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Analysing soccer using perturbation attempts

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ABSTRACT

James N, D. Rees GD, Griffin E, Barter P, Taylor J, Heath L, Vučković G. Analysing soccer using perturbation attempts. *J. Hum. Sport Exerc.* Vol. 7, No. 2, pp. 413-420, 2012. Dynamical systems theory describes how behaviours can deviate through a series of states (stable or unstable) before returning to an original stable state. It has been suggested that squash performance exhibits properties akin to a dynamical system and demonstrated that squash experts were able to reliably discriminate weak or strong shots that gave one player a distinct advantage over their opponent. They argued that experts were essentially identifying “perturbations” which they defined as incidents that change a system state from a stable to an unstable situation or vice versa. Similarly, in this paper we examine ball possession in soccer and consider those where neither team has a distinct advantage as being a stable situation and perturbation attempts as those where an effort is made to gain a distinct advantage. This study assessed the relative frequency and success rate of perturbation attempts in relation to the match status (match score at the time of the incident). A hand notation system was designed to record the variables of interest (players involved, pitch locations, behaviours performed and behaviour outcomes). Eight domestic league matches from the 2007/2008 season involving a Coca-Cola League One team were analysed. Results indicated that the home team made significantly less perturbation attempts (11.78% of total possessions) compared to the away teams (17.54%) but that generally perturbation attempts were more likely to be unsuccessful than successful ($Z = 2.37$, $p < 0.05$). Future studies need to assess if the frequency of perturbation attempts and perturbation success rates are related to playing standard. **Key words:** DYNAMICAL SYSTEMS, PERTURBATION ATTEMPTS, SOCCER

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INTRODUCTION

The primary objective of performance analysis is to support coaches and players in the decision making process by providing relevant information regarding performance (O'Donoghue, 2006). Furthermore, it may also be beneficial to go beyond descriptions of performance and to move towards the prediction of future performances (Grehaigne et al., 2001). Trying to predict future performance on the basis of previous performances is known as "performance modelling" where the basis for any prediction model is that performance is repeatable to some extent. That is, events that have previously occurred will occur again in some predictable manner. One of the first scientific papers to assess the extent to which performance was repeated, investigated squash shots (McGarry and Franks, 1996), and found little evidence of a shot pattern i.e. an invariant behavioural response, to similar situations. The reason for this finding was perhaps that the complexity of the analysis did not match the complexity of the sporting situation examined. For example, if shots responses to all shots played to the front right of the court are examined as a whole no pattern may be found. However if the shots were separated according to shot type (boast, straight and crosscourt drop shot) and the proximity to the side wall (close or not) then perhaps clearer shot response patterns may emerge. Alternatively, it may be the case that elite sports players do not necessarily respond in the same way to similar situations but vary responses to confuse the opposition (James, 2007). Scientists have recognised that this type of analysis is complex and have consequently considered different methods to simplify the process. One such approach is to assess sporting contests as a 'dynamical system', a term that originated in mathematical and physical sciences (Clark, 1995). This theory considers behaviours that are seen to deviate through a series of states before returning to an original stable state (Kelso, 1995). Kelso described a dynamical system as a structure that is self-organising and generates a pattern of stability for a specific set of circumstances. Putting this theory into a sporting context McGarry and Perl (2004) suggested that regularity in performance could be as a result of changes within the system as opposed to being imposed by external influences. Whilst this theoretical perspective may or may not have merit in a sporting context one concept of primary relevance to this theory is the idea that particular events can change the system from a state of regularity to a more chaotic state.

McGarry et al. (1999) suggested that squash performance exhibits properties akin to a dynamical system and demonstrated that squash experts were able to reliably discriminate weak or strong shots that gave one player a distinct advantage over their opponent. They thus argued that these experts were essentially identifying "perturbations", which they defined as incidents that change a system state from a stable (invariant) to an unstable (variant) situation or vice versa. Using a similar methodology (Hughes et al., 2001) reliably identified the skill elements that changed a stable situation (no distinct advantage for one team) in a soccer match to a situation that was clearly advantageous for one team.

Sports research in perturbations has thus far primarily considered events that successfully change the situation from no advantage to advantage or vice versa. Consequently, only events where this change (a perturbation) has taken place are examined and then the outcome of the situation evaluated e.g. a goal, shot or no shot resulted. This approach tends to neglect events that were unsuccessful in making this change to the situation, i.e. no perturbation took place. Whilst the relatively low number of perturbations in comparison to the total number of events makes analysis of a sporting event less time consuming, and hence appealing, it does not take into account the attempts to perturb the situation which were unsuccessful. This paper presents a conceptual model of soccer in which the analysis of successful and unsuccessful "attempts to create perturbations" may lead to a better understanding of tactical play and lead to the creation of performance profiles of value to coaches.

Soccer performance can be considered in terms of possession whereby at any point in time either one team is in possession of the ball or neither team has possession. When neither team has possession, the situation could be viewed as relatively unstable as both teams will be trying to obtain control of the ball. Contrastingly, when one team is in possession of the ball, but has no particular tactical or positional superiority over the opposition, the situation can be deemed as relatively stable. In the final scenario, deemed unstable, one team may have possession of the ball and have a distinct advantage over the opposition which could result in a goal being scored. This conceptual view of soccer fits into the dynamical systems theory whereby behaviours are seen to deviate through stable and unstable states. The mechanism for system change, between stable and unstable, is more debatable as if this is not due to self-organisation then sport performance would not be deemed a dynamical system. To determine whether soccer performance can be viewed as a dynamical system it is necessary to determine whether patterns of stability and instability consistently occur for specific set of circumstances. This can only be debated when sufficient data is available and hence cannot be answered currently.

The focus of this paper is the situation where one team has possession of the ball. As each player contribution was analysed individually each behaviour could have occurred in open play or at the outset of a set piece. Whilst behaviours during open play were the focus of this paper set pieces were also analysed as they tend to account for a reasonably large proportion of goals scored (e.g. set pieces accounted for 35.6% of goals scored in the 2004 European Championship; Yinannakos & Armatas, 2006). In both set piece and open play situations, the player in possession of the ball can pass the ball into an advantageous area or pass the ball to a team mate who is not in an advantageous position. In the open play situation the player can also attempt to dribble past an opponent. These three options can be simplified into a two choice scenario, “an attempt to create a perturbation” by dribbling past an opponent or playing a pass into an advantageous area of the pitch, or “maintaining possession” where a pass is made to a teammate who is in an area of the pitch which is not advantageous. The focus of this paper will be “attempts to create a perturbation” although the number of times a player chose to maintain possession will be counted, as will losses of possession that result in a perturbation for the opponents, as it is hypothesised that the analysis of perturbations and perturbation attempts out of all possessions may be indicative of a team’s strategy. This equates to the distinction between the “long ball” style of play, where there are relatively few passes per team possession and thus the relative frequency of perturbation attempts would be high, and “possession football” where there are a lot of passes per team possession and thus the relative frequency of perturbation attempts would be low. Taking this perspective to its logical conclusion it is expected that where a team has a low frequency of perturbation attempts per team possession the successfulness in creating a perturbation would be higher than for a team with a high frequency of perturbation attempts. This is because it is expected that teams with a low frequency of perturbation attempts (possession football) play a more patient game and are more selective, and thus potentially more successful, in when they choose to make a perturbation attempt. It is also envisaged that if teams play different styles of soccer then the methods of trying to create a perturbation would be different. Whilst this would support the distinction between long ball and possession soccer (see James, 2006 for a discussion on this point) this analysis also has the potential for discriminating individual team styles of play as it may be the case that certain players within a team are designated as the players to try to create perturbations. This may be seen in the situation whereby two midfield players on a team were designated as “holding” (a more defensive role) or “attacking” (play passes to the attackers) players.

MATERIAL AND METHODS

Eight domestic league matches from the 2007/2008 season involving one Coca-Cola League One team (home team) were analysed from video recordings. Each match was viewed twice using a hand notation system specifically designed to code the relevant events for each team separately (home and away teams). Each action was analysed to establish whether the player in possession was attempting to create a perturbation. If a pass or dribble was not deemed to be an attempt to create a perturbation a “maintaining possession” was recorded. An “attempt to create a perturbation” was only recorded if the pass or dribble had the potential to place the opponents under a significant disadvantage. This was defined as a potential goal scoring opportunity and was thus dependent on the area of the pitch. For example, a player could dribble past an opponent but if the opponents had enough players in defensive positions between the ball and their goal a perturbation would be deemed to have occurred. On the other hand, if the outcome of a pass or dribble would, for example, be a two on one situation near the opponent’s penalty area, then a clear advantage and goal scoring opportunity would exist, hence a perturbation attempt was recorded. If the pass or dribble was successful i.e. the pass was received by the teammate or possession was maintained after dribbling past the opponent, the perturbation attempt was deemed successful. Crucially, if a perturbation pass was attempted, but for whatever reason the pass was incomplete, then a perturbation attempt was recorded but the outcome was unsuccessful. Finally when perturbation attempts were successful, the outcome of the play was recorded as a goal, shot saved, shot off target, shot blocked, player fouled or if the significant advantage was negated and play returned to a relatively stable situation i.e. no particular tactical or positional superiority over the opposition, the perturbation attempt was considered “smoothed over” (term used by Hughes et al., 1998a).

This study also assessed perturbation attempts in relation to the match status i.e. match score at the time of a behaviour, as this has been shown to influence teams’ strategy e.g. Jones et al. (2004), Lago-Peñas and Dellal (2010). Finally a record was kept of all variables of interest (pitch locations, skills performed, players involved and outcomes) for each individual player behaviour.

Reliability

In performance analysis research reliability measures determine the accuracy of events that have been coded (James et al., 2007). In this study an intra-observer reliability test was performed where one game was randomly selected and analysed on three separate occasions with sufficient time between each analysis to prevent memory effects. It should be noted that the intra-observer test does not demonstrate a system to be objective, it merely shows that the system can be used consistently by the operator (O’Donoghue, 2007). The percentage error equation (Equation 1) suggested by Hughes et al. (2002) was used to determine how reliably the analyst coded match events.

$$\% \text{ error} = (\sum (\text{mod } (V_1 - V_2))) / V_{\text{TOTmean}} \times 100 \quad (\text{Equation 1})$$

Three % errors (analysis 1 v analysis 2; analysis 1 v analysis 3 and analysis 2 v analysis 3) were calculated for each variable of interest. All % errors used in this paper were less than 5%, for determining if a perturbation was attempted or not (1.78%, 2.57% and 0.78%); the outcome of a perturbation attempt (0.00%, 1.90% and 1.90%); the outcome of the play (0.00%, 4.30% and 4.30%) and match status (0.00%, 1.90% and 1.90%). Greater errors were found for player identification (maximum value 7.7%) and pitch location (maximum value 7.7%) and so were not used in this paper.

Statistics used

Since the data involved collecting frequency counts with binomial distributions, a non-parametric approach to significance testing (Wilcoxon Signed Ranks Test) was used.

RESULTS

The home team attempted to create a perturbation between 30 and 70 times per match ($n = 385$) which was significantly more ($Z = 2.38$, $p < 0.05$) than the away teams, between 28 and 50 times per match ($n = 317$). However the rate of perturbation attempts per possession was significantly lower ($Z = 2.39$, $p < 0.05$) for the home team (11.78% of total possessions) compared to the away teams (17.54% of total possessions). Perturbation attempts were more likely to be unsuccessful for home (59.65%) and away (71.74%) teams than successful ($Z = 2.37$ (away $Z = 2.52$), $p < 0.05$). Whilst the home teams success rate for perturbation attempts was higher (40.35%) than the away teams (29.26%) this was not significant ($p = 0.09$). It should be noted that the lowest success rate (17%) for the home team coincided with their only defeat during this analysis.

Perturbation attempts were most likely to be passes (home 63.4%; away 56.15%), of which 36.07% were successful for the home team (20.70% away teams). The home team was equally as likely to attempt a perturbation with set pieces (18.7%; 31.94% success rate) as dribbling (17.4%; 58.21% success rate). Away teams however were more likely to attempt a perturbation with set pieces (36.91%; 34.19% success rate) in comparison to dribbling (6.31%; 60% success rate). Perturbation attempts whereby the team without possession of the ball attempted a tackle were very rare (2 for both home and away teams) all of which were unsuccessful.

The home team was more likely to attempt to create a perturbation when drawing (1 attempt every 1.72 minutes) than when winning (every 2.08 minutes) and when losing (2.20 minutes). In contrast, the away team was more likely to attempt to create a perturbation when losing (1 attempt every 1.88 minutes) than when drawing (every 2.59 minutes) and when winning (3.06 minutes). The home team's 150 successful perturbation attempts (away team = 91) resulted in 14 goals (away team = 6; Table 1).

Table 1. Outcomes of Home and Away Team's Successful Perturbation Attempts.

	Goal	Shot saved	Shot off target	Shot blocked	Fouled	Smoothed over
Home team	14	29	45	18	4	40
Frequency						
%	9.33%	19.33%	30.00%	12.00%	2.67%	26.67%
Away teams	6	15	25	19	2	24
Frequency						
%	6.59%	16.48%	27.47%	20.88%	2.20%	26.37%

DISCUSSION AND CONCLUSIONS

There were, on average, 78 perturbation attempts per game, which is a lot less than the average of 118.2 perturbations per game reported by Hughes et al. (2001). This may suggest a difference in opinion on what constitutes a perturbation, a sampling issue related to the types of playing style in the selected teams, or that the frequency of perturbations is related to playing standard (Hughes et al., 1998b) used English Premier League and 1996 European championship matches). Of particular interest to this study was the rate of perturbation attempts out of all individual possessions as it was thought this might be indicative of a team's strategy. Significant differences were found whereby the home team made less perturbation attempts (11.78% of total possessions) compared to the away teams (17.54%). It was expected that where a team had a low frequency of perturbation attempts per possession the success in creating a perturbation would be higher than for a team with a high frequency of perturbation attempts. To some extent this hypothesis was supported as the success rate for perturbation attempts was higher (40.35%) for the team with less perturbation attempts per possession (home team) than it was for the away teams (29.26%). However the difference was not significant ($p = 0.09$) suggesting that the hypothesis cannot be supported currently. It will be interesting to see whether significant differences are apparent when analysing teams of a higher playing standard and to see whether the rate of perturbation attempts per possession can be used as a performance indicator. Alternatively, as hypothesised in this paper, the rate of perturbation attempts per possession may indicate whether teams tend to play a possession style of football or adopt a more direct approach. More data from different teams are required to assess this although the home team in this study was widely regarded as playing a possession style similar to teams such as Barcelona and Arsenal. Most teams in the league analysed, English third division (League One), are referred to as being more direct in their play.

The majority of perturbation attempts for all of the teams in this study involved passing the ball with success rates of between 20 and 35%. However, the home team, who made less perturbation attempts per possession, were three times as likely to try to create a perturbation by dribbling with the ball. Since success rates for perturbation attempts using dribbling were relatively high, about 60% for all teams, this would see a good strategy. It may be the case that when a team plays a possession style of football they are more likely to produce opportunities to dribble with the ball in offensive areas of the pitch. The results do lend support to the original contention that if teams play different styles of soccer then the methods of trying to create a perturbation would be different. On the basis of these results it would appear tactically astute to encourage dribbling as this behaviour had a relatively high success rate for creating perturbations. Advice for a coach may be to encourage their team to pass the ball to the best dribblers or to simply encourage more players to dribble in the opponents half of the pitch.

Match status i.e. match score at the time of a behaviour, has typically shown that both successful and unsuccessful teams tend to keep the ball for longer periods when they were losing compared to winning and successful teams have longer possessions when in winning situations than unsuccessful teams (e.g. Jones et al., 2004). This study expanded on this research by looking at what the players did with the ball when in possession. Longer possessions suggest more passes before attempting a perturbation, and hence a lower frequency of perturbation attempts per possession, since a perturbation attempt is likely to increase the risk of losing possession. In contrast to this logic the away teams in this study attempted to create more perturbations when losing than when winning or drawing. However it is also logical that if a team is losing and is trying to score to get back into a drawing position then they must try to create perturbations to facilitate goal scoring. It may be the case therefore, that in losing situations the reason for longer possessions is because the opposition do not attempt to regain possession as aggressively as in

winning and drawing situations. This data suggests that the team in possession also changes their strategy in terms of how often the attempt to create a perturbation. The away teams were more likely to attempt to create a perturbation whereas the home team were least likely. Whilst the data set is too small to make concrete inferences it is suggested that it would be useful to assess whether this finding holds true for a larger data sets using different playing standards.

Of the 241 successful perturbations in this study 20 resulted in goals (perturbation to goal ratio of 12:1). This is lower than the 6:1 found by Hughes and Reed (2005) although they looked at English Premier League teams, potentially suggesting this ratio is a performance indicator (an indicator of success). It also confirms the suggestion of Hughes et al. (1998a) that the identification of perturbations allows coach and analyst to focus on the most relevant aspects of a match in regards to its outcome.

This study has suggested that the analysis of perturbation and perturbation attempts can help coaches and players ascertain a team's strategy. It was found that the rate of perturbation attempts out of all individual possessions may be indicative of a team's strategy and that it would appear tactically astute to encourage dribbling as this behaviour had a relatively high success rate for creating perturbations. Also, the few incidences where a perturbation attempt resulted in an advantage for the defending team suggests that there is a low level of risk associated with perturbation attempts. Future studies can improve on the conclusions of this study by analysing the areas of the pitch from which particular teams are most likely to attack, and whether individual players are primarily responsible for successful perturbation attempts. Another useful improvement would be to identify weakness in a team by identifying the areas of the pitch or players through which that team is most likely to concede a successful perturbation attempt.

A hand notation system was used in lapsed time for this study, which means that analyses could only be presented to coaches for interpretation post match. It would be beneficial if the same data could be available to a coach during the actual match so that tactics and strategies could be altered, if necessary. This would require a computerised system linked to a recording of the game so that individual perturbation attempts could be viewed by the coach as required.

The techniques used in this study could also be applied to other sports and disciplines. It is recommended that different playing standards are used in the future to see whether this has an effect on the results. Also using a sample of teams may produce general information that loses the important messages, which may be team specific, suggesting profiles of individual teams may be of more benefit to coaches.

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