Snooker Science: A Cross-Discipline Scoping Review

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Supplementary Materials to

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Content

Table S1. Studies included for data extraction.

Higher Order Theme	Lower Order Theme	Data Type	Title	Publication Date	Lead Author	Geographical Location	Participants	Study Design	Study Aims (s)	Protocol	Measures	Findings
Psychology	Cognitive	Primary Data	The effects of goal orientation and perceived competence on cognitive interference during tennis and snooker performance	1999	Hatzigeorgiadis, A	United Kingdom	n = 92 tennis (players mean age = 32.16), n = 90 non-elite snooker players mean age = 28.5). All players were non-elite club members and regular participants in local and regional competitions and leagues.	Experimental (Between Groups)	Examine the validity of the Thought Occurrence Questionnaire (TDQ) as a measure of cognitive interference. Assess whether goal orientation is related to the cognitive interference experienced by athletes whilst performing their sport.	Authors undertook initial sampling meetings with club managers to discuss the purpose of the study and present a sample questionnaire. The nature of the participants required was outlined and an estimation for the number of participants that could be included was obtained. In subsequent visits, a series of questionnaire were distributed to and completed by the athletes.	Cognitive interference was using the Thought Occurrence Questionnaire (TOQ). Goal Orientation was measured using the Task and Orientation in Sport Questionnaire (TEOSQ). Perceived competence was measured using an adapted three item scale from the Intrinsic Motivation Inventory (IMI). Participants were required to complete the TOQ about thoughts from previous competitions (e.g., during snooker or tennis). Multiple group path analysis was conducted to test the structure of the relationship between constructs. Confirmatory factor analysis (CFA) was used to validate the TOQ.	A poor fit between the data and TOQ was identified from the factor analysis. Perceived competences (low, high) were considered important in determining the relationship between ego orientation and escaping thoughts. Task orientation was negatively associated with thoughts of escape from the task irrespective of perceived competence. The relationship between ego orientation and 'thoughts of escape' was moderated by perceived competence. There was a positive relationship between ego orientation and 'thoughts of escape' in low perceived competence group, whilst in the high competence group the association was non-significant. Path analysis outlined a statistically mean difference in perceived competence between high and low groups for the tennis and snooker samples.
Psychology	Visual-Perceptual, Cognitive	Primary Data	Visual-perceptual and cognitive differences between expert, intermediate, and novice snooker players	1994	Abernethy, B.	Australia	n = 29 male participants: 7 expert, seven intermediate, and 15 novice snooker players. The expert snooker players group were ranked in the top 30 within Australia (average experience 16.7 years, range 8-30 years), the intermediate group were club players (average experience 19.9 years, range 1.5-45 years), and the novice group were selected from an undergraduate student pool (<1 year of experience). Greater experience in the intermediate and expert groups was a function of age differences (12-61 years, average 36.9,	Comparative, Cross-Sectional	Study 1: Determine if expert players display performance levels on basic visual tests that are beyond population norms and those of intermediate and novice players. Study 2: Determine (1) if expertise in snooker is dependent upon superior pick-up of display structure; and (2), if so, what elements (global spatial configuration or the position of specific local elements) are central to this pick-up of perceptual structure. Study 3: Examine planning and evaluation of shot options capabilities in expert, intermediate, and novice players using a thinking-aloud protocol and a more structured evaluation task.	Study 1: clinical examination for uncorrected visual defects Two qualified optometrists performed a clinical examination for uncorrected visual defects and testing on the expert and intermediate groups. The second stage of testing involved a comprehensive assessment of all participants on a range of standard optometric tests to determine if there were any systematic expert-novice differences in general visual performance that may be contributing factors to snooker performance. Participants who normally wore corrective lenses whilst playing snooker were required to do so throughout all testing phases. Study 2: sport-specific perceptual measures Pattern recall and recognition tasks were given to expert, intermediate, and novice snooker players. Pattern recall task: Stimuli was 54 slides, showing three distinct types of pattern presentation. Equal numbers of slides (n = 18) depicted structured game situations in which the normal colours were present, structured game situations in which all the balls were of a uniform (red) colour,	Study 1: Mean acuity, phoria and depth perception scores for the expert, intermediate and novice groups Study 2: Pattern Recall: Mean percentage of stimulus items correctly recalled as a function of player expertise and display structure. Patter Recognition: Mean percentage of correct recognition as a function of player expertise and slide type. Study 3: Expert, intermediate, and novice group scores from the thinking-aloud task (Mean ± SD). Mean rating for the evaluation task on how advantageous each situation was were made for each score scenario.	The battery of general visual tests and sport-specific perceptual and cognitive tests applied to the expert, intermediate, and novice snooker players provided insight into the nature of expertise in self-paced, static aiming tasks. General visual skills do not distinguish between expert and novice snooker players. Instead, expert snooker players demonstrate an ability to accurately evaluate and distinguish the relative strengths and weaknesses in a variety of snooker game situations (decision making) and rapidly encode, recall, and recognise structured perceptual information to plan prospectively six or more shots ahead of the current shot.

							median 42 years in the intermediate group, 20 to 45 years, m = 21.6, median = 21 in the expert group). The novice group was more homogeneous (18 to 29 years, m = 21.6, median = 21).			and unstructured situations in which balls of different colour were present. All slides were photographed from the same position directly in front of the table and at an angle and height similar to that from which a player would approach the table when about to begin a new game. Pattern recognition task: 28 slides were used for recognition task. Half of the slides the participants had seen previously in completing the pattern recall task and an evaluation task. The other slides were new depicting slight modifications to situations previously experienced in the recall and evaluation tasks. Of the previously seen slides, 7 were randomly selected from the pattern recall task and seven from the evaluation task, with those slides from the pattern recall task being composed of three structured colour slides, two unstructured colour slides, and two structured slides presented with balls of uniform colour. The number of balls shown in the slides varied from five to 20 with the angle and height of the view of the table identical in all slides. Study 3: sport-specific cognitive measures Thinking-aloud task: Using Six key points in a video recording of 1988 competition match between two of the world's leading professional players, the authors recreated the spatial arrangement of the balls on the table at these crucial points in the game was reproduced onto a full-size snooker table, and made 35 mm colour slides of these positions were made. Participants were presented with each slide for 8 seconds and asked to evaluate how advantageous the displayed situation was for the next person to play under conditions: (1) where the scores were equal; (2) the player was 10 points ahead; or (3) the player was 10 points behind. Evaluation task: Twelve 35 mm slides were used for the evaluation task. The slides were photographed from the same position and camera height as described for the recall and recognition tasks and depicted three variations of each of four-game situations: (1) an early game situation in which all but one of the reds remained on the table (leaving, excluding penalties, a minimum of 72 and a maximum of 147 points in the game); (2) an early midgame situation in which seven reds remained (leaving a minimum of 48 and a maximum of 83 points); (3) a late midgame situation in which only one red remained (leaving a minimum of 30 and a maximum of 35 points); and (4) an end game situation in which only the brown, blue, pink, and black balls remained (for a total of 22 points).		

Psychology	Decision Making	Primary Data	Scores on Field Independence and Performance in Snooker	1992	McMorris T	United Kingdom	25 male snooker players of intermediate skill and a control group of 25 male undergraduate majors in sports science who played soccer, rugby, field hockey, or tennis. Intermediate skill for both groups was set as having played for at least five years as a competitive amateur. None of the control group had any experience in playing snooker, so none took the decision-making test.	Comparative, Cross-Sectional	Compare the field-dependence scores of male intermediate-level snooker players with those of intermediate-level sportsmen engaged in other sports, (e.g., soccer, rugby, field hockey, and tennis) Examine the relation of scores on field dependence and performance on a snooker decision-making test.	All participants were administered the Group Embedded Figures Test (Oltman et al., 1971) to estimate field independent scores. Snooker players also took a decision making test of 12 typical snooker situations. In the snooker decision making test, the participant had to state which of the red balls he would 'pot' and what would be the follow up shot. The correct decision scored two points. Where a decision would have resulted in a nonoptimal score in the game, one point was awarded. Where no score would have resulted, no points were awarded. Authors proposed that the protocol had face validity as the problems posed were typical of those found in snooker. All situations were observed in real match play and were acknowledged by three snooker coaches as being typically found in snooker at an intermediate level. A split-half test was conducted and this estimated the reality by a Spearman-Brown Rho of 0.70 ($p < .01$)	Mean ± SD Group Embedded Figures Test Score for intermediate snooker group and intermediate sport group. Mean ± SD Group Snooker decision making test score for intermediate snooker group.	The snooker group score significantly higher on the Group Embedded Figures Test than the control group. Mean score on the Group Embedded Figures Test for snooker players was 16.7 (SD = 1.0) and for the control group 12.4 (SD = 5.1). The mean and standard deviation for snooker players on the decision-making test were 36.6 and 2.08; the maximum score possible was 48.0. There was a significant association (r = 0.78) between scores on field dependent and decision making in snooker.
Psychology	Motivation	Primary Data	Antecedents of Emotions in Elite Athletes: A Cognitive Motivational Relational Theory Perspective	2007	Uphill, M	United Kingdom	12 (1 woman and 11 men) international athletes (junior n = 3, senior n = 9). Selected on basis that they competed for their country and some competed professionally. Sports represented in the sample: badminton (2), golf (2), rugby union (3), athletics (2), archery, sailing, snooker (1). Participants aged 19 to 37 years (Mage 27 years, SD 6.03)	Qualitative (Semi-Structured Interviews)	Explore the association between specific appraisal components and a range of sport-related emotions experienced by athletes, Conduct a hierarchical content analysis of athletes' emotional experience to explore whether core relational themes would represent a composite summary for each emotion.	Participants recruited via phone, letter or in-person. A semi structured interview guide was developed - the interview guide consistent of three sections based on Lazarus' (1991) cognitive motivational relational theory and interview guidelines from the literature. Interview duration was between 60 and 90 min - the order of questions and specific probes differed slightly between the athletes, depending on their responses.	First section of the interview was an introduction, asking participants their experiences playing sport or emotions within competition. Second section of the interview contained lead questions and elaboration probes relating to the eight of Lazarus' (1991) discrete emotions (anger, anxiety, guilt, happiness, pride, relief, sadness, shame). Data was analysed from the focus on the individual to the group. For each emotion incident, a deductive content analysis organize raw data using predetermined categories, inductive analysis was also performed and this allow themes such as 'mixed emotions' to emerge. Group-based data analysis was conducted using hierarchical content analysis.	Concurrent inductive and deductive content analyses suggested that primary and secondary appraisal components (goal relevance, goal congruence, ego-involvement, blame/credit, coping potential, future expectations) were associated with a range of emotions: anger, anxiety, guilt, happiness, pride, relief, sadness, and shame. A hierarchical content analysis provided some support for Lazarus' (1991) core relational themes.

Psychology	Cognitive	Primary Data	Thinking Aloud: An exploration of cognitions in professional snooker	2018	Welsh, JC	United Kingdom	7 male professional snooker players comprising super-elite (rank, < 5, n = 1), elite (rank < 17-48, n = 2), and lower ranked professionals (rank > 64, n = 4). Participant age ranged from 27 to 40 years (m = 34, SD = 4.5) with 185 hours (m = 26.4, SD = 3.6) years of experience.	Qualitative (Think-Aloud)	To employ a think aloud procedure to examine the real-time cognitions of professional snooker players during solo practice performances within naturalistic settings.	Level 3 think aloud was used during a self-assigned solo snooker practice session. Participants recorded their thoughts before and after shots and were encouraged to describe their thoughts between shots. If participants were quiet for >20 s they were encouraged to resume the think aloud.	Think aloud verbalisations were transcribed in verbatim. A line-by-line inductive content analysis was used. Transcripts releveled 761 stressors from 85 sources and 1349 coping strategies from 103 sources.	Super-elite and elite professional snooker players' real-time, cognitions were generally directed towards stressors, coping strategies, and snooker-related aspects. Authors outline how results supports the transactional model of coping (Lazarus, 1999) as thought processes changed continuously during performance, and in particular, at highly dynamical situation-specific moments. Authors discuss how the exploratory findings support the proposal that problem-focused strategies are vital psychological characteristics of expert and optimal performances in general.
Psychology	Mental Toughness, Coaching	Primary Data	The influence of mental toughness on responses to feedback in snooker: A real-time examination	2023	Welsh, JC	United Kingdom	Study 1: 40 male snooker players (age = 30.6, SD = 11.2 y), Study 2: 40 male snooker players (age = 33.0, SD = 13.4 y) Club (n =4), amateur (n = 11), national (n = 10), professional (n = 15)	Experimental (Between Groups)	Study 1: To examine the effects of feedback on snooker players break-off performances using a false ranking list. Study 2: To examine the influence of mental toughness upon feedback (positive and negative) given by a coach during real-time break-off performances of snooker players.	Study 1: Participants completed 10 break-offs with feedback (20 received positive feedback and 20 received negative feedback) provided after the initial five break-offs. Participants were required to land the cueball as close to a piece of card (positioned directly behind the green or yellow ball) as possible. A false competitive ranking list was used to investigate the effects of mental toughness in overcoming feedback. Study 2: Replication of Study 1 protocol but feedback was provided by a male World Professional Billiards and Snooker Association (WPBSA) coach.	Break-off accuracy, Mental Toughness Questionnaire 48 (MTQ48).	Study 1: Break-off accuracy decreased after feedback (p = .03). Non-significant difference between feedback types (p = .38). Break-off accuracy significantly decreased after feedback in Experiment 1, but there was no interaction with the nature of feedback or Mental Toughness Questionnaire 48 (MTQ48) variables. Study 2: In experiment 2, feedback was delivered by a WPBSA coach and resulted in a significant effect on performance. Specifically, negative feedback improved performance whilst positive feedback impaired performance. The Life Control subscale of the MTQ48 was a significant covariate. The results suggest that negative feedback, delivered constructively by a WPBSA coach, may act as a catalyst for performance enhancement in snooker and that this is moderated by mental toughness.
Biomechanics	Cue Action	Primary Data	Acquiring Expertise in Precision Sport - What Can We Learn from an Elite Snooker Player?	2021	Kong, PW	Singapore	n = 1 professional snooker player (age = 37 years; stature = 173 cm; body mass = 70 kg).	Case Study	Comprehensively profile the biomechanical characteristics of the cueing movements of one professional snooker player.	The authors investigated the kinematic and kinetic variables during different shot types (warm-up, stun, top spin, backspin, stop). Participants were required to pot as many balls of the 3 balls as possible for each shot type (3 trials x 5 shots type). For each shot type, participants were required to pot as many of the three balls as possible, with the pot success rate calculated as a performance measure. The object ball had to be potted in the pocket for the trial to be recorded as successful. Passive retro-reflective markers were placed on the participants upper body and both cue tip and butt, with kinematic data captured during all shots. Additionally, the participant stood on two force platforms (one under each foot) to capture kinetic data during all shots. Across all tasks, the cue ball was placed on the participant's right side on the 'yellow spot' where the yellow ball was placed at the start of each snooker frame. For tasks that included long shorts (backspin and stop), a black object was placed at the intersection of the midpoint and the line crossing the cue ball and the corner pocket. For short shots (warm-up, stun and topspin, an object ball was placed at the midpoint	Kinematics variables: joint angles, cue stick speed, cue stick angle (cueing technique). Kinetic variables: ground reaction force, centre of pressure. Kinematic data was captured using a three-dimensional motion capture system (400Hz, Vicon, MX, Oxford). Kinetic data was captured using two force platforms (800 Hz, model 9253A, Kislter). Kinematic and kinetic data capture was synchronised. Inter-trail variability was calculated as the standard deviation of the three trials in each type of shot. Performance variables: pot success rate.	Pot success rate was consistent between shot types at 1/3. The cueing technique used was similar across the five types of shots demonstrated by small inter-trial variability – the discrepancy angles were small across all 15 trials (<1°). The discrepancy angle for each shot type was the degree of overlap in cue stick positions between the last practice swing and final stroke. Elbow flexion/extension contributed approximately 130° range of motion (ROM) towards the delivery of the cue stick whilst wrist flexion/extension contributed <30° ROM. Cue tick speed at impact differed between the five types of shot. The cue speed at impact was lowest in the warm up (warm-up = 1.24 ± 0.04 m/s) and highest in the back spin shot (4.02 ± 0.04 m/s), although the success rate was consistent (1/3 across all shot types). The cue speed of the stop shot was 2.99 ± 0.15 m/s, whereas the stun and spin shots were similar in cue tip speed at impact 2/57 ± 0.11 m/s and 2.58 ± 0.23 m/s. Ground Reaction Force (GRF) profile was similar across all five shot types with relatively small changes when normalised to BW. There was no clear difference between Centre of Pressure (COP) data between the five shot types, although the GOP transfer between the two feet a key moments in the final stroke releveled a slightly lean towards the left foot (59.6% to 61.7%).

										between the cue ball and the position of the black ball.		
Biomechanics	Skills Test, Balance	Primary Data	The Effectiveness of Core Muscle Training on Skill and Balance for Snooker Players	2022	Soflaei, M	Iran	32 recruited, 2 refused to participate. n = 30 intermediate and advanced male snooker players (Age range = 18-40 years; snooker break = >30). Two groups n = 15 piltates n = 15 control	Pre-post	Investigate the effect of six weeks of core muscle training by performing Pilates exercises on the skill and balance of snooker players.	Each group performed their respective training programme 3 times per week for 6 weeks. A series of tests were performed before and after the respective training programme. Pilates group performed Pilates exercises three session per week consisting of 30 mins pilates plus 1 hour of snooker training per session. Control group completed a 1 hour snooker training ocurse 3 times a week and asked to engated in 30 minutes of gentle aerobic activity such as slow walking prior to their snooker practice. 5 mins of warm up 20-25 of Pilates or slow walking 5 mins of cool down 1 hour of routine snooker training A line-up test was used to record break scores, and the balls were arranged in a specific pattern in a row on the table. Players pocketed a red ball first, then a coloured ball of their choice - any coloured ball that fell into the pocket was returned to its place on the table. After all the red balls had successfully dropped into the pockets, the remaining coloured balls were hit based on ascending scores. The game was terminated if the players failed to pot a ball, and the break score was recorded. This test was repeated 3 times at 30-60 sec intervals, and the best score from the three trials was recorded as the major break score. In the foul number test the cue ball was placed along the gang, and players were asked to hit the black ball and pot it. If the player failed to sink the target ball with the cue ball, this was recorded as a foul. Four cue balls were used, and the test was repeated x 3 with 30-60 secs rest between tests. The minimum number of fouls in the three attempts was recorded as the player's score. The stork balance test was repeated three times for each player and three times for each leg with 30 to 60 seconds rest between each repetition. The best time between the three repetitions was recorded as the result of the stork balance test.	Snooker Skill: Foul count test Line-up test Balance: Stork balance test	Significant pre-to post-intervention improvement for balance and break scores in the Pilates group ($p < .05$) but no significant difference in foul score ($p = .80$). No significant pre- to post-intervention change in balance or skill scores in the control group.

Biomechanics	Coaching, Skil Test	Primary Data	Systematic Snooker Skills Test to Analyze Player Performance	2014	Chung, DHS	United Kingdom	n = 18 (6 novice, 6 intermediate, 6 experts); age range = 11-55 years (novice = <30 break; intermediate = 31-70 break; expert = >70 break)	User Study	To develop and introduce a systematic skills test to measure snooker player performance	Authors propose a snooker skills test including: a power control test, angles test, top/back spin test, side spin test, cue alignment test. The user-study reports data for the power test, angles test, and back spin test. For the angles test, a 1 meter ruler was place along the corresponding table edge with video footage recording the expected contact point along this cushion. The back spin test was recorded using a high-speed camera (200 fps) with a specialist half white, half black ball. Distances were measured in cm using a tape measures. Power test: The cue ball is placed on the brown spot. The participant strikes the cue ball down the table with the aim of stopping the cue ball as close to the bottom table cushion as possible. The mean distance from the cue ball to the bottom cushion is measured and reported. Angles test: Participants have to judge the correct contact point along the cushion such that the cue ball bounces and falls into a target pocket. The ideal contact point is measured and deviation between the observed bounce and ideal contact point will result in the ball missing the pot. The player is scored by measuring the distance and how far (if) the cue ball misses the pocket. Backspin test: The cue ball is placed in line with the both the blue and yellow spots, and a red ball is placed on the blue sport. Participants have to pot the red ball into the middle pocket and apply back spin such that the cue ball is also potted into one of the middle pockets (the opposite middle pocket that the red is potted due applying back spin). Performance in this test is measured by counting the number of revolutions the cue ball undertakes and post success.	Power control test - mean (SD) distance from the cushion (cm). An equation was used to calculate a power control SCORE = 1/1 (1+ Distance from Cushion). min, first quartile, median, third quartile, and max distance from cushion reported. min, first quartile, median, third quartile, and max score in the power control test. Angles test - mean (SD) distance from bounce point recorded (cm). distance from bounce point recorded as alpha. An equation was used to calculate a angle test SCORE k1/(1 + alpha) + k2*(1 - miss) + k3*PotWhite min, first quartile, median, third quartile, and max distance from alpha in the angles test. min, first quartile, median, third quartile, and max score in the angles test. Backspin test - mean (SD) ball revolutions from the top spin test, calculated using the equation: SCORE = (k1*Revolution+k2*PotRed) / (k3*(2-PotWhite)) min, first quartile, median, third quartile, and max number of ball revolutions in the back spin tests min, first quartile, median, third quartile, and max score in the top spin test.	Authors suggest that each test demonstrated strong correlation between the different classification banks – although the correlation analysis was not reported. In all skills test the expert players outperformed the participants in other classification bands – suggesting that the outlined snooker skills test can effectively measure snooker performance. When examining distances the shot consistency (interquartile range) improved towards the expert level classification Scores from the power control test, angles test, and backspin tests demonstrated improvements in median scores in moving novice to expert, but differences in the interquartile range between levels were reduced. Authors state that it was difficult to measure the ball's number of revolutions and therefore backspin test was challenging to record. Following conversations with a snooker coach, the authors used the k coefficient to weigh the measurement depending on the objective of each snooker test. However, the authors recommend researching to examine this approach further.
Notational Analysis (Snooker Outcomes)	Modelling, Complex Networks	Secondary Data	Evaluating the effectiveness of different player rating systems in predicting the results of professional snooker matches	2022	Collingwood JAP	United Kingdom	Data set was sampled from Snooker.org (Ardalen) and CueTracker.net (Florax). Data from CueTracker. Net uses ranking position and prize money earned by players at the start and end of the season. Data from Snooker.org lists the seeding of players at each cut off. These data were used to identify the prize money ranking of each player at every cut off in the 2016/2017, 2017/2018 and 2018/2019.	Statistical Modelling	Consider different approaches to measuring the ability of professional snooker players and how this informs our understanding of the expected results of matches played.	The following models were assessed through the ability to predict the result of snooker matches (i.e., word rankings – based on prize money earned, players win %, along with paired comparison approaches – Bradley-Terry and Elo models. Subset of matches were also analysed to identify the strengths and weakness of models and potential improvements Authors acknowledge the limitations of the models: Limited information on 'new players' could lead to less certainty for resultant predication of matches involving 'new players' – in particular for the word ranking model, which the authors suggest is likely to underestimate this potential. The Bradely-Terry model considers the strength of opposition faced when assessing a players performance, so authors expected this to generate	The following measures were used to assess the accuracy of predictions made by the models: Prediction Accuracy (proportion of matches that higher rated player won), Log-loss score (scoring rule that applies a higher penalty relative to how incorrect the forecast was), Calibration (ratio of expected wins over actual wins for the highest rated plater), Discrimination (models ability to discrimination between results by comparing mean predictions where the higher-rated player won/lost the match. Further Analysis: To further understand these results the authors identified three areas where there are	The models tended to underestimate the performance of 'new' snooker players and this is the main limitation of using the World Rankings to predict performance. Accounting for the strength of opposition faced by the highest-ranked snooker players is shown to be relevant; although this is less true for lower-ranked players. Models based on two years of snooker competition results out-perform those based on a single year but there is some indication that accounting for a recent improvement in form may be advantageous.

							Authors use these data to estimate the probability of one played winning a frame against another based on their relative rating accordioning to the four models. Where required the model parameters were determined using results from the 2016/2017 season. Predications were then generated for the 2017/2018 and 2018/2019 season and analysed			stronger predictions that the players win % model. Authors also consider if the current form of the player is likely to affect performance. The Elo model is designed to be the most sensitive to changes in a players form. The authors also compared models based on 1 year and 2 year results. World Ranking model was based the prize money counting towards the official rankings at the relevant cut-off for each event. The Win%, BT and Elo models were updated according to the same cut-off points in order to allow for a direct comparison with the World Rankings. The probability of a player winning a single frame was modelled and derived the probability that the player will win the match using a sequence of independent Bernoulli trials.	differences between the models: (1) the modelling of new players, (2) whether they consider the strength of opposition, and (3) whether they consider recent form of the players. The authors examined how well the models are calibrated for particular subsets of matches, along with the log-loss scores.	
Notational Analysis (Snooker Outcomes)	Complex Networks	Secondary Data	A complex networks approach to ranking professional Snooker players	2021	O'Brien J	Ireland	Data was sampled from CueTracker.net. Competitive progressional matheses that took place between 1968 and 2020 were included. The quality of the match was considered with focus on games that professionals compete it, which fall under the categories: League, Invitation and ranking events. The data used 657 tournaments featuring 1221 unique players competing in 47710 matches. Each season is split over 2 years so the season which begins in one calendar year concludes during the following calendar year. As such the authors reference the seasons by year in which they begun that is the 2018 and 2019 season would be referred to as the 2018 season.	Statistical Modelling	Investigate the quality of different ranking schemes in comparison to the PageRank approach using similarity metrics. Introduce a graphical tool known as a rank-clock to Snooker which allows one to interpret how a players rank has changed over the course of their career	Authors used detailed analysis of matches played in the sport of Snooker during the period 1968–2020 to calculate a directed and weighted dominance network based upon the corresponding results. For validation and comparative purposes the authors also used the official rankings of Snooker players from World Snooker (the governing body of the sport from the period 1975–2020. The rank-clock as a visualisation tool was also introduced to provide a novel approach that could be used by snooker policy-makers to quantify the success of snooker competitors over the temporal period of their careers.	player name start of player career end of player career wins page rank prize fund player rank by year in-strength rank world snooker winner by year Jaccard similarity between the ranking procedures.	When using a ranking procedure based on the PageRank algorithm incorporating the number of wins a player has over their carer and quality of opponent face in these wins, John Higgins is the highest performing snooker player of all time, with Ronnie O'Sullivan placing in second place. Findings demonstrate that prior to it revisitation snooker was failing to capture the dominance of players through its point-based rank system. However, the change in the ranking system to a prize money basis is also inaccurate. The PageRank algorithm can be applied across temporal periods in each of which may identify the strongest player of each snooker era. The rank-clock could be used as novel data visualization approach with which snooker policy-makers may quantify the success of competitors over the temporal period of their careers.
Notational Analysis (Snooker Outcomes)	Modelling	Secondary Data	Criteria for a tournament: the World Professional Snooker Championship	2009	Clarke SR	Australia	Matches were sampled from the last three qualifying rounds	Statistical Modelling	Determine how well the criteria of fairness, balance and efficiency are satisfied in the	The authors used statistical techniques to analyse the annual world professional snooker championship, and determine	For each match the authors recorded the score of the losing player, the year in which it was played, the	The full model containing all predictors was not statistically significant and explained less than 1% of the variance of the dependent variable. None of the independent variables made a statistically significant contribution to the model. Authors

							and the first round of the Word world professional snooker championship. Four rounds in each of 4 years were sampled, with 16 matches in each round. Of the 256 matches, however, two were walkovers and one was unfinished, as one of the players withdrew through illness. These three matches were excluded from the analysis.		World Professional Snooker Championship.	how well the criteria for fairness, balance and efficiency are satisfied.	round, and whether the match was won or lost by the player entering the tournament in that round, his lower-ranked opponent having qualified by winning his match in the previous round. The authors also recorded the rank of both players in each match, taken from the ranking lists published at the start of the season. For some players, mostly entering the third round as qualifiers, rankings were not available and the authors assigned to them a rank of 10.	suggest that a snooker player entering the tournament has about the same probability of winning his first match, whatever the round at which he enters. Fairness and balance: The probability of winning a match: Of the 253 matches, 154 were won and 99 lost by players entering the tournament and playing their first match. The authors take 154/253 = 0.609 as an estimate of the probability that a player entering the tournament wins the match. The mean losing score in the 154 matches won by the entering player was 5.63, whilst the mean losing score in the 99 matches lost by the entering player was 6.17. Authors explain how this is to be expected as a losing player higher up in the rankings to have a higher score than a losing player lower in the rankings Fairness and balance: The probability of winning a frame: If frames are independent, if a player's chance of winning a frame is p and if a match is won by the first player to win n frames, then the probability of the player winning the match p can be calculated using a negative binomial or binomial formulation. Authors outline that if a player's probability of winning a frame against a certain opponent is 0.531, then his probability of winning 10 is 0.609 and vice versa. Independence of frames within matches and independence between match: As players take turns taking the opening shot of each frame, the authors state that the hypothesis that frames have independent outcomes is at least plausible. A player entering the tournament will score 0, 1,2, 3... 9 frames if he loses the match, and the probability that his opponent will score 0, 1 , 2, 3 ... 9 frames if he wins it. Authors outlined how these probabilities can be used to determine the expected number of scores (out of 253) of the losing player of the 154 matches in which the entering player wins and the 99 matches in which he loses. The entering (higher-ranked) player's score comes first. The major contribution to chi-square occurs at the low scores in matches won by the player entering the tournament. The authors propose that perhaps players give up hope of winning too quickly when faced with an opponent above them in the rankings. Efficiency: How many frames are needed in a match?: Authors outline that the assumptions of independence between frames and a constant probability of winning each frame do not hold here the match is won by the first player to win N frames. The authors note that in a first-to-ten frames match a player whose probability of winning a frame is 0.53 has a probability 0.60 of winning the match and a player whose probability of winning a frame is 0.56 has a probability 0.70 of winning the match and so on according to their progress in specific tournaments. Authors state how the findings demonstrate that rankings are a stable measure of players' ability. Authors outlined that determining the number of frames in a match requires a balance between the need to keep matches short and the need to give the better player an appropriate chance of winning.

Notational Analysis (Snooker Outcomes)	Modelling	Secondary Data	Estimating age-dependent performance in paired comparisons competitions: application to snooker	2024	Baker, RD	United Kingdom	Data was sampled from www.cuetracker.net. Data sets included 109,733 matches with 1642 players. There was a total of 789,763 frames played. Of these players, 71.7 % had birth dates supplied, these being the better-known players.	Statistical Modelling	To explore the relationship between snooker player age and performance	The authors present a model for the outcome of snooker matches that estimates the strengths of players, and allows for those strengths to vary deterministically with time. The authors use this model to identify the greatest ever snooker players (Ronnie O'Sullivan and Stephen Hendry) and use estimated strength curves in a random effects model estimating the relationship between performance and age. The methodology extends the model of Baker and McHale (2017) used in women's tennis to enable forecasting of future performance and consider identifying players that over achieve.	Two datasets were used from www.cuetracker.net Data set 1 included matches played. Overall, 789,763 frames were played. Data set 2 included the biographical data such as date of birth. Despite being recorded in the database as a victory for one player over another, some matches were not played for various reasons (e.g., the player was ill). These walkovers were ignored in the analysis, leaving 109,733 matches with 1642 players. Of these players, 71.7 % had birth dates supplied.	Peak snooker performance occurs between the ages of 25 and 30.
Notational Analysis (Snooker Outcomes)	Simulation	Secondary Data	Simulating the progression of a professional snooker frame	2023	Collingwood JAP	United Kingdom	To determine suitable inputs to the model, post-match video analysis was used been used to collect data on 31,298 shots played during all 734 frames contested over the 46 matches in the 2018 World Championship finals and 2019 Masters Both tournaments are contested by the 16 highest-ranked professional players, with an additional 16 players qualifying for the World Championship after progressing through three qualifying rounds. The data gathered therefore reflect the play of top professionals. To be consistent with the scope of the model, shots played during visits which started after one player required snookers were not included in this analysis.	Simulation	To explore the utility of a Monte Carlo simulation model to simulate the progression of a frame of snooker played by professional-level players	Developed a Monte Carlo simulation of a snooker frame to inform the probability that a top professional will pot a ball on the table.	The model used the inputs: phase of frame, object ball, status of visit, shots played on a new visit, shots on which first read was potted, points scored in the first scoring visit, 50+ points in first scoring visit, 100+ points scored in first scoring visit, total clearances, frames 'won' on a first scoring visit, scoring visit per frame, shots between scoring visit, points scored per scoring visit (all), player 1 makes a first scoring visit, frames on by player 1, frames with a 50+ break, frames with a 100+ break. To be consistent with the model's scope, shots played during visits that started after one player required snookers were not included.	The probability of potting a ball for each shot changes as the frame progresses. The scoring power (defined as the proportion of successful pots by a player i.e., a player's break-building capabilities) of a player within the simulation can be adjusted to reflect players with slightly greater / weaker break-building ability. Authors outline that tactical awareness and safety play were harder to measure.