

Decision-making skills and deliberate practice in elite association football referees

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Abstract

We examined sport expertise as a function of role. In study 1, referees were better than players in a video-based decision-making task. This provides evidence that there are role-specific skills within one domain or sport. In study 2, we examined the training activities that could be influential in the development of skills in sports officials. Elite association football (soccer) referees retrospectively reported time spent in and perceptions of training activities for three periods: their first year of formal refereeing, 1998 (before formal training programmes were available), and the current year (2003). This allowed us to examine an area of skill with a limited culture of practice, where performance simulations with direct feedback are usually not feasible. The results showed that referees specialize early and, as they develop, they engage in greater volumes and types of training. Competitive match refereeing is considered a relevant activity for skill acquisition that does not fit Ericsson and colleagues' (1993) original definition of deliberate practice. Our findings indicate that actual performance is a significant activity for skill acquisition and refinement.

Keywords: *Expert performance, skill acquisition, deliberate practice, officiating*

INTRODUCTION

Expertise research considers how performers are able to deal with complex tasks and overcome limitations to become highly skilled. One domain in which exceptional accomplishments are often highly visible is sport. This visibility has made sport an attractive domain for expertise researchers. We have thus accumulated a great deal of information about expert performers and how they differ from novice performers. For example, there is a large body of literature detailing the characteristics of experts compared with novices, their training, and their biographic histories (birthplace, birth date, sporting histories) (e.g. Baker, Côté, & Abernethy, 2003; Côté, MacDonald, Baker, & Abernethy, 2006; Williams, Davids, & Williams, 1999; see also Starkes & Ericsson, 2003, for a review).

One of the unique aspects of sport as a domain, however, is that people play many roles. Presumably, a coach, player, and referee from the same sport have a common knowledge base (e.g. declarative knowledge about the goals and general performance within that sport), but are often required to perform

different tasks within the context of that sport. For example, a coach's role is to train the athlete and devise performance tactics and strategy. An athlete's role involves physical and perceptual-cognitive training and performance. Finally, although it varies from sport to sport, in open field sports the role of the referee is similar but arguably more complex than that of the athlete, in that it requires a high degree of physical fitness, as well as complex decision making in the application of the laws of the game.

From an expertise research perspective, the complexity of the rarely examined role of the open-sport referee is intriguing for several reasons. First, understanding skill in this role will help us understand how performers in similar roles deal with overwhelming demands and ill-defined problem spaces (e.g. military command, medical diagnosis).

Second, although there are examples in the literature of tests of domain specificity by comparing, for example, general memory skills with memory for items from a domain of skill (e.g. chess, soccer), role-specificity has not received extensive examination. The question remains: How domain-specific are

domain-specific skills? It is possible that performers in one domain acquire skill for different but related roles, with transfer of skill between these roles. There is evidence that pattern recall of game-related stimuli (player positions) is a skill that can be transferred by proficient athletes between sports with similar structures (e.g. soccer, field hockey). Abernethy, Baker and Côté (2005) showed that expert performers had better overall recall than non-experts, even for sports that were not their sport of expertise. Thus, for recall of clips of netball action, performance was best by expert netball players, followed by experts from other sports (basketball, hockey), and then non-expert netball players. Smeeton, Ward and Williams (2004) reported similar findings. Skilled soccer, volleyball, and field hockey players were asked to identify previously viewed action sequences from all three sports. The skilled field hockey and soccer players were able quickly and accurately to identify both the soccer and field hockey action sequences, showing transfer of skill between sports, probably due to the similarity in the structure of both sports.

There is no similar evidence of transfer of key role-related skills *between* roles, however. Although it is difficult to identify and define “core skills” for each sport role, there is evidence that the development of knowledge and skills is at least influenced by the role that is occupied. For example, Allard, Parker, Deakin, and Rodgers (1993) assessed basketball referees, coaches, and players on five different tests: (1) general basketball knowledge, (2) rules, (3) Fédération Internationale de Basketball Association (FIBA) hand signals, (4) recall of pictures depicting both random and actual plays, and (5) infraction (foul/violation) detection and naming. Performance on these tests differed by group. Specifically, the referee-specific tasks (rules, signals, naming of fouls/violations) were performed better by referees than the other two groups, coaches reflected their coaching skill in their superior recall of pictures of real versus random plays, and players were better than the other groups in overall recall of pictures of plays (real and random). The authors concluded that performance and, by inference, knowledge within a domain varies based on the role occupied.

Williams and Davids (1995) also provide evidence that there are differences in the perceptual-cognitive skills of sports performers based on role and expertise. Using video clips, the authors found that both high-skill and low-skill players were faster in predicting the destination of a soccer pass than a group of disabled spectators. The disabled spectators responded after ball contact, which was later than the two groups of players, who responded before the ball was kicked. This relative delay on the part of the spectators reflects the fact that they were not accustomed to, and did not need to account for,

the time pressures of performing the skill, since they never had completed passes in a game. These findings have implications for comparisons between the roles of player and referee. Put simply, referees observe players perform game-related actions and react by applying the rules, whereas players perform game-related actions and observe or react as referees apply the rules. Players do not regularly make rule application decisions, and thus referees should outperform them.

In summary, based on the role-specificity evidence of Allard *et al.* (1993) and Williams and Davids (1995), we hypothesized that a test of a core referee skill (application of the laws of the game) would reveal superior performance by referees than players. This hypothesis was addressed in study 1.

A final reason for our interest in referees as a population within expertise research relates to the acquisition of skill. The exposure, experience, and practice necessary for the development of domain-specific skills have received a great deal of attention in the sport expertise literature. An extremely useful tool in examining the role of practice in expert performance is the theory of deliberate practice, advanced by Ericsson, Krampe and Tesch-Römer (1993). The premise of this theory is that expertise is gained through the deliberate practice activities of the performer. Following Ericsson *et al.* (1993), to qualify as *deliberate practice*, activities must be monitored, with immediate and informative feedback, effortful, and not inherently enjoyable. Moreover, the motivation to engage in deliberate practice must be to improve performance and not, for example, for financial or social rewards. Findings have shown a monotonic relationship between the amount of deliberate practice and standard of performance, such that a minimum of 10,000 hours or 10 years of deliberate practice is required to attain expert performance. This has been shown to be the case for music as well as various sports (e.g. Ericsson *et al.*, 1993; Helsen, Starkes, & Hodges, 1998; Hodges & Starkes, 1996; Starkes, Deakin, Allard, Hodges, & Hayes, 1996).

There are notable developments in the evolution of the deliberate practice theory that have arisen due to its application to sport. For example, physical effort became distinguished from mental effort (Hodges & Starkes, 1996). Where activities such as chess and violin playing involve minimal physical performance, sport skills are achieved primarily through the use of larger muscle groups both in gross and fine movements. Thus physical effort gains a larger focus within sport skills, in contrast to activities such as chess and violin playing. Indeed, in wrestling and figure skating, participants differentiate activities according to the amount of concentration required versus the amount of effort required (Starkes *et al.*, 1996).

A second important development in the theory of deliberate practice in sport was the move to examine different types of sport. Expertise was first investigated in individual sports like wrestling and figure skating, before being addressed in team sports (Helsen *et al.*, 1998). This move provided an elaborated view of practice activities, differentiating individual and team activities as two forms of practice. Thus, in examining the specific activities (and not simply the amount of time spent) of international, national, and provincial soccer players, Helsen *et al.* (1998) examined individual practice, team practice, sport-related activities, and everyday life activities. Each activity was rated by participants on the dimensions of relevance to improving soccer performance, effort, enjoyment, and concentration.

The theory of deliberate practice was devised from, and has been examined in, populations with structured practice environments and with clear opportunities both for performance simulations and feedback (e.g. athletes, musicians). Recent discussion of the theory of deliberate practice (Ericsson, 2005) indicates that there is a need to examine skills that are developed in the absence of a culture of practice, and where simulations are extremely difficult (e.g. medicine, fire fighting). In this respect, officiating is an ideal skill, and sport might once again be influential in the development of the theory of deliberate practice. Although officials often come from a playing background with a strong culture of practice, this same culture is not as developed for the role of the referee. For example, it is only recently (1998) that structured training programmes were put in place for soccer officials at the highest standard of competition (Fédération Internationale de Football Association – FIFA). Moreover, it is not usual for referees to have regular opportunities for simulations with immediate feedback and evaluation. Thus, although it does not qualify as a deliberate practice activity, we considered “work”, or competitive refereeing, to be an important activity that could provide the greatest opportunities for skill acquisition and refinement for this and similar populations.

Singer and Janelle (1999) support the position that time spent in and experience of match-play are important for predicting performance. In a study of training in elite and sub-elite soccer players, Ward, Hodges, Williams, and Starkes (2004) also found that match-play fitted Starkes and colleagues’ redefinition of deliberate practice to include activities that are rated high in relevance, effort, concentration, and enjoyment. They contend, however, that match-play does not provide opportunities for learning as clearly as other activities (e.g. work with a coach) – a significant component of deliberate practice. It could be, however, that activities other than those that fall under the strict

definition of deliberate practice still contribute to skill development. For example, Côté, Baker, and Abernethy (2003) identified a continuum of activities that are characterized on dimensions such as the goals of the activity and the amount of inherent monitoring. The continuum includes free play, deliberate play, structured practice, and deliberate practice. The greatest distinctions between structured practice and deliberate practice are that structured practice is monitored, as opposed to monitored *carefully*, and correction is not immediate, but may come from discovery learning. Structured practice nonetheless contributes to skill acquisition, and in the case of tasks such as refereeing, might be the most significant practice. We thus felt that it was important to understand perceptions of, and amount of time spent in, match refereeing (exhibition and league) as a significant skill acquisition activity for referees.

Given the characteristics of the referee role, we were interested in referees’ assessments of training activities as well as therapeutic, match/match-related, coaching/playing, and everyday life activities using the deliberate practice framework. In study 2, a group of elite soccer referees completed deliberate practice questionnaires, providing information on their training activities for the first year they officiated, 1998 (when structured training programmes were put in place), and 2003, when the programmes were still in place.

We hypothesized that training volumes would increase over the three periods and as referees evolve from players to officials, and acknowledge the specificity of roles, playing-related and coaching-related activities would become less relevant to improving refereeing performance. We speculated that the greatest amount of “training” is done during competitive match refereeing, or “work”, and thus the questionnaires included assessments of match and match-related activities. In a sport like soccer, officials move about the field with the players, and thus have significant physical demands placed on them. Because of the culture of training for athletes and the well-developed knowledge of physical training, we hypothesized that referees would spend a great deal of time in physical training. In contrast, we expected much less training of perceptual-cognitive refereeing skills (e.g. application of the laws), even at the higher levels of performance (2003, the most current year). In addition, given that referees are markedly older than players, we were interested in therapeutic activities, and hypothesized that their relevance would increase over time.

In summary, we focus on skill in open-sport officiating as a means to examine role-specificity within one domain or sport. Study 1 compares soccer players and referees in a test of the application

of the laws of the game. Because sport refereeing is a role with no clear culture of practice and for which simulations of performance are difficult, we were also interested in the training activities of referees at the highest standards of performance, and have developed what we speculated to be role-specific skills (shown in study 1). Study 2 examines the volume of and perceptions of training activities in elite soccer referees over three periods (first year of officiating, 1998, 2003).

STUDY 1

Methods

Participants

Data are presented for a total of 41 participants. One group consisted of seven Belgian elite referees who were on the FIFA (Fédération Internationale de Football Association) list of referees. Referees on this list are called upon to officiate international matches in the various UEFA (Union des Associations Européennes de Football) competitions (e.g. UEFA Cup, UEFA Champions League), UEFA being one of the six FIFA Confederations. They can also be appointed to officiate at qualifying matches as well as the final rounds of the various FIFA tournaments (e.g. Olympic tournaments, World Youth Championships, World Cup), which represent the highest standards of soccer played in the world. Referees are appointed to the FIFA list primarily based on their match reports and the associated marks. These match reports are standardized protocols that are used for all international matches as well as for all the games in the national leagues. A second criterion for appointment and re-appointment is results on fitness tests, which are submitted to FIFA every year and are collected during courses as well as tournaments. International referees are also tested on their language skills. For all referees in this study (who belong to the European Confederation of UEFA), this means they have to pass an English test. Finally, age is also a consideration for appointment as a FIFA referee. Given that the maximum age is 45 (after which referees are retired), associations can only nominate referees younger than 35 years of age.

The seven elite referees had a mean 19.4 years of refereeing experience ($s = 4.2$), mean 8.7 years of playing experience ($s = 4.2$), and mean age of 37 years ($s = 4.4$). A second group consisted of 34 youth academy soccer players who were attending a soccer academy full time and playing for top Belgian clubs, and who were on the national team for their age group. The mean age of the players was 16.3 years (range = 14–18), and they had a mean 10.1 years of playing experience ($s = 1.4$). None of the players had

any refereeing experience. An independent t -test comparing the two groups (FIFA referees and academy soccer players) confirmed that they were similar in terms of accumulated number of years playing experience ($t_{39} = 1.6$, $P = 0.12$). The aim of this comparison was to confirm that the group of players had accumulated equivalent playing experience as referees but no refereeing experience.

Materials and procedure

The participants first completed a brief questionnaire in which they reported the number of years they had played, refereed or coached, as well as estimates for the number of hours per week that they practise to play, coach, or referee. Participants then completed a video-based tackle assessment task. Digital film clips of soccer tackles were provided by FIFA and UEFA and displayed on a large screen with an LCD projector. Two blocks of 20 clips each were shown. Participants were instructed to make a decision about the tackle shown in each clip, choosing one of four possibilities: (1) no foul, (2) free kick, (3) free kick followed by a yellow card, or (4) free kick followed by a red card. After each clip there was a window of 10 s to make a decision before the next clip was shown. The correct decision had previously been established for each play by a FIFA panel of experts. The number of the clip was announced before each trial to ensure that the participants were being attentive at the start of each clip. The participants were tested in groups: one of referees and one of players. Group members were instructed to refrain from communicating with each other during testing.

Analysis and results

The first analysis compared performance by referees and players. In view of the complexity of the task, the first block of 20 trials was used as practice, with analysis performed on the second block of 20 trials. For the test block, response accuracy was calculated and expressed as the percentage of correct responses for the total number of trials ($n = 20$). The player and referee groups differed in performance on this task. Referees were quite proficient with a mean accuracy rate of 80.6% ($s = 6.7\%$). In contrast, players were accurate on only 55.1% of the trials with a large standard deviation of 13.0%. Although obtaining a sample of elite referees resulted in age differences between the two groups that could not be avoided, as well as a comparison between very different sample sizes (7 vs. 34), these performances differed, as indicated by the results of a one-way analysis of variance with Group as the two-level factor (referee, player): $F_{1,39} = 16.2$, $P < 0.001$.

Next, we examined the relationship between practice activities and experience, and performance on this task. Because all of the participants had playing experience, we performed a regression analysis with accuracy as the independent variable and years played as the dependent variable. The model was not significant ($F_{1,39} = 0.95$, $P > 0.05$), indicating that playing experience is not related to accuracy in this law application task. Because we were interested in the relationship between role-related experience and performance on this task, we performed a multiple regression using years of officiating, hours per week in refereeing practice, years on the FIFA list, weekly playing practice, and years of playing experience. For the group as a whole, a stepwise regression identified hours per week in refereeing practice as a moderately good predictor of accuracy ($F_{1,38} = 12.51$, $P < 0.01$) with an R^2 of 0.25 ($R^2_{\text{adj}} = 0.23$). This result can be viewed as support for the idea that there are role-related differences, and that practice activities contribute to these differences. On the other hand, it could simply reflect that our players had no refereeing experience and that referees had little playing practice.

Given the division between our groups in terms of experience, and the fact that referees engaged in hardly any playing training, we examined only the group of players to determine whether hours per week of training to play had an influence on accuracy. The model was non-significant ($F_{1,31} = 1.44$, $P > 0.05$). Similarly, because only the referees had any refereeing experience, we examined referee-related variables in this group only. A regression model using hours per week of practice for refereeing and accumulated years of refereeing experience did not produce any significant results ($F_{1,6} = 0.50$, $P > 0.05$). Using only the group of referees, however, reduced the sample size considerably to just seven, which is problematic for regression analyses.

Discussion

Compared with players, referees showed superior performance in a referee tackle assessment task. This provides evidence that there may be core role-related skills and thus role specificity within one domain or sport. We also found evidence that refereeing practice contributes to this skill and thus to role specificity; however, the nature of the differences between our groups (i.e. players had no refereeing experience) and the small number of referees was a problem.

Given these results, we were interested in understanding more about the training activities that elite soccer referees engage in, as well as their perceptions of these activities. The deliberate practice theory provides a framework for examining training, and

sports referees provide a population with a weak culture of practice and performance skills that are demanding and difficult to replicate in simulations. Study 2 used a deliberate practice questionnaire to examine training in elite referees for three points in their careers.

STUDY 2

Methods

Participants

Twenty-six elite European soccer referees participated in this study. Seven participants were Belgian international referees on the FIFA list who had also participated in study 1. Nineteen referees were from the English Premier League, some of whom were also on the FIFA list ($n = 7$). All of these referees officiate in the various UEFA and FIFA competitions. The remaining 12 match officials were of the highest standard in their country. All together, the sample thus consisted of 26 highly experienced top European referees. The referees as a group had a mean age of 40.8 years ($s = 4.9$), had begun refereeing at a mean age of 19.5 years ($s = 3.5$), and thus had accumulated a mean of 21.3 years ($s = 4.3$) of refereeing.

Materials and procedure

The referees were asked first for biographic data related to their experiences in soccer, with the emphasis on refereeing (e.g. age began refereeing, number of years refereeing, and number of matches in national leagues and international tournaments). After this, retrospective recall methods were applied to collect data on time spent in various training activities (reported in minutes per week) and each activity's perceived relevance to improving refereeing. For retrospective ratings of relevance, the participants were instructed to specify as accurately as possible how relevant they felt the activities were to improving referee performance at that time. That is, how relevant they perceived the activities to be at the time that they were doing them.

On a second questionnaire a week later, the participants indicated current perceptions of relevance, effort, enjoyment, and concentration for each activity in addition to activities from the following categories: therapeutic, match/match-related, coaching/playing, everyday life. Ratings were provided on a scale of 1 ("low") to 10 ("high"). The addition of these categories provides more detail on current training. The list of practice activities was based on those identified for soccer players in previous research (Helsen *et al.*, 1998) and adapted

to the role of the referee through consultation with two referee-coaches. To ensure completion of the questionnaire and minimize the burden on participants, we chose to focus on three specific points in referees' careers. The three years for which these data were recorded were: first year of officiating (as part of a formal league), 1998 (the year training programmes were put in place by FIFA), and the current year (2003 – training programmes were still in place). This also allowed us to assess the impact of training programmes on activities and how they are perceived. Although the age and skill of the referees differed somewhat in these three target years, for the purposes of training activities engaged in by officials, the three years represent the same relative stage of skill development.

For the first questionnaire, data (time spent and ratings of relevance) were collected for 15 activities from two categories: on-field and off-field training (see Table I for a list of the specific activities under these categories).

Within the on-field training category, there were five running activities of different intensities (e.g. recovery vs. high intensity). Given that referees in this study make regular use of PolarTM heart rate watches in training, both a percentage of maximal heart rate and a rating of perceived exertion were associated with these activities. For example, high-intensity running was described as running at 85–90% of maximal heart rate, with a rating of perceived exertion of 6–10 on a 10-point scale where 10 indicates “maximum exertion”.

Reliability of the data

While retrospective recall can be problematic due to systematic biases and inaccuracies in recalling past events (Smith, Leffingwell, & Ptacke, 1999), Ericsson and Lehmann (1996) argued that experts typically monitor both progress and performance, and thus minimize potential inaccuracies compared with novices. While our limited access to the elite participants in this sample prevented in-depth reliability checks, we did have access to concurrent training information that allowed checks to be made between the self-report and heart rate data.

During the questionnaire collection period, referees maintained their training activities and habits. It is normal practice for both groups of officials (Belgian and English) to use PolarTM heart rate monitors. Each referee uses a monitor to record heart rate during training sessions in the week to two weeks between group training sessions. The referee-coaches then download the data files stored on the monitors after group sessions (for which heart rate is also recorded) to ensure that the referees are training within heart rate zones appropriate for that week

Table I. Activity categories used in the two questionnaires.

Questionnaires 1 and 2

On-field activities

- Recovery runs (65–75% maximal heart rate, RPE 0–2)
- Low intensity runs (75–85% maximal heart rate, RPE 0–2)
- High intensity runs (85–95% maximal heart rate, RPE 6–10)
- Speed-endurance runs (>95% maximal heart rate, RPE 6–10)
- Speed and agility (RPE 2–5)
- Coordination and running

Off-field activities

- Strength training (e.g. use of free weights or resistance exercises)
- Flexibility
- Technical refereeing skills
- Other training (e.g. cycling for fitness)
- Video training
- Game-playing tactics
- Psychological skills training (e.g. imagery, relaxation training)
- Referee meetings
- Language practice

Questionnaire 2 only

Therapeutic activities

- Physiotherapy
- Sauna/Jacuzzi

Match/match-related activities

- Refereeing league games
- Refereeing exhibition games
- Travel to referee

Coaching/playing activities

- Meetings, coach
- Meetings, player
- Travel to coach
- Travel to play
- Coach training courses
- Playing in an organized league
- Spectating soccer (live or televised)
- Reading about soccer

Everyday life activities

- Sleep
 - Study/work
 - Active leisure
 - Non-active leisure
 - Travel (e.g. for work)
-

(given time of season, upcoming games, and other considerations). The referee-coaches compiled these data to indicate time spent in different heart rate zones. In addition, time spent during a session and the type of session (e.g. recovery) is indicated.

The heart rate data files were used for 16 referees to provide an indication of the reliability of the questionnaire reports of average time spent in activities. We compared time spent in specific heart rate zones with reports of time spent in corresponding activities (e.g. high-intensity running). To check the correspondence between these two measures (self-report vs. heart rate monitor data), we used Pearson

product-moment correlations. The correlation between these two data sets yielded an r of 0.59 ($P=0.017$), indicating reliability of the data collected via the questionnaires. The reliability is considered high in light of the small sample size ($n=16$) and the fact that the data were collected during a period of light training, whereas the questionnaire asked for reports of *mean* time spent in activities.

It is difficult to test the reliability of retrospective reports of perceptions (i.e. relevance). Again, however, Ericsson and Lehmann (1996) stated that experts monitor their progress and performance. We assume that the relevance of practice activities is monitored as a key component of progress and performance, and that experts will provide minimal inaccuracies when giving retrospective reports.

Analysis and results

The data were analysed in three sections: (1) biographical data, (2) time spent and perceived relevance over the three target years for on-field and off-field training activities, and (3) current perceptions of training activities on the dimensions of relevance, effort, enjoyment, and concentration.

Biographical data

Fourteen of the participants were FIFA referees and 12 were not. Appointment to the FIFA list is an important achievement. Such an appointment can thus be used as an indicator of expertise in refereeing. Using the FIFA referee sub-sample, we explored the relationship between different sources of experience in soccer and appointment to the FIFA list.

FIFA referees were younger (mean 39.1 years) than non-FIFA referees (mean 43.1 years; $t_{23} = -2.20$, $P < 0.038$). While the two groups of referees did not differ in the number of years they had officiated, coached, or played, a t -test comparing refereeing start age showed a main effect of Group ($t_{23} = -2.63$, $P = 0.015$), whereby the FIFA referees began refereeing at a younger age (mean 18.1 years, $s = 2.2$) than the non-FIFA referees (mean 21.4 years, $s = 4.0$). As a whole, the FIFA referees had formally officiated for a mean 16.4 years ($s = 2.95$) before being represented on the FIFA list.

To understand the relationship between different types of experience and being represented on the FIFA list, we used Pearson product-moment correlations to compare number of years to obtain FIFA list status with number of years practised in the first year of refereeing. The correlation ($r = 0.24$) was not significant ($P = 0.41$). We then selected the referees who were not on the FIFA list in 1998 and

correlated the number of hours practised in 1998 with number of years to obtain FIFA list status. This also was not significant ($r = -0.02$, $P = 0.96$).

Number of years to obtain FIFA list status was not correlated with either accumulated number of years playing (mean 9.43 years, $s = 5.14$; $r = 0.08$) or accumulated number of years coaching (mean 1.5 years, $s = 4.20$; $r = -0.24$), indicating that coaching and playing experience are not related to the time taken to achieve FIFA list status. It should be noted, however, that only three referees indicated any experience of coaching.

Time and relevance of activities in the three target years

On-field activities. The on-field category comprised six running-based activities (recovery, low-intensity, high-intensity, speed endurance, speed/agility, and coordination). We used one-way repeated measures analyses of variance to compare three levels of Year (first, 1998, current). [Note that the values could be conflated for each activity given that these data are reported by the same participants.] A Tukey's *post-hoc* test was applied to any significant results. These analyses showed main effects with yearly increases in training volumes for all activities (recovery: $F_{2,48} = 72.18$, $P < 0.01$; low-intensity: $F_{2,50} = 4.00$, $P = 0.02$; speed endurance: $F_{2,50} = 21.06$, $P < 0.01$; speed/agility: $F_{2,50} = 23.44$, $P < 0.01$; coordination: $F_{2,50} = 5.21$, $P = 0.009$) except high-intensity running, which did not change from year to year ($F_{2,50} = 2.21$, $P = 0.12$). Specifically, the volume of speed endurance training was greater in the current year (2003) than in 1998, which was in turn greater than the volume in the first year of refereeing. For coordination, speed/agility, and recovery training, volumes were greater in the current year than 1998, but did not differ between 1998 and the first year of officiating. Finally, for low-intensity training, the volumes in the current year and 1998 did not differ, but were both greater than the volume reported for first year. Figure 1 illustrates these results and where the differences lie.

We also compared ratings of relevance for the six on-field activities for each time period, again using one-way repeated measures analyses of variance and Tukey's *post-hoc* tests. Figure 2 shows the results of these analyses. Relevance ratings increased across years, including those for high-intensity running (recovery: $F_{2,50} = 20.25$, $P < 0.01$; low-intensity: $F_{2,50} = 10.16$, $P < 0.01$; high-intensity: $F_{2,50} = 23.33$, $P < 0.01$; speed endurance: $F_{2,50} = 43.47$, $P < 0.01$; speed/agility: $F_{2,50} = 37.12$, $P < 0.01$; coordination: $F_{2,50} = 8.79$, $P < 0.01$). Specifically, relevance ratings for recovery, high-intensity, and speed endurance training were higher in the current

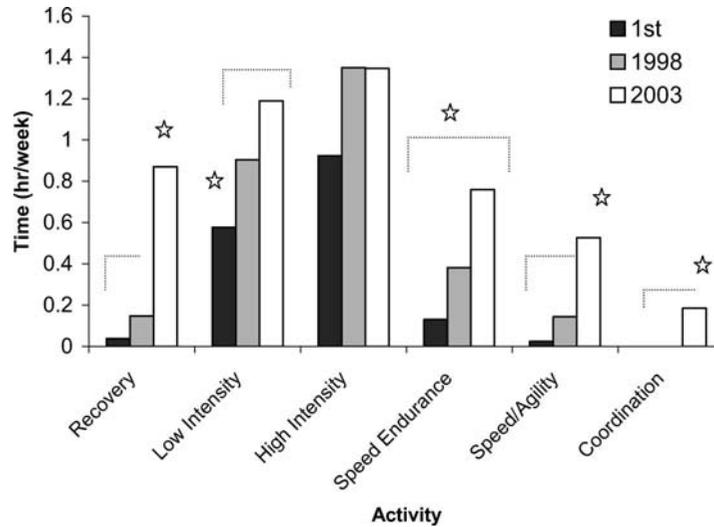


Figure 1. Training volumes for on-field activities for the first year of officiating, 1998, and the current year (2003) (hours per week). ☆ $P < 0.01$. Dotted lines indicate results of *post-hoc* tests.

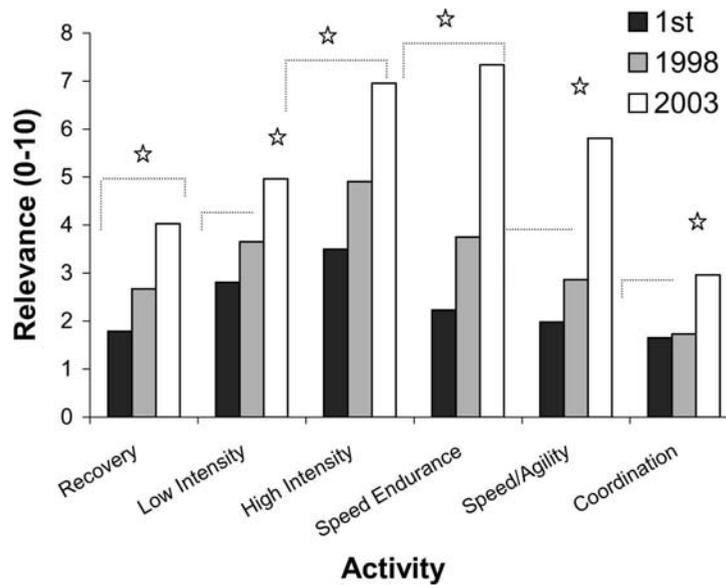


Figure 2. Mean ratings of relevance for on-field activities for the first year of officiating, 1998, and the current year (2003). ☆ $P < 0.01$. Dotted lines indicate results of *post-hoc* tests.

year than in 1998, and in turn higher in 1998 than in the first year of officiating. For low-intensity, speed/agility, and coordination activities, ratings for the current year were greater than for 1998, but did not differ between 1998 and the first year.

Off-field activities. The same analyses were performed for the off-field training activities (strength, flexibility, technical refereeing skills, other training, video training, playing tactics, and psychological skills training). Figure 3 shows yearly volume (displayed in minutes per week) increased for all

activities (flexibility: $F_{2,50} = 5.91, P < 0.01$; technical skills: $F_{2,50} = 5.14, P < 0.01$; video training: $F_{2,50} = 12.19, P < 0.01$; playing tactics: $F_{2,50} = 4.46, P < 0.05$; psychological skills training: $F_{2,50} = 17.19, P < 0.01$), with the exception of strength training ($F_{2,50} = 1.46, P = 0.24$) and other training (e.g. cycling) ($F_{2,50} = 2.61, P = 0.08$). Although not significant, other training is the only activity that shows a pattern of decreasing volume over the years. More specifically, more time was spent in flexibility, technical skills, and game tactics in the current year and 1998, which did not differ from each other, than

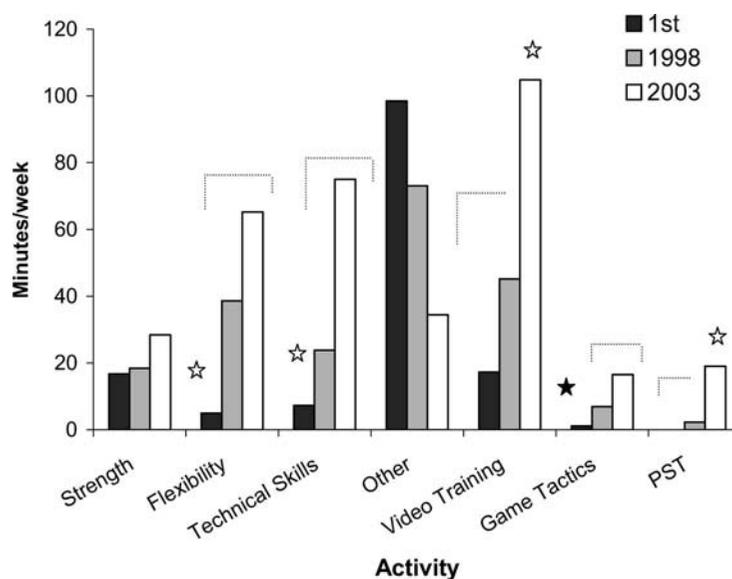


Figure 3. Training volumes for off-field activities for the first year of officiating, 1998, and the current year (2003) (minutes per week). ☆ $P < 0.01$; ★ $P < 0.05$. Dotted lines indicate results of *post-hoc* tests. PST = psychological skills training.

in the first year of officiating. More time was spent in psychological skills training and video training in the current year than in 1998. The volume in these activities did not differ, however, between 1998 and the first year of officiating.

Similarly, Figure 4 shows that perceived relevance increased across years for all activities (strength: $F_{2,50} = 9.8$, $P < 0.01$; flexibility: $F_{2,50} = 25.25$, $P < 0.01$; technical skills: $F_{2,50} = 11.10$, $P < 0.01$; video training: $F_{2,50} = 15.30$, $P < 0.01$; playing tactics: $F_{2,50} = 11.11$, $P < 0.01$; psychological skills training: $F_{2,50} = 17.19$, $P < 0.01$) except other training ($F_{2,50} = 0.19$, $P = 0.83$). Specifically, for all significant results, there was the same pattern of higher relevance ratings for the current year than 1998, with in turn higher relevance ratings in 1998 than for the first year.

Perceptions of activities

Ratings on four dimensions. For each activity on each dimension (i.e. relevance, effort, enjoyment, and concentration), ratings were calculated and compared with the overall mean for all activities (on that dimension) using mean hypothesized *t*-tests. Significant differences were determined using Bonferroni's method for alpha adjustment, with alpha divided by the total number of activities (i.e. 33). Results are shown in Table II, with means significantly above and below the overall mean indicated.

A large number of activities were rated higher in relevance than the grand mean for this dimension. As can be seen in Table II, four of six on-field activities and four of nine off-field activities were rated high in relevance. Specifically, high-intensity runs, speed

endurance, speed/agility, and coordination received high ratings. High ratings were also given for flexibility and sleep, indicating the need for recovery and injury prevention in response to high-intensity training.

Coaching and playing activities were rated lower in relevance than the mean (player meetings, travel to coach, travel to play, playing, and reading about soccer). Referees distinguished specifically between the relevance of refereeing league games and refereeing exhibition games. Officiating in league games was an activity rated not only significantly higher than the grand mean, but highest overall (9.3). Refereeing exhibition games, in contrast, was rated lower than the overall mean (3.7), though not significantly so. It would appear that for professional referees, league refereeing is seen as one of the most relevant activities for improving performance.

The same on-field activities that were rated higher than the mean for relevance were also rated higher for effort (high-intensity runs, speed endurance, speed/agility, and coordination). Only two off-field activities were rated as requiring high effort (strength training and technical referee skills). [For simplicity, technical referee skills were placed under the category of off-field training activities. Over the years, however, activities under this label have evolved to represent an integration of physical, technical, and tactical aspects of refereeing such as positioning, which takes place on the field and requires physical effort. This evolution explains ratings on the effort dimension.] Once again, league and exhibition refereeing were distinguished, with league refereeing perceived to be the most effortful

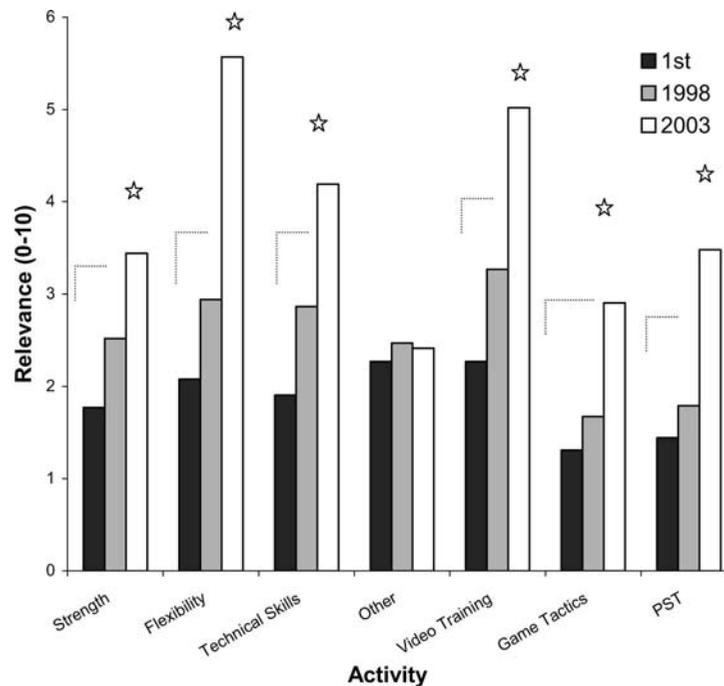


Figure 4. Mean ratings of relevance for off-field activities for the first year of officiating, 1998, and the current year (2003). ☆ $P < 0.01$. Dotted lines indicate results of *post-hoc* tests. PST = psychological skills training.

activity (9.2) and exhibition refereeing ranked lower than the overall mean (4.8), although not significantly so. Activities that were rated low in effort were those related to coaching and playing (player meetings, travel to coach, and travel to play). Not surprisingly, the other low effort activities were reading about soccer, sleep, and non-active leisure.

Referees indicated high enjoyment for three on-field activities (speed endurance, speed/agility, and coordination) and only one off-field activity (technical refereeing skills). Not surprisingly, refereeing league games was highest in enjoyment (9.1), with refereeing exhibition games somewhat less enjoyable, but again not significantly different to the overall mean (4.3 vs. 5.4, respectively). Sleep and active leisure were also rated as highly enjoyable. Five of the eight coaching and playing activities were rated low in enjoyment (coach meetings, player meetings, travel to coach, travel to play, and coach training). The exception to average and lower than average ratings was spectating soccer, which was rated significantly above the mean on enjoyment.

For concentration ratings, the same pattern was again observed, with the on-field activities of high-intensity running, speed endurance, speed/agility, and coordination training rated above the mean. Referees indicated that great concentration is also required for technical refereeing skills, video training, and referee meetings, with all three rated higher than the mean. Referees once again distinguished between refereeing exhibition and league games,

with league games requiring greater concentration (mean = 9.4) than exhibition games (mean = 4.2). Travel to referee is also an activity requiring high concentration, with a mean rating of 7.5. Finally, very little concentration was associated with recovery training, sauna/jacuzzi, player meetings, travel to coach, sleep, and non-active leisure.

Relationships between dimensions. To determine the relationships between the dimensions of relevance, effort, enjoyment, and concentration, we converted the average ratings for each activity to z -scores and then correlated the dimensions using a Spearman's rho analysis. A Bonferroni correction was again made to adjust the alpha level. The correlations indicated a relationship between ratings of effort and enjoyment ($t_{31} = 3.74$, $P < 0.001$, $r = 0.56$, indicating 31% of the variance accounted for), and ratings of effort and concentration ($t_{31} = 13.27$, $P < 0.001$, $r = 0.92$, indicating 85% of the variance accounted for). In contrast to previous studies (e.g. Ericsson *et al.*, 1993), there was no relationship between relevance and effort ($t_{31} = 0.85$, $P = 0.4$, $r = 0.15$).

Discussion

These data show that both the volume of training and the relevance ratings, almost regardless of activity, increased over the three periods examined. With regard to increasing volumes of practice, this finding supports our hypothesis and is generally in line with

Table II. Mean ratings of training activities evaluated on four dimensions.

Category	Dimension ^a			
	Relevance	Effort	Enjoyment	Concentration
On-field training activities				
Recovery training	6.4	3.3	5.7	3.2* ^L
Low-intensity	6.9	4.9	6.2	4.5
High-intensity	8.6* ^H	8.3* ^H	6.7	7.4* ^H
Speed endurance	8.7* ^H	9.1* ^H	6.8* ^H	7.9* ^H
Speed and agility	8.2* ^H	7.3* ^H	7.2* ^H	7.0* ^H
Coordination	8.0* ^H	7.3* ^H	7.0* ^H	7.4* ^H
Off-field training activities				
Strength	5.7	6.7* ^H	5.3	6.0
Flexibility	7.5* ^H	5.8	6.0	5.8
Technical refereeing skills	8.9* ^H	6.6* ^H	7.8* ^H	8.1* ^H
Other (e.g. cycling)	5.7	5.7	6.3	5.7
Video training	7.7* ^H	4.3	6.0	7.2* ^H
Game-playing tactics	6.0	4.7	5.3	6.2
Psychological skills training	6.8	4.9	5.2	6.1
Referee meetings	7.6* ^H	5.9	5.8	6.7* ^H
Language practice	4.5	3.2	4.0	3.5
Therapeutic activities				
Physiotherapy	6.4	5.0	6.1	4.4
Sauna/jacuzzi	6.2	2.1	5.6	1.9* ^L
Match activities				
Refereeing league games	9.3* ^H	9.2* ^H	9.1* ^H	9.4* ^H
Refereeing exhibition games	3.7	3.8	4.3	4.2
Travel for refereeing	7.9	6.8	4.3	7.5* ^H
Coaching/playing activities				
Meetings, coach	4.0	3.4	3.2* ^L	3.8
Meetings, player	2.4* ^L	2.0* ^L	2.0* ^L	2.2* ^L
Travel to coach	2.9* ^L	2.6* ^L	2.0* ^L	3.3* ^L
Travel to play	1.7* ^L	2.1* ^L	1.8* ^L	2.3
Coach training	4.1	3.2	3.3* ^L	3.7
Playing soccer	3.1* ^L	3.6	4.5	3.7
Spectating (live or TV)	7.1	3.9	6.7* ^H	5.2
Reading about football	4.1	2.8* ^L	4.6	2.5
Everyday life activities				
Sleep	8.3* ^H	2.4* ^L	7.9* ^L	2.0* ^L
Study/work	4.2	4.7	2.6	5.5
Active leisure	5.2	4.6	7.4* ^H	4.5
Non-active leisure	4.4	1.5* ^L	5.9	3.3* ^L
Travel	2.7	4.7	4.2	5.5
Overall mean	5.9	4.8	5.4	5.1

^aRated on a 10-point scale where 1 = "low" and 10 = "high".

*Above or below the overall mean (^Llower than mean, ^Hhigher than mean).

the pattern shown repeatedly in the deliberate practice literature of a monotonic increase in practice with skill (Ericsson *et al.*, 1993; Helsen *et al.*, 1998; Starkes *et al.*, 1996; Young & Salmela, 2001). Relevance has been examined in cross-sectional comparisons between expert and novice performers, but less frequently so using a longitudinal design. Using retrospective recall, our results showed that relevance ratings increased over time. This finding is in contrast to previous research that has reported no differences in perceptions of relevance for activities between different skill groups (e.g. Helsen *et al.*, 1998). Although this could reflect the different

methods used, it might also reflect that referees do not have a clear understanding of relevant training when they begin officiating.

As they acquire skill, referees also gain insight into appropriate training and training in general becomes more relevant. This is in contrast to the strong culture of practice in athletes, for whom training and practice in general are perceived as relevant from the start. They also show early specialization, and in contrast to our hypothesis, appear to recognize early on that playing and coaching are not highly relevant activities. As referees become "elite" officials and continue to specialize, not only does the volume of

training increase, there is also differentiation of practice activities. In the first years of officiating, training is focused on high-intensity running. As referees become “elite” officials, they maintain their large volume of high-intensity running, as well as increase time in virtually all other activities, adding different types of training to their existing activities.

The emphasis placed on the motor demands of performance can be seen when relevance ratings for refereeing league games (actual performance) were compared with refereeing exhibition games in the second part of the questionnaire. We could argue that the basic perceptual-cognitive demands of refereeing a league game are comparable to refereeing an exhibition game. However, examining heart rate provides evidence that the physical demands are different. For example, one referee officiating in two matches in the same week spent 77% of a “schools match” at 60–75% of maximal heart rate and 4% of the time at 76–85% of maximal heart rate. In contrast, when refereeing a league match, the referee spent 29% of the time at 60–75% of maximal heart rate and 58% at 76–85% of maximal heart rate. Not surprisingly, this implies that there are much higher physical demands at higher standards of match-play. Elevated heart rates could also result from increased anxiety and pressure, concentration, and even more strenuous perceptual-cognitive features (e.g. speed of action) in league rather than exhibition games. Our results support our hypothesis, however, and indicate that referees are particularly aware of the greater physical demands in league games, based on the higher relevance ratings for tasks with similar physical demands to performance (e.g. speed endurance) than tasks with similar perceptual-cognitive demands (e.g. refereeing an exhibition game). This finding also implies that actual performance in refereeing league games provides the closest “practice” conditions in terms of physiological demands. Referees feel league games are relevant practice during which they acquire or refine skills.

Several activities, while highly strenuous, are also very enjoyable to referees, a pattern previously shown among athletes (e.g. Young & Salmela, 2001). This is reflected in the relationship between effort and enjoyment. Finally, the strong relationship between effort and concentration indicates referees acknowledge that some activities require both physical and mental effort. For example, speed endurance, speed/agility, and coordination are activities rated high in both effort and concentration.

Referees acknowledge, however, that some activities with low physical demands are relevant. Indeed, the lack of a relationship between effort and relevance is a unique finding in this study and is likely indicative of the emphasis placed on declarative knowledge by referees. Video training and referee

meetings, where declarative knowledge is addressed, are activities rated by referees as high in relevance and low in effort. In addition, as referees gain expertise and perform at higher standards with inherently greater physical demands, there is a greater need for physical recovery, especially given that referees are older than their athlete counterparts (mean current age = 40.8 years), with lengthy careers (mean years refereeing = 21.3 years). These two factors are reflected in the high relevance ratings for sleep, a low effort activity. That therapeutic activities are high in relevance that increases over time supports our hypothesis.

The idea of role specificity is supported by our findings. Referees perceive refereeing league games as high in relevance, effort, enjoyment, and concentration but deemed refereeing exhibition games and playing/coaching activities much less so. Whereas several training activities are perceived to be high on all dimensions (e.g. speed endurance, speed/agility, coordination), several playing/coaching activities are low on all dimensions (e.g. player meetings, travel to play). Although this suggests that elite referees do not participate in playing and coaching activities, it is also indicative of their perception that playing and coaching have limited applications to refereeing. Although the analysis is based on a small sample, and thus there are limits to the conclusions we can draw, when we examined the FIFA referee subsample, coaching and playing experience was not related to variables associated with becoming elite referees.

OVERALL CONCLUSIONS

In this study, we examined decision-making skills and their relation to deliberate practice patterns in elite soccer referees. Referees outperformed players in a test of application of the laws of the game using video clips of soccer tackles. This supports the idea that skills differ by the role that one occupies within a sport and illustrates that, although players are constantly exposed to refereeing and refereeing decisions, this exposure does not result in skills as great as those of referees in a referee-specific task (tackle assessment). This finding provides a new perspective on the expert performance approach. In their meta-analysis of expert sport research, Thomas, Gallagher and Lowry (2003) indicate that to elicit expert–novice differences, researchers should use laboratory tasks with high ecological validity. Our findings suggest that ecological validity should be accompanied by considerations of role.

We also assessed how referees acquire skill and whether this differs from athletes. We were interested in training activities of referees given that they represent a role with a much weaker culture of

practice, where simulations of performance are often not feasible. This is similar to experts in fields such as medicine and the military. Using methods from the theory of deliberate practice, we examined training and perceptions of training for the first year of officiating, and two years where structured training programmes were in place (1998 and the current year, 2003).

This is the first study in which practice activities and the link to specific skills have been examined in elite referees. Study 1 showed that elite referees are not simply retired coaches or players who have gone on to excel in another role within their sport. Rather, they specialized early on as referees and committed a great deal of time to skill development. Although we argue that at the beginning of their careers they do not emphasize training or understand what activities are important, as they become more expert, referees commit more time and practice becomes more diverse with a greater variety of training activities. While these referees officiate at the highest standard of play, they have a mean age of 41 years of age. The importance of keeping up with the pace of the modern games is reflected in the perceived relevance of speed and agility-type physical skills.

In contrast, these referees do not spend a great deal of time training purely cognitive skills and do not rate refereeing exhibition games as relevant to improving performance. This surprising finding could be due to the slower pace of exhibition games and thus their limited replication of performance demands. An examination of novice referees officiating games of a lower standard, where the pace is much slower, could be used to compare the perceived importance of cognitive, decision-making, and declarative knowledge skills to physical conditioning at different stages of development in expertise.

Although study 1 showed that referees were better than players at applying the laws of the game, study 2 indicated that this skill developed primarily through refereeing matches, rather than structured perceptual-cognitive training with feedback. While the referees in this study benefit from the guidance of referee-coaches, they undertake little practice that receives performance feedback. Recall that two main criteria of deliberate practice are that practice is monitored and that feedback is immediate and informative (e.g. Ericsson *et al.*, 1993). Given these criteria and the fact that the officiating of league games was considered the activity most relevant to improving refereeing, we propose that referees engage in structured rather than deliberate practice, as per the definitions of Côté *et al.* (2003).

Currently, referee-coaches have a stronger role to play in strength and conditioning than in skill acquisition. Training can replicate the physical conditioning demands of games, but there is little

emphasis on responding to players, decision making, and game positioning skills. The practice and acquisition of these skills, together with feedback in training and match-play, could hasten expert performance. The development of perceptual-cognitive training tasks such as those in study 2 presents a partial solution to the current lack of refereeing feedback during practice.

The lack of feedback from practice explains why the sub-sample of FIFA referees took 16 years of practice and experience on average to reach the elite level of the sport. When compared with the “10-year rule” within the expertise and deliberate practice literature, this is a longer “training” period than reported previously (e.g. Helsen *et al.*, 1998). It should be kept in mind, however, that appointment to the FIFA list may be a conservative measure of expert performance. Although FIFA panel referees are clearly the most elite performers with ongoing performance assessments, many referees may become expert within a shorter time frame using other criteria, such as refereeing the top games within their respective leagues (e.g. the English Premier League).

This work represents an advancement of the knowledge related to expert refereeing as well as the acquisition of role-specific knowledge and skill in sport. It provides evidence that there are core skills (e.g. application of the laws of the game) on which referees outperform players. In a second study, we also showed that the methods from the theory of deliberate practice can be used to study training, but are limited in their ability to explain skill acquisition for populations where performance simulations are risky or not feasible and there is a limited culture of practice. Instead, other training activities and “work” or performance itself play the most significant roles in skill acquisition.

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