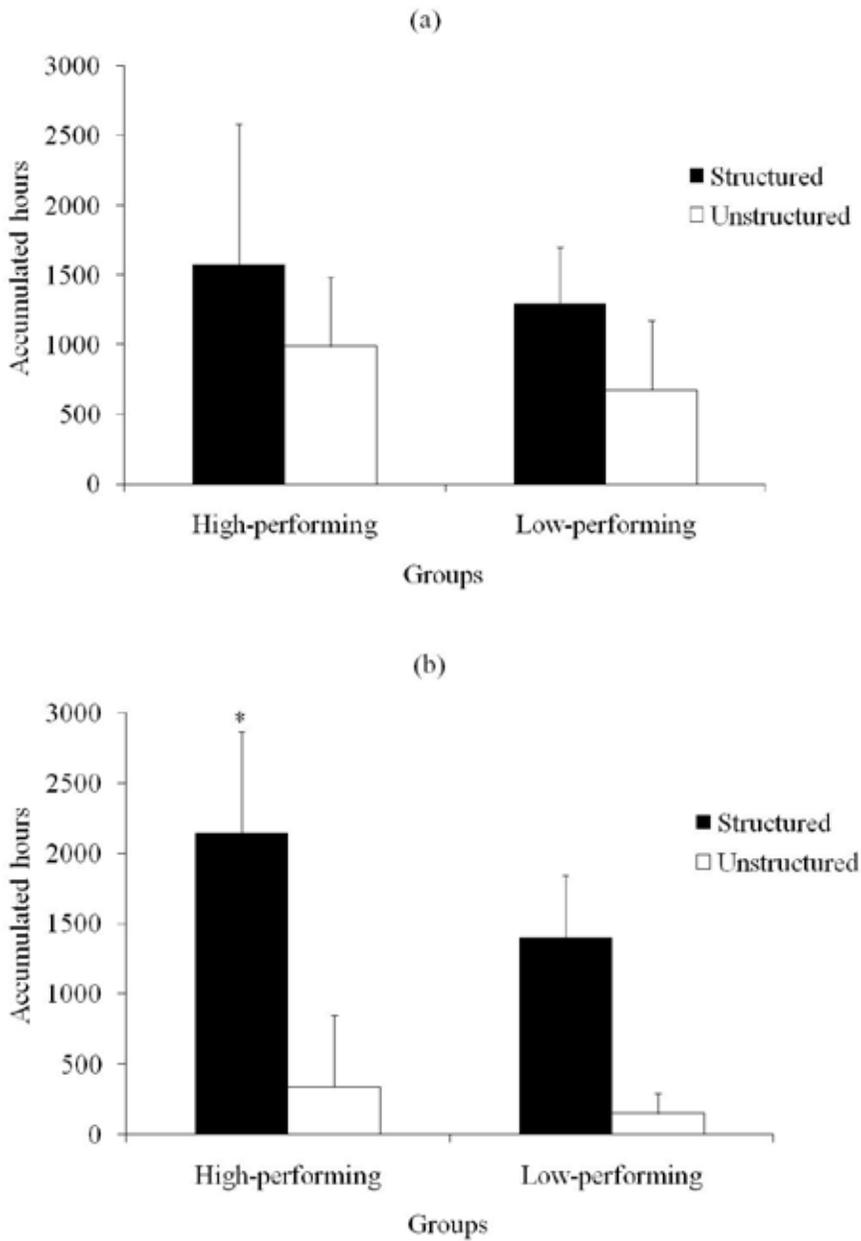


Figure 2 — The total hours accumulated in structured and unstructured cricket activity by high-performing and low-performing anticipators between (a) 6–12 years of age and (b) 13–15 years of age.

Table 1 The Results of Separate ANOVAs on Hours Accumulated in Cricket Activity

Variable and Comparison	MS	MSE	F	Cohen's Effect Size
Hours accumulated, 6–12 years				
Group	1,349,397.74	804,588.45	1.68	0.49
Activity	5,473,730.32	630,830.65	8.67*	0.72
Group × Activity	3,669.50	630,830.65	0.01	0.29
Hours accumulated, 13–15 years				
Group	3,268,619.96	253,782.52	12.88*	0.50
Activity	3.479×10^7	253,431.66	137.27*	0.70
Group × Activity	1,166,456.04	253,431.66	4.60*	0.26

Note. $df = (1, 28)$.

* $p < .05$.

Table 2 The Statistical Analyses for the Proportion of Structured Activity Hours Spent in Batting Activity and the Proportion of Coach-Led Batting Practice Hours Spent in “Nets”

Variable and Comparison	t	Cohen's d	Mean (SD)
Proportion of structured activity hours spent in batting activity			
6–12 years	0.06	0.02	HP = 47% (24)
			LP = 46% (24)
13–15 years	3.53*	1.40	HP = 56% (13)
			LP = 41% (10)
Proportion of coach-led batting practice hours spent in “nets”			
6–12 years	0.70	0.01	HP = 78% (19)
			LP = 83% (21)
13–15 years	2.47*	0.90	HP = 72% (18)
			LP = 88% (18)

Note. HP = high-performing group; LP = low-performing group. $df = (1, 28)$.

* $p < .05$.

compared with the low-performing group ($M = 41\%$, $SD = 10$). Table 2 also shows that the high-performing group ($M = 72\%$, $SD = 18$) spent a significantly lower proportion of coach-led batting practice in “nets” practice (as opposed to match-like situations) compared with the low-performing group ($M = 88\%$, $SD = 18$).

Table 3 The Statistical Analyses for Engagement in Other Sports

Variable and Comparison	<i>t</i>	Cohen's <i>d</i>	Mean (<i>SD</i>)
Number of other sports			
6–12 years	1.70	0.61	HP = 4.5 sports (3.7) LP = 2.6 sports (2.4)
13–15 years	1.67	0.61	HP = 4.7 sports (4.0) LP = 2.7 sports (2.3)
Hours accumulated			
6–12 years	0.48	0.26	HP = 1314 hr (1656) LP = 965 hr (858)
13–15 years	0.51	0.24	HP = 680 hr (621) LP = 551 hr (424)

Note. HP = high-performing group; LP = low-performing group. $df = (1, 28)$.

In this age range, nine of the low-performing group only ever practiced batting in the “nets” (as opposed to match-like situations), whereas only three of the high-performing group spent all of their batting practice in the “nets.”

Other Sports

Table 3 shows the group means and statistical results for engagement in other sports. The number of other sports that participants engaged in and the hours accumulated in those sports did not differentiate groups for either of the two developmental stages examined (i.e., 6–12 years of age; 13 and 15 years of age). Participants engaged in an average of 3 other sports in each stage. However, two participants in each group did not engage in any other sports. In contrast, one participant in the high-performing group reported engaging in 13 other sports between 6 and 12 years of age. Moreover, three participants in the high-performing group reported engaging in 10–13 other sports between 13 and 15 years of age. Soccer was the most popular other sport in which batters participated. Altogether, 13 participants from the high-performing and 11 from the low-performing group engaged in soccer between 6 and 12 years of age. Only two of the participants from the low-performing group stopped playing soccer at 12 years of age, whereas all other participants continued into the 13–15 years age range.

Discussion

We examined whether two groups of elite cricket batters who were classified as either high- or low-performing based on their performance on a film-based test of anticipation skill could be differentiated based on the activities engaged in during their development years. Participation history data for both groups were collected using questionnaires. We expected the main differences in activity profiles to occur in the later stages of development between 13 and 15 years of age (Weissensteiner

et al., 2008). High-performing anticipators were predicted to have accumulated more hours in structured cricket activity between 13 and 15 years of age (i.e., the specializing years), especially batting activity compared with the low-performing anticipators. We also expected the high-performing group to achieve certain milestones (e.g., start age in academy) earlier compared with their low-performing counterparts. In the early stages of their development, both groups were expected to follow the tenets of the DMSP (Côté et al., 2007).

As predicted, the high-performing group accumulated more hours between 13 and 15 years of age in structured cricket activity compared with the low-performing group. Moreover, during this period, the proportion of structured activity hours in batting activity was greater for the high-performing compared with the low-performing group. In addition, the high-performing group spent significantly less time in “nets” practice compared with the low-performing group, which suggests that their superiority was caused by spending more time facing bowlers in match-like situations, as opposed to bowling machines and non-match-like situations in the nets. The two expert groups were more accurate at identifying types of spin delivery compared with the novice group, which suggests that experts face more spin deliveries during their development than novices (Renshaw & Fairweather, 2000). The high-performing group was more accurate at identifying types of pace deliveries compared with the low-performing. Our findings support and extend those reported by Weissensteiner et al. (2008) in showing that differences in activity amounts between high- and low-performing anticipators only emerge later in development. Weissensteiner et al. hypothesized that there is an increase in ball speed during this latter period, which constrains batters to use early postural information from bowlers to anticipate delivery type. Therefore, those batters who accumulate more hours in batting activity facing these deliveries become superior at anticipating the type of delivery. In contrast, they hold that in the earlier years of development there are lower ball speeds, implying that batters can use information from ball flight to make these decisions. An alternative interpretation of our results is that this ability is not dependent on an increase in ball speed of deliveries in later development and is simply a result of an increased accumulation of hours in batting activity during this period or an accumulation of significantly more hours in cricket activity across development. Further research is required to examine whether these findings are specific to cricket or can be generalized across sports and tasks.

We hypothesized that between 6 and 12 years of age the participation histories of both groups would follow the tenets of the DMSP (Côté et al., 2007). The two groups were not differentiated based on the number of other sports engaged in during this period. The mean number of three other sports was slightly lower than the number of other sports reported previously by ice hockey (Soberlak & Côté, 2003; $M = 6.0$) and team sports players (Baker et al., 2003a; $M = 8.6$). The number of hours in other sports during this early period equated to around 3–4 hr per week. Although both groups engaged in some other sports during this period, findings do not lend full support to the notion of early diversification proposed in the DMSP (Côté et al., 2007). Variations in method between studies (e.g., in our study we specified that participants must have engaged in another sport for a minimum of 3 months) or culture (e.g., the climate in Australia compared with England) may account for these different findings between studies. Participants engaged in four other sports between 13 and 15 years of age and the number of hours in other

sports during this early period equated to around 3–4.5 hr per week. Although we did not test statistically the observed differences in participation in other sports between the two age ranges, findings do not show a discernable drop in other sports participation in the latter age range, which contradicts the late specialization tenet of the DMSP (Côté et al., 2007). However, the numbers of other sports were lower than reported previously (e.g., Baker et al., 2003a) and although these players are considered experts at the youth level, there is no guarantee that they will progress to professional status in adulthood, which may be confounding some of the data.

We predicted that the high-performing group would achieve certain milestones (e.g., start age in elite Academy) earlier compared with the low-performing players. However, differences were not observed between groups for the achievement of any milestones. Participants started playing cricket at 6 years of age, which supports the tenet of the DMSP. Participants started playing organized cricket league at 8 years of age and progressed to junior County level 2 years later. Both groups started at a County Academy at 15 years of age. Many milestones are often externally-imposed on players by the cricket authorities or society itself. For example, players cannot join an academy team until they are 15 or 16 years of age. Moreover, batting ability is likely made up of several components, such as shot selection, technical skill, and the ability to recognize type of delivery from the movements of a bowler before ball release. Batters likely demonstrate strengths in some components and weaknesses in others. Therefore, the superior ability of the high-performing group to anticipate delivery type does not necessarily mean this group had strengths on other components of performance. When component strengths and weaknesses are combined batting ability becomes more equal and certain milestones may not differentiate. In future, there is a need to quantify the relative importance of each component of cricket batting for superior performance of this task in the real world. Researchers should also examine the developmental activities that cause other components of cricket batting activity, such as shot selection. To examine the issues above, retrospective analyses of participation history profiles or examination of the microstructure of deliberate practice “in situ” can be conducted.

In summary, we examined the developmental activities that contribute to the ability of cricket batters to recognize type of delivery from a bowler before ball release. Accuracy scores on an objective test of this ability were used to create two groups: high-performing and low-performing anticipators. Questionnaires revealed that during the early stages of development there were no between-group differences in hours accumulated in cricket and other sports, as well as milestones achieved. The high-performing anticipators appear to have acquired their superior skill through engaging in more hours in structured cricket activity, in batting during that activity, and in batting practice that was realistic to the match between 13 and 15 years of age, as well as more total hours in cricket activity across their development, compared with low-performing anticipators.

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