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A Game Informatical Comparison of Chess and Association Football ("Soccer")

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Abstract

Games which persist across cultures and eras are not static institutions; they evolve when they do not go extinct. Changes of rules, styles and strategies contribute to the evolution of games. Western chess and football continue to grow in popularity after more than a century of codification and periodic changes. We apply the game refinement measure to football, and compare the results to that of chess. Also we consider the results of the sub-game in football and the match game in chess. Using the analogy of the round match in chess applied to the information of the sub-game in football, we found the result of game refinement in championship football to be similar to that of championship chess.

Keywords: *Game, Refinement theory, soccer, football.*

1. Introduction

Games proceed as a series of plays in a match, segmented and accumulating towards a unified end. Some games, like chess, are played in a round-match tournament setting, with the final decision composed of the accumulation of matches. Knowing this it seemed to us that there might be some comparison between the outcome of plays, we call "sub-match," with the outcome of match sets in round-match play. We also wanted to apply game-refinement measure in the sub-match to round-match.

Football is that sport known to most people on Earth, played on a "pitch" or field between two teams of eleven players with a spherical ball. It is played over by 250 million players in over 200 countries, making it the world's most popular sport [6]. A wide-scale survey launched by FIFA in summer 2000 indicates that over 240 million people regularly play football, along with almost five million referees, assistant referees and officials who are also directly involved in the game [1].

Another game played by many people around the world is chess. Completely unlike football, chess is a two player game played on a game board comprised of 64 squares arranged in an eight-by-eight grid. World Chess Federation (FIDE) estimates there are over 700 million chess players in the world [3]. It is one of the world's most popular games, played at home, in clubs, online, by correspondence, and in amateur and professional level tournaments.

Significant differences between these games are the number of players involved, and the simultaneous nature of football movements vis-a-vis the alternating single movements on the chessboard. After disassembling and reassembling each game from various aspects, however, we identify that both have preponderances of draw games and other dynamic similarities. Other approximate similarities between the two games are the number of players (pieces) and some aspects of ground (board) control. These provide good opportunity for us to explore the game-refinement theory in the sub-game and the round-match game.

Chief of FIFA Sepp Blatter in 2004 ranted against the draw game. In addition to his plea for a handful of other rule changes on such topics as women's uniforms, game clocks and wider goal frames, Blatter also appealed for every single Association game to have a decisive winner and loser. While most considerations remain just that, considerations, a great number of evolutionary rule change suggestions are proposed inside the major football organizations every year. The games are full of tradition or players and aficionados; however, each suggestion of a rule change can be expected to meet strong reactions from the public, as did Blatter's. World Football writer Will Tidey raised the question: Wouldn't football be more exciting if UEFA hosted a best-of-seven series instead of the one-off championships for which it is known?

> "Where the real intrigue comes into the
> post season for basketball, baseball and
> hockey in the U.S. is the expanded nature of
> the competition. Sporting battles are waged
> not in a desperate evening but over an evolving
> series in which the narrative can shift on
> a game-by-game basis." [11]

The online reaction may or may not be representative, but an anecdotal review of the responses to Tidey's question were resoundingly (often profanely) opposed to any change to any kind of round-match format. The overwhelming and emotional resistance even to the question of a change foretells an emotional opposition to change generally. While the writers of this paper are not advocating any rule changes, we propose a scientific treatment of the game as an evolving series of games and rules. Our aims and findings are descriptive, not prescriptive. We attempt to quantify some game aspects as objective measures of entertainment. Such an understanding could be a useful contributor to discussions of cause and effect of proposed rule changes.

We will apply game-refinement theory to the game of football, and compare the degree of game sophistication with previous findings for the level of refinement in board games such as chess. First, we discuss gamerefinement theory in Section 2. Then, we describe the sub-game with reference to football in Section 3. Section 3 presents the round-match game with reference to the game of chess. Finally, we provide some discussion in Section 4 and draw a few conclusions.

2. Game Refinement Theory

Game refinement theory examines the relationships between skill and chance, and the relationship of entertainment to the evolution of games. Iida et al. [5] identify game refinement as a continuing pattern of changes in noble uncertainty. One of the goals of this study is to understand the current condition of succor and chess in terms of game refinement. Once we are able to compare the sub-game with the match game, we might also be able to measure some of the effects of rule changes on game information.

Maintaining balance throughout the duration of games is important to their enjoyableness. It is more interesting both for players and observers when the information of the outcome of the game is unclear until the very end, when game information culminates and results in game certainty. Majek and Iida have made clear that outcome uncertainty is directly correlated with game entertainment [9]. Games are the epitome of uncertainty – this is not to confuse the uncertainty of games with games of chance, however. On a ten point scale of chance, at one extreme we find games such as Roulette, a game the result of which is supposed to be completely random. Chess, boxing, and for the most part all sports are found at the other extreme of no-chance, with very tightly constrained rule sets for the purpose of eliminating chance in favor of skill.

Certainty in games occurs at a time when that information is unified and known, that is, not until the game is finished. The inverse, game uncertainty, then is the measure of uncertainty which arises from the missing game information. Iida et al. [5] have found that games with a high value for entertainment maintain some uncertainty until the end of the game. It is perhaps the scientific justification of many coaches' mantra: The game is't over until it's over.

Game refinement theory was invented based on the concept of uncertainty of game outcome. Furthermore, it is believed that the refinement of games' uncertainty s one of the quantities which has contributed to the success or extinction of games historically.

> "The surviving [chess] variants went through the sophistication/ optimization of the game rules to maximize the entertainment impact such that the depth of lookahead...is more critical for [the outcome] of the game" [7].

It is presumed that a measure of game refinement including quantities for game length, complexity, and depth will help us to understand that factor of entertainment which overcomes the barriers of time. Statistics seem to hold a certain fascination for the players, observers and commentators of games. That is because games, fundamentally, are comprised of information, and it is the more or less spontaneous composition of that information which provides the outcome of win, lose or draw. [10] proposed a logistic model of game uncertainty. [9] and [7] defined the information of the game result as the amount of solved uncertainty $x(t)$, such that

$$x'(t) = \frac{n}{t}x(t) \qquad (1)$$

where the constant n is a parameter determined by the difference of skill between the two players of a game, and $x(0) = 0$ and $x(D) = B$. Note that Note that $0 \leq t \leq D$, $0 \leq x(t) \leq B$.

The equation implies that the rate of increase in the solved information $x'(t)$ is proportional to $x(t)$ and inversely proportional to t. D is the functional or informatical game length expressing the size of the data set, ratio of passes to shots, not temporal length of game time t. Solving Eq. (1) as shown below in Eq. (2) and graphically in Figure 1, we get:

$$x(\mathrm{t}) = B\left(\frac{t}{D}\right)^{n} \quad (2)$$

Assume that the solved information *x(t)* is twice derivable at $t \in [0,D]$. The second derivative here indicates the acceleration of the solved uncertainty along game progress. It is the difference of the rate of acquired information during game progress.

$$x''(t) = \frac{B}{D} n(n-1)t^{n-2} \quad (3)$$

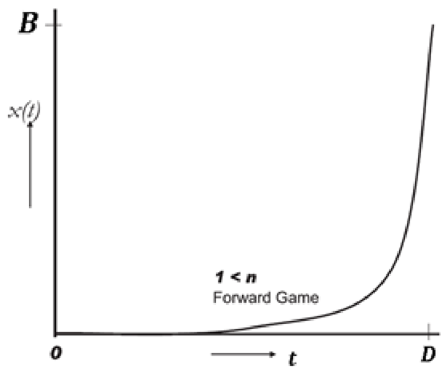

Fig. 1 Logistic model of game-outcome uncertainty

A "good" dynamic seesaw game, in which the result is unpredictable until the very last moves of the endgame, corresponds with a high value of the second derivative at $t = D$. This implies that game is more exciting, fascinating and entertaining when this value is larger. Iida et al. expected that this property is the most important characteristic of a well-refined game [4]. At $t = D$ (the last move in the endgame), Eq. (3) becomes:

$$x''(D) = \frac{B}{D} n(n-1)D^{n-2} = \frac{B}{D^2} n(n-1) \quad (4)$$

The second derivative represents acceleration of the solved uncertainty along the game progress. It is the difference of the rate of acquired information during game progress. Then if we plug-in averaged values, e.g. for chess, D becomes the average length of game, in terms of average number of moves. The average branching factor in a game, the average number of possible moves is represented by B. Then $\frac{B}{D^2}$ or its root square is $\frac{\sqrt{B}}{D}$ a possible measure of the sense of thrill in game play.

The theory has been successfully applied to chess and other board games with a strong implication to explain the human sense of game entertainment and the evolutionary history of games [8]. Consider the refinement measures of major world chess variants, for which typical values of game refinement, $\frac{\sqrt{B}}{D}$ appear in Table 1. These values are not static, but change together with changes in rules, customs, and strategic variations [8]. We measured recent levels of game refinement in two of the best known games in the world, and discuss those values for uncertainty and refinement.

Table 1: Measures of game refinement for various board games [8]

Game	B	D	$\frac{\sqrt{B}}{D}$
Western chess	35	80	0.074
Chinese chess	38	95	0.065
Japanese chess	80	115	0.078
"Go"	250	208	0.076

3. Game Refinement in Football

Due to the 11-player simultaneous movement and other obvious differences, the attempt to apply the idea of game refinement theory to football requires different modeling to achieve the same measures of game information as in chess. Limitations have always arisen when applying this theory to field games and video games. Of special concern is the need for a model which generates an accurate statistic for the branching factor *(B)* and game length *(D)*. A reasoned approach and initial modeling follows.

Regulation football matches go 90 minutes. The team which scores the most goals by the end of the match time wins. If the score is tied at the end of the game, either a draw is declared or the game goes into extra time and/or a penalty shootout, depending on the format of the competition.

A football sub-game is the process by which the team in possession of the ball tries to score goal. Just as the result of a round match is the sum of game outcomes, so is the information of game outcome the sum of subgames. Or, to put it another way, information of the sub-game is a subset of the game outcome, which is a subset of the information of round match outcome. The definition of possible moves is the set actions available to the person or team member at

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a given time. A model to define the possible movements, considerations and payoffs for each individual in a football game would require an extraordinary number of calculations and may be unnecessarily complex anyway. We will consider the field rather like a chessboard, and model the movement of the ball in order to simplify things.

In this model, the sub-game consists of 11 possible moves (Figure 2). In the set of possible moves, 10 out of 11 possible moves are passing to another team member and one is shooting on the opponent's goal. The primary objective of the sub-match for the passer is to achieve a shot on goal; the objective for the defender is to prevent the shot. Of course it is also true that second and third objectives are also present. The attacker may also wish to advance the ball to a certain position or avoid a certain defender's parry. Likewise, the defender's second objective will be to become the shooter by stealing the ball away from the passer/shooter, or maybe to protect a piece of the playing field from penetration, but for the time being we will weigh the largest part of the games, passes and shots, and develop those as the metric of the sub-game.

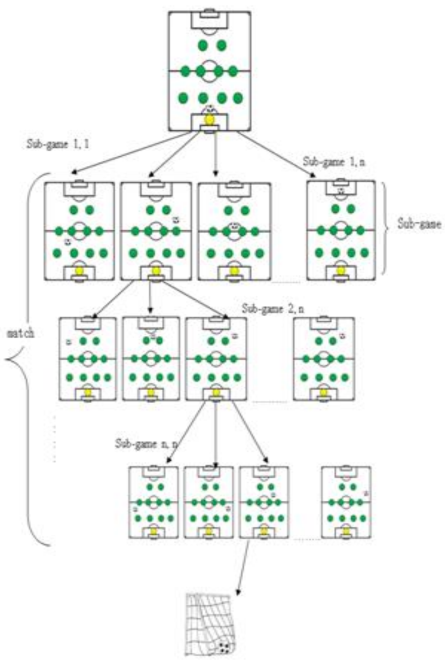

Fig 2 The Sub-game in Football

Now that we have clarified the meaning of sub-game we want to find statistics of the branching factor *(B)* and game length *(D)* for football. Statistics of average game length are comprised of data from the Union of European Football Associations "UEFA", including the number of shots *(S)* and passes attempted *(P)*. Data was collected from [2] UEFA Champions League. From the collection of the data S (number of shots) and P (passes attempted) we know game length *(D)*. Recall that the game length *D* is not the temporal game length but the functional game length in terms of passes and shots taken. Based on our definition of the possible actions *(B)* and game length *(D)* in football, we found the following averages (Table 2):

Table 2: Game refinement values in World Championship football during the last four seasons

Four Seasons	Posible Move *(B)*	Shots *(S)*	Passes Attempted *(P)*	$D\left(=\frac{P}{S}\right)$	$\frac{\sqrt{B}}{D}$
2009/10	11	3352	116542	34.77	00.95
2010/11		3374	128776	38.17	00.82
2011/12		3345	133718	39.98	00.83
2012/13		3180	130945	41.18	00.81

Solving $\frac{\sqrt{B}}{D}$ for the sub-game in football, we get

$$\frac{\sqrt{11}}{41.18} = 0.081 \qquad (5)$$

Table 3: Round match and draw data of FIDE World Championship chess and UEFA football

Game	Draw Average	Match Average	Win or Lose Match Average
Chess	60%	19.5	7.8
Football	88%	22	2.64

We know from the football data of 2012-13 season in Table 2 that in the sub-match, out of 11 possible moves, one of those moves is a shot on-goal on average of every 41.18 times. Also, there is an average of about 22 shots on-goal in a UFEA championship game (88% save average, 2.64 goals), (Table 3), which gives us the value *D* for the match. A shot on-goal will determine either saved (no-point), point "for" or point "against." Therefore the complexity *B* is 3, and the depth *D* is 22, which for $\frac{\sqrt{B}}{D}$ yields 0.079.This refinement measure corresponds closely to that of a round match value, even though in this case we are considering the match as the sum of sub-matches.

The results shown in Tables 1, 2 and 3 indicate some similarity of game refinement values in football and other games such as major chess variants. We realize that the data used is approximate, and the model is simplified (without regard to steals, penalty kicks and so on). This initial finding purports a level of game refinement in football not so far off that of centuries-old chess variants.

4. Discussion

Owing to the extremely high level of skill among players in the most competitive world championship settings, a high level of draw games can be expected. As can be seen, of those games composed of sub-games with a high average draw ratio, a large data set will be required, a higher number of sub-games that is, to determine a clear winner. Many spectators and participants have expressed that a high draw ratio feels unsatisfactory. Over the last 100 years of world champion chess however, a draw average of over one-half seems to be the norm. Perhaps any complaints are more of a reflection of changing tastes and sensibilities.

The way we see UFEA football and FIDEWorld Champion chess, a similar game dynamic exists in the submatch in football and round-match chess championship. We are also aware of the delicate balance between entertainment, skill, and fairness in competitive games, and we can use a simplified model of game information to help us better understand the mathematical interplays afoot among the complex of human emotions and sensibilities. It is apparent that both UFEA and FIDE championship competition rules are in periods of postrefinement where both football and chess must find their respective balancing points in order to evolve. The following equation expresses the result we observed for UFEA football and FIDE chess:

$$Rd = 25d^2 + 7 \tag{6}$$

where the value of the round match *Rd* is equal to 25 times the square of *d*, plus 7. Since this is our first effort to measure the round match, it remains to be seen whether this value might also appear in other games.

So far, we have examined only the sub-game in football, and the round match in Western chess. It has not missed us that other measures for the match game in football, or the sub-game in chess also exist. Furthermore, by no means do we see this metric as limited to board games and football. Just for example, a wealth of various sub-game data is kept by the National Hockey League, ranging from hits and turnovers to face off wins. Conventional wisdom among NHL officials and fans, and among game fans generally, seems to provide that higher scoring games are more exciting, and provide better ratings than lower scoring games. Previous studies in ice hockey have included the inter-arrival times of goals, and loose analyses of shot types and distances. However, game refinement theory as such has yet to be applied to ice hockey and the prospect for that study to yield a valuable result is encouraging.

5. Conclusions

We have applied the measure of game refinement in chess to a data set of professional football with the intent of illuminating on the meaning of sub-games and round match games. Our model of game refinement shows a $\frac{\sqrt{B}}{D}$ value of 0.081 in the sub-game, corresponding to an R value of 0.079 in the match for UEFA Champions league football. By comparison, we found the values $\frac{\sqrt{B}}{D}$ 0.074 and R 0.089 for classic chess, and R 0.123 in FIDE World Champion Chess competition since 2006. Furthermore, we discovered that the submatch in football has undeniable strategic and mathematical similarities to the round match in chess. As it has been said, football is like a game of chess played on the grass.

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