Evolution of game-play in the Australian Football League from 2001 to 2015

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Abstract

This study investigated the evolution of game-play manifested via team performance indicator characteristics in the Australian Football League (AFL) from the 2001 to 2015 seasons. Mean values for 18 performance indicators were collated for every AFL team over 15-seasons. A multivariate analysis was used to uncover temporal trends in the dataset. Compared to the 2004 season, the 2005 to 2010 seasons were characterised by large growth in the counts of handballs (d = 0.83; 90% CI = 0.22 – 1.43), disposals (d = 1.24; 90% CI = 0.59 – 1.87), uncontested possessions (d = 1.37; 90% CI = 0.71 – 2.01), clangers (d = 2.14; 90% CI = 1.39 – 2.86), and marks (d = 1.43; 90% CI = 0.76 – 2.07). Contrastingly, effective disposal percentage declined rapidly during the same period. The number of inside 50 m counts remained stable throughout the 15-season period. The ordination plot of league-wide performance indicator characteristics illustrated a distinct cluster from the 2001 to 2004 seasons, an abrupt shift from the 2005 to 2009 seasons, and an emergent (re)stabilisation from the 2010 to 2015 seasons. Results demonstrate the synchronous league-wide evolution of game-play in the AFL from the 2001 to 2015 seasons. Amongst other constituents, this evolution likely reflects the introduction of modernised coaching strategies, rule changes and changing perceptions of rule interpretations.

Key words: Data visualisation; sport analytics; team sports; dynamical systems

Introduction

Australian football (AF) is a team invasion sport that requires player's at all developmental levels to possess a unique set of physical, technical and perceptual qualities (Coutts, Quinn, Hocking, Castagna, & Rampinini, 2009; Dawson, Hopkinson, Appleby, Stewart, & Roberts, 2004; Woods, Raynor, Bruce, McDonald, & Robertson, 2016). Despite being played across a range of developmental levels, its premier competition is the Australian Football League (AFL). Since its origination in the mid 1800's, the game has evolved drastically. Early AF game-play resembled a chimera of rugby and soccer (football). Dribbling the ball along the ground was common, as players rarely picked-up the ball during contested situations (Coventry, 2015). When players did pick up the ball, the common attacking style was to carry the ball at speed into an opponent's defensive territory, while the handball, which is prolifically used as a mode of ball disposal in the 'modern game', was largely absent (Coventry, 2015). Despite being created without an offside ruling, coaches in early AF rarely developed game-plans that afforded their players the freedom to push forward of the ball, similar to tactics utilised in rugby (Coventry, 2015). In 2016, the modern game retains some of the fundamental aspects of early AF, but has globally evolved into a faster game, with players being heavier, taller, and arguably more skilful (Burgess, Naughton, & Norton, 2012; Norton, Craig, & Olds, 1999).

Undoubtedly, improved player athleticism and professionalism has contributed to the evolution of game-play within elite AF (Norton et al., 1999). However, modernised coaching styles, improved skill execution generated through enriched training and development environments, and modified interpretations of the games rules are all factors which are likely to have resulted in the emergence of the modern game. For example, 'charging', as it was referred to in the late nineteenth century, described a player carrying the ball by force into an opponent's defensive area. This tactic was nearly identical to those used in rugby, and was seen as a blight on the game of AF (Coventry, 2015). Thus, the 'holding the ball' ruling was introduced in an attempt to remove this tactic from the game (Coventry, 2015). However, teams had already begun to evolve to deny opposition the ability to

exploit the charging tactic as an attacking style. Specifically, the use of short kicks began to emerge, which limited an opposition's time in possession of the ball; referred to as 'possession football' in the modern game (Coventry, 2015).

In addition to these intrinsic evolutionary responses, it appears that AFL coaches have more recently adopted tactics from other team invasion sports; notably field and ice hockey, soccer and basketball. In these sports, players use possession tactics to maintain control of the game, probing the opponent's defensive line to look for attacking opportunities. As such, kicking backwards and across defensive areas, historically viewed as a poor tactic in early AF, emerged within the modern game of AF (Coventry, 2015). This tactic is typically referred to as 'switching' in modern parlance, and functions in theory by exploiting a team's weakness on the 'fat side' of the ground where defensive lines are stretched in response to attacking players running into space. Attempting to limit this tactic, teams began to implement a zone, or full-ground, team defence that functions by limiting the space opposition players have to run into by avoiding a 'man-on-man' style of play (Coventry, 2015). This emergent zoning tactic appears to be oriented around a 'repossession' style of game-play. What is evident from the history of AF is that several forces act to drive its evolution.

Given the considerable interest in the games evolution from both the scientific and non-scientific AF community, it is surprising to note that very little data has been published describing the evolution of the modern game at the elite level. This is in contrast to the growing body of work describing the evolution of game-play characteristics in similar team invasions sports, such as soccer (i.e., football) (Barnes, Archer, Hogg, Bush, & Bradley, 2014; Bush, Barnes, Archer, Hogg, & Bradley, 2015). For example, Wallace and Norton (2014) described the evolution of World Cup final games between the 1996 and 2010 tournaments. In this study, it was noted that the speed at which the ball travelled across the pitch had increased, coinciding with an increase in player density, and emergence in collective team defensive strategies (Wallace & Norton, 2014). Preliminary evolutionary work in AF by Norton et al. (1999) examined the evolution of game-speed in the Victorian Football League (VFL)

and AFL, finding that game-speed had almost doubled between the 1961 to 1997 seasons. This was correlated with a reduction in total game-time involving game-play (i.e. more non-goal stoppages), and an increase in the velocity with which the ball travelled across the field (Norton et al., 1999). Despite this work describing some aspects of game-play over three decades, its use to illustrate the evolution of the modern game (e.g. from 2001 onwards) is limited. In partial acknowledgement of this, work has attempted to describe changes in modern game-speed at both the elite junior and senior level. Burgess et al. (2012) compared the physical activity profiles of elite under 18 (U18) and AFL players between the 2003 to 2009 seasons. This work demonstrated that when compared to the 2003 season, AFL players in the 2009 season travelled a greater distance per minute of game-time, performed more sprints per minute of game-time, spent a longer duration of game-time at 'sprinting' speeds, and accumulated a larger duration of game-time on-field (Burgess et al., 2012). This study did not analyse the seasonal variation within the 2003 to 2009 seasons, rather compared the physical profiles of players in these two seasons. Consequently, it is difficult to discuss the emergent physical properties of game-play within this seven year period, or illustrate the dynamicity with which game-speed appears to have evolved.

In addition to these studies, recent research has indicated an inverse relationship between physical and technical skill match activity profiles in the AFL (Sullivan, Bilsborough, Cianciosi, Hocking, Cordy, & Coutts, 2014). Specifically, winning reflected a positive correlation with a reduced physical output and an increased number of efficient technical skill involvements (Sullivan et al., 2014). This suggests that modern team tactics are focusing more on the development of game-plans oriented around the generation of efficient technical profiles at the collective (team) level to win games. However, the evolution of team technical skill profiles within the AFL has largely been neglected by the sport science community. Elucidating this evolution could objectively describe the emergence of modern coaching tactics, while providing insight into the evolving technical skill demands of the modern game.

The primary aim of this study was to investigate the evolution of modern (2001 – 2015) game-play within the AFL manifested via team performance indicator characteristics. A secondary aim of this work was to present a unique data visualisation approach for the explanation of game-play evolution within team sports. Thus, beyond its practical implications specific to elite AF (namely, the proposed evolutionary trajectory of future coaching tactics within the AFL, perceived rule interpretations, and training practices implemented in the elite junior developmental pathways), this work presents a unique statistical approach to visualising multivariate datasets, which can be used to describe the evolutionally dynamics of game-play in other football codes.

Methods

Data

Team performance indicators were acquired from a commercially accessible provider (http://www.afl.com.au/stats); Champion Data Pty Ltd (Southbank, Australia). The performance indicators reported by this provider have been validated for use in the explanation of match outcome in the AFL (Robertson, Back, & Bartlett, 2016). Ethical declaration was granted by the relevant Human Research Ethics Committee. The 18 performance indicators used in this study were similar to previous research in AF (Robertson et al., 2016; Woods, Joyce, & Robertson, 2016), and are each presented, along with their description, in Table 1.

******INSERT TABLE 1 ABOUT HERE******

Data from every game within the 2001 to the 2015 seasons (15-seasons) were collated. Mean values for each performance indicator were used to more accurately reflect a team's technical skill match profile over the course of a season. There were a total of 16 teams in the AFL from 2001 to 2010, 17 teams in 2011, and 18 teams from 2012 to 2015, resulting in a total of 249 observations. The difference in team numbers was due to the inclusion of the Gold Coast Suns in the 2011 season and the Greater Western Sydney (GWS) Giants in the 2012 season.

Statistical Analysis

A multivariate analytical method was used to uncover trends in the dynamics of the team performance indicators. Multivariate methods were chosen as they enabled us to map the whole-of-team game styles rather than analysing individual indicators and making inferences based in sets of models. Further, a multivariate method allowed us to capture the temporal trend, simultaneously accounting for all the variables in the dataset. While univariate models (e.g. linear regression) can offer powerful insight into individual team performance indicator variability over time, the multivariate technique used here allows for simultaneous analysis and visualisation of the data. For the current dataset, a particular form of multivariate analysis called nonmetric multidimensional scaling (NMDS) was used. This method has been used extensively across many fields of strongly quantitative sciences, such as ecology (Faith, Minchin, & Belbin, 1987; Minchin, 1987), bioinformatics (Taguchi & Oono, 2005; Zu & Yu, 2009), and linguistics (Fox, Flege, & Munro, 1995). Fundamentally, NMDS is an analysis of similarity of an *n* x *p* data matrix where the *n* rows represent the samples (e.g. teams) and the *p* columns (e.g. performance indictors) represent the variables measured within each sample. From the *n* x *p* data matrix, a distance matrix is calculated based on the ranked similarities. Ranked similarities are preferred when no assumptions are made about the underlying distribution of the data.

Using the full suite of performance indicators, a matrix of dissimilarity scores was created using the *metaMDS* function from the 'vegan' package (Wood, 2003). The Bray-Curtis dissimilarity measure was the method used to calculate the dissimilarity matrix. The dissimilarity matrix was then plotted in two dimensions and convex hulls were used to highlight the team match profiles grouped by season. All data was plotted together, with separate team ordinations also plotted to show the temporal change of each teams match profile within the 15-season period. The relationships between the ordination and the individual team performance indicators were visualised by overlaying ordination surfaces. The ordination surfaces were fitted using generalised additive models employing an isotopic smoother via thin-plate regression splines (Oksanen, Blanchet, Kindt,

et al., 2015). The season average match activity profile dissimilarity scores were plotted for the winning and losing grand final teams over the 15-seasons. This enabled a comparison between the 'dominant' (i.e., the grand final representatives) teams' profile within each season analysed relative to the remaining teams within the league. It is possible that the strategies implemented by these dominant teams would contribute to a league-wide evolution. Lastly, where appropriate, the effect size of season on each performance indicator was calculated using Cohen's *d* statistic (Cohen, 1988), where an effect size of d <0.2 was considered small, d = 0.21 – 0.50 moderate, d = 0.51 – 0.80 large, and d ≥0.80 very large (Cohen, 1988). Effect sizes, and subsequent 90% confidence intervals (90% CI) were calculated in the 'MBESS' package (Kelly, 2016), with all analyses being undertaken using *R* version 3.2.2 (R Core Team, 2015).

Results

Individual team performance dynamics

As illustrated in Figure 1, when compared to the 2004 season, the 2005 season led to the beginning of major growth in the count of handballs (d = 0.83; 90% CI = 0.22 – 1.43), disposals (d = 1.24; 90% CI = 0.59 – 1.87), uncontested possessions (d = 1.37; 90% CI = 0.71 – 2.01), clangers (d = 2.14; 90% CI = 1.39 – 2.86), and marks (d = 1.43; 90% CI = 0.76 – 2.07) generated during game-play. Effective disposal percentage was the only performance indicator included in the sample to show a rapid sustained decline from the 2005 to 2010 seasons (d = -3.15; 90% CI = -2.25 – -4.02) (Figure 1). However, after nearly a decade of decline, this performance indicator stabilised in the 2010 season and shows indication of increasing (Figure 1). Over the entire sample period, the trend in the number of inside 50 m counts has remained relatively steady (d = 0.27; 90% CI = -0.29 – 0.84) (Figure 1). Stoppages and clearances were at a 15-season low during the 2006 and 2007 seasons. These trends were reflected in the technical skill profiles of winning and losing teams competing in the grand final within the analysed period (Figure 2).

******INSERT FIGURE 1 ABOUT HERE******

******INSERT FIGURE 2 ABOUT HERE******

Multivariate team performance dynamics

The dissimilarity matrix solution was reached after eleven runs (stress = 0.13, rmse = 2.7 x 10^{-4}, maximum residual = 3.3 x 10^{-3}). The ordination plot shows a cluster of teams from the 2001 to 2004 seasons (Figure 3). There is a clear and abrupt shift in team performance indicator characteristics during the 2005 season, arcing across the ordination space and then stabilising in the 2010 season (Figure 3). For the next five seasons, the teams clustered around a similar position on the ordination surface (Figure 3). Coinciding with the abrupt shift in team performance indicator characteristics, the grand final winning teams in the 2004, 2005, 2006, and 2010 seasons were positioned on the boundary of the ordination surface relative to the runners up and remaining AFL teams within each of these respective seasons (Figure 3).

******INSERT FIGURE 3 ABOUT HERE******

The ordination plots for each team are illustrated in Figure 4. Despite slight idiosyncrasies for each team being observed, these plots globally demonstrate that all the teams within the 15-season period (with the exception of the GWS Giants and the Gold Coast Suns) possessed a similar 'arc' pattern, beginning in the 2004/2005 seasons, and ending in the 2010/2011 seasons.

******INSERT FIGURE 4 ABOUT HERE******

Discussion

This study illustrates the synchronous, league-wide, evolution of team performance indicator characteristics within the AFL between the 2001 to 2015 seasons. In doing so, it presents a set of novel data visualisations to the sport sciences, highlighting their use for describing evolutionary trends in multivariate datasets. An analysis into the individual team performance dynamics demonstrated that from the 2005 season a rapid shift in the increased count of handballs, disposals, uncontested possessions, clangers, marks, and tackles emerged. Concurrently, effective disposal

percentage sustained a decline from the 2005 to 2010 seasons, while, despite high between team variances, the number of inside 50 m counts remained relatively steady across the 15-season period. These collective trends were reflected in the activity profiles of both winning and losing grand final teams across this period. The multivariate analysis of team performance dynamics illustrated a stable cluster of team profiles from the 2001 to 2004 seasons, and 2011 to 2015 seasons. However, there was a clear, and somewhat abrupt, shift in team performance indicator characteristics between the 2005 to 2010 seasons at the collective (league-wide) level. Amongst other constituents, it is proposed that the continued modernisation of coaching styles and the changing perception of rule infringements are primary drivers of the collective evolution of team performance indicator characteristics seen within the modern era.

The dynamic and league-wide transition in team performance indicator characteristics from the 2005 to 2010 season is of considerable note, and is suggestive of the evolution of coaching strategies and team tactics imposed across the AFL. Comparative to the 2001 to 2004 seasons, the 2005 season saw a drastic increase in the count of handballs, total disposals, uncontested possessions, clangers, and tackles. Combined, these metrics indicate that the game evolved rapidly into 'possession football', where teams attempted to control the speed of game-play. Interestingly, the grand final winning side in the 2005 season (the Sydney Swans), were heavily scrutinised by the broader AF community for introducing a defensive style of play, oriented around ball possession; effectively starving the opposition of possession. This type of tactic appears to have emerged from basketball and field/ice hockey, where it is common for winning teams to be characterised by shorter and more frequent passes, which is believed to afford them with greater control over the game 'tempo' (Ortega, Palao, Gómez, Lorenzo, & Cardenas, 2007). Ultimately, this provides a team with the opportunity to continually probe an opposition's defensive structure waiting for an opportunity to score. This dynamic shift toward possession football in the 2005 season seems to have arguably resulted in a drastic league-wide reaction (Figure 3), perhaps as teams attempted to adapt to the more congested, tempo controlled, style of football that had emerged.

Of interest was the league-wide (re)stabilisation of team performance characteristics from the 2010 season onwards. Differing from the 2005 to 2009 seasons, the 2010 season showed a decline across multiple indicators; namely the count of handballs, disposals, and uncontested possessions, while the number of clangers and tackles appeared to continually increase. This suggests that game-play shifted from a possession style of football, to a re-possession style of football. Teams appeared to become more equipped at regaining ball possession from their opposition; with game-play seeming more congested, indicative of the rise in stoppages. The emergence of this re-possession style of football is supported by trends in literature at that point, with Johnston et al. (2012) highlighting an AFL team's ability to regain and maintain possession of the ball as being critical in determining their on-field success. Thus, it seems that from the 2010 season onwards, coaches actively (and somewhat collectively) developed game-plans oriented on the implementation of full ground zones; reflected by the decline in uncontested possession counts, and the simultaneous rise in contested possession counts (Figure 1).

The relative positioning of the grand final winning teams on the ordination surface reflects their influence on the dynamic shift in game-style in the 2004, 2005, 2006, and 2010 seasons. When compared to the other AFL team's performance indicator characteristics within these seasons, grand final winning sides were generating considerably unique styles of play. It is speculated that the abrupt league-wide shift in team performance indicator characteristics from the 2005 season was a 'knee-jerk' reaction in response to the evolving game-styles implemented by the dominant sides within these seasonal periods (namely the Adelaide Crows, Sydney Swans, West Coast Eagles, Geelong Cats, and Hawthorn). Further, it is of note that within the cluster of seasons in which the team performance indicator characteristics appear to have stabilised (2001-2004 and 2011-2015); the grand final winning sides orient the middle of each ordination surface. This indicates that although the dominant sides within each of these clusters were playing a style of football similar to the other teams, they were seemingly more equipped at playing that 'current' evolutionary style.

The trends reflective in the data indicate that the 2005 season saw the prolific league-wide emergence of possession football, while the 2010 season led to the emergence of a team defensive zoning style, oriented around repossession football. The current trend (from 2014 onwards) is suggestive of a blended game-style; one that adopts both a possession and re-possession style of play. For example, despite the initial emergence of repossession football from the 2010 season, it seems as though the game has begun to evolve back to a possession style of football from the 2014 season onwards. Accordingly, it appears that coaches are blending elements of previously dominant tactics as they strive toward a unique tactical combination.

These results hold implications for the development of prospective junior AFL players, which warrants discussion. Coaches within the developmental pathway should look to implement training interventions that equip juniors with the capability to 'switch on' and 'switch off' possession football, while collectively being able to implement a zone defensive structure when attempting to obtain possession from their opposition (re-possession football). In doing so, prospective juniors may be more advantageously positioned to transition into the 'current' game-style in the AFL given their intrinsic understanding of current game-play.

Beyond the implications this work holds for AF at all developmental levels, it presents a unique statistical approach for illustrating dynamic trends in multivariate datasets in the sport sciences. Data visualisation is becoming an increasingly prominent form of statistical methodology in a range of domains, such as pharmacology and chemistry (Clark, Williams, & Ekins, 2015), computer science (Ellis & Dix, 2007), and ecology (Specht, Guru, Houghton, Keniger, Driver, Ritchie, & Treloar, 2015). It provides graphical means for which scientists and practitioners can interpret the connections between multiple variables within larger datasets, while concurrently elucidating emergent trends over time beyond what is granulated through more traditionally utilised linear approaches (Ellis & Dix, 2007). This study demonstrates the power of data visualisation in sport science, where large, multivariate datasets are commonly reported upon. By doing so, it presents a methodological

foundation that scientists working in other football codes can follow when illustrating evolutionary patterns in player, team, or league characteristics over time.

Conclusion

This study illustrates the synchronous, league-wide, evolution of game-play in the AFL using a novel data visualisation approach to the sport sciences. Between the 2001 to 2015 AFL seasons team performance indicator characteristics underwent dynamic and league-wide evolution. The data clearly demonstrates a drastic change in team performance indicator characteristics from the 2005 to 2009 seasons, perhaps indicative of the introduction of modernised coaching styles oriented around possession football. However, from the 2010 season onwards, coaches adopted a more collective zone defensive tactic oriented around re-possession football, where teams looked to limit an opposition's space, and thus utilisation of the possession football tactic. The 'current' style of play reflects a blend of both possession and re-possession football, where teams are looking to control the tempo of the game and implement a zone defence when required. Future work should continually monitor the evolution of game-play within the AFL to illustrate the emergence of a 'new' style of play. Additionally, those working and researching in team sports are encouraged to apply the unique data visualisation approaches presented here when describing emergent trends in game-play.

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371 **Table 1.** The performance indicators and corresponding description as used within this study

Performance indicator	Description
Kicks	Disposing of the ball with any part of the leg below the knee including kicks off the ground
Handballs	Disposing of the ball by striking it with a fist while it rests on the opposing hand
Disposals	Summation of kicks and handballs
Contested possessions	Possessions obtained while in congested, and physically pressured situations
Uncontested possessions	Possessions obtained while a player is under no immediate physical pressure from the opposition
Effective disposals	A disposal that results in a teammate possessing the ball who was the intended target
Clangers	An unforced turnover of ball possession stemming from a disposal
Marks	When a player catches a kicked ball that has travelled more than 15 metres without another player impeding the ball or it having hit the ground
Contested marks	A mark recorded while engaging in a congested, physically pressured situation
Marks inside 50	A mark recorded while a player is in their forward 50 m zone
Hit-outs	An action of clearing the ball from a ruck contest to a teammate by tapping the ball into space
Clearances	Disposing of the ball from a congested stoppage in play
Centre clearances	An action of clearing the ball from a centre ball-up ruck contest
Stoppages	A stoppage in play called by the umpire as the ball is unable to be

	cleared by players
Rebound 50	An action of moving the ball from the defensive 50 m zone into the midfield zone
Tackles	Using physical contact to prevent an opposition in possession of the ball from getting an effective disposal
Bounces	The number of bounces accrued while running with the ball
Inside 50	An action of moving the ball from the midfield into the forward 50 m zone

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Figure 1. Temporal dynamics of each team performance indicator from 2001-2015.

Note: Each point represents the average of a team's performance indicator per season. The orange line represents a LOESS smooth to the data and the vertical dashed lines represent a speculated transition point in the data – refer to Appendix A for inferential statistics supporting these speculations.

Figure 2. Mean season performance indicators for winning and losing AFL grand final teams from 2001-2015.

Note: The green line represents grand final winners and the red line that of the losers. The vertical dashed lines represent the speculated transition point in the data – refer to Appendix A for inferential statistics supporting these speculations.

Figure 3. An ordination plot using non-metric multidimensional scaling of a distance matrix calculated from the team performance indicators for seasons 2001-2015.

Note: The polygons represent the extent of team distances for one season, while the coloured overlayed lines represented the winning (green) and losing (red) grand final teams, "DNP" denotes did not place

Figure 4. Non-metric multidimensional scaling plot for each team from the 2001-2015 seasons

Appendix A. Segmented models showing the 'break points' in the dataset as illustrated in Figure 1 and 2.

It is obvious that there are two periods, within the time series of the performance metrics, where a change in the trend occurs. These two periods are approximately around 2004-05 and 2010-11. We took three performance metrics from the total dataset - clearances, disposals, handballs - and fit segmented models (sometimes referred to as 'piecewise' models) to the data to estimate the periods where the transitions in the data occurred. That is – where are the 'break points' in the data. In our case we are estimating the year when the transitions occurred. We did so using the *segmented* package (Vito and Muggeo 2008) in *R* (R Core Team, 2016). Segmented modelling fits regression models to data in a piecewise way by iteratively searching for the join points of two or more linear regression fits to the data. One specifies *a priori* points of where these joins occur – our speculated transition points. For these model fits we specified the years 2004 and 2011 as the hypothesized break points. The reader must bear in mind that these are not strictly hypotheses, but starting points for the model to search through the parameter space in order to estimate the break points. The models converged easily on solutions for all three models. These fits support two transitions in the data around 2004-06 and 2008-10, supporting our speculation made in Figure 2.

Performance metric	**Break point 1**	**Break point 2**
Clearances	2006.6 (0.276)	2010.9 (0.675)
Handballs	2003.9 (0.410)	2009 (0.256)
Disposals	2003.6 (0.335)	2008.5 (0.283)

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