POSSESSION VERSUS POSITION: STRATEGIC EVALUATION IN AFL

ABSTRACT

In sports like Australian Rules football and soccer, teams must battle to achieve possession of the ball in sufficient space to make optimal use of it. Ultimately the teams need to score, and to do that the ball must be brought into the area in front of goal – the place where the defence usually concentrates on shutting down space and opportunity time. Coaches would like to quantify the trade-offs between contested play in good positions and uncontested play in less promising positions, in order to inform their decision-making about where to put their players, and when to gamble on sending the ball to a contest rather than simply maintain possession.

To evaluate football strategies, Champion Data collected the on-ground locations of all 350,000 possessions and stoppages in two seasons of AFL (2004, 2005). By following each chain of play through to the next score, we can now reliably estimate the scoreboard "equity" of possessing the ball at any location, and measure the effect of having sufficient time to dispose of it effectively. As expected, winning the ball under physical pressure (through a "hard ball get") is far more difficult to convert into a score than winning it via a mark. We also analyse some equity gradients to show how getting the ball 20 metres closer to goal is much more important in certain areas of the ground than in others. We conclude by looking at the choices faced by players in possession wanting to maximise their likelihood of success.

KEY WORDS

Notational Analysis, Australian Rules Football, Tactical Coaching

INTRODUCTION

Australian Rules Football (informally known as "AFL" after the Australian Football League) is played with an oval ball on an oval field at high speed, leading to it sometimes being called "What Rules?" by the unschooled observer. Compared to more structured football codes such as American football or rugby league where a "phase of play" always starts in a simply-defined formation, the free-flowing nature of Australian football creates extra dimensions for analysis. This paper describes the qualitative framework for evaluating the phases of AFL and presents empirical interpretation of data from the 2004 and 2005 seasons.

AFL coaches are clamouring for this sort of analysis to inform their strategies and training procedures. They know that being in possession of the ball is important, but this research can show exactly how much it's worth on the scoreboard to take a contested mark, compared with someone from the opposition grabbing the loose ball spilled from the pack. They also know that position is important. They must create opportunities in positions near goal, but their players often have to choose whether to aim at a riskier proposition close to the goalmouth or maintain possession in a worse position. Dynamic programming based on empirically derived parameters can answer this dilemma.

Dynamic programming was first applied to AFL (Clarke and Norman, 1998) to answer the question of whether players should concede a point on the scoreboard in order to gain clean possession afterwards. A thesis (Forbes, 2006) based on Champion Data's statistics uses a Markov model approach to map out the probabilities of transitions between AFL's phases to predict scoreboard results.

American football, where position is effectively one-dimensional and there are only four phases – the "downs" – has been analysed using dynamic programming in a famous paper (Romer, 2002), and a rating system (Schatz, 2005) called DVOA (Defence-adjusted Value Over Average) evaluates actions with respect to a model of scoreboard value similar to the one created in this paper. The fast-flowing and open sport of ice hockey has recently been modelled using a "semi-Markov" approach (Thomas, 2006).

The modelling undertaken here is largely exploratory – this is a mass of new data which requires further detailed research.

METHODS

Match Equity and Field Equity

Various authors have employed a plethora of terms to describe the expected value of actions on sporting fields. Studeman (2004) describes the repeated reïnvention and relabelling of "Win Probability Added" in baseball. Bennett (2005) has a good simple description of how to value an action that alters the probability of winning the match.

The terminology we use in this paper is derived from the theory of backgammon (Keith, 1996), a game in which the players compete to win points, the first to n points winning the match. We assume teams of equal strength, although much of the reasoning below is still valid for uneven teams. ***Match Equity*** is the probability of the team to win the match from this moment, or more specifically:

$$\begin{gathered} E_M(m,t,\boldsymbol{x},\varphi) = p_{win} + \frac{1}{2}p_{draw} \\ 0 \le E_M \le 1 \end{gathered} \tag{1}$$

The Match Equities of each team in the contest sum to one. A team is always aiming to increase its Match Equity until it reaches one – certain victory. I.e., it is looking for actions which maximise ΔE_M, or at the very least have $\Delta E_M \ge 0$. As noted in Equation 1, Match Equity is a function of four parameters:

- the score margin, m
- the time remaining in the match, t
- the position on the field, $\boldsymbol{x}$
- the possession state or phase of play, φ

AFL typically has about 50 scores in a match of 80 live minutes. We define s_{typ} as the typical score of a game (in AFL's case, the goal worth 6 points is dominant), and t_{typ} as the typical time between scores (approximately 100 seconds in AFL). We can roughly decouple the first two parameters from the others by noting that if we discard any knowledge of $\boldsymbol{x}$ or φ, we can build a satisfactory model of winning probability based only on the time remaining t and changes to the margin m. The phase and location information can be treated as a perturbation of the match-winning probability model E_M.

To model the net potential value on the scoreboard of the current state of play, we introduce ***Field Equity***:

$$E_F(\boldsymbol{x},\varphi) = \sum_i (p_{i,team}s_i - p_{i,opp}s_i)$$
$$-\max(s_i) \le E_F \le \max(s_i) \qquad (2)$$

where

- s_i is the value of the i^{th} type of score
- $p_{i,q}$ is the probability of the next score being of type i by team q

The Field Equities of each team in the contest always sum to zero. The Field Equity fluctuates as play progresses until either team scores, at which team it precipitates an actual change to the margin m and E_F is reset to zero. AFL has two different restart phases, one being a centre bounce after a goal (where obviously each team has equal chances and $E_F = 0$), the other being a kick-in from the goalmouth after a behind. Remarkably, empirical evidence suggests that the average team has zero residual equity in the behind restart phase (see Table 1 in RESULTS).

Changes to Match Equity, Decoupled

$$\Delta E_M \approx \Pi(m,t) \cdot \Delta E_F(\boldsymbol{x},\varphi)$$
$$\Pi = \frac{\partial E_M}{\partial m} \qquad (3)$$

The "Pressure Factor" multiplier Π is the impact an instantaneous change to the margin would have on the match-winning chances of the teams. Empirically, kicking the first goal in an evenly-matched contest increases E_M from 0.50 to about 0.56. The decoupling transfers the potential held in the field position into improved match-winning probability. It allows us to assume that a team that increases E_F to +2 soon after the start of a game increases its match-winning probability to about 0.52, but if only a quarter of the match is left and $m = 0$, ΔE_F of +2 could imply ΔE_M of +0.04, from 0.50 to 0.54. A detailed formula for Π is beyond the scope of this paper. Henceforth the term "equity" (E) will refer to Field Equity and we will assume the time remaining is effectively unlimited.

The decoupling assumption only breaks down when both t and m are of the order of t_{typ} and s_{typ} respectively – i.e., when the game goes down to the wire, the added quantum of a major score could be the difference between a win ($E_M = 1$) and a loss ($E_M = 0$), and the time left on the clock must be considered.

Data Collection

Champion Data has been logging qualitative AFL statistics by computer since 1996. All statistics are classified live by a caller at the venue, connected by phone to a reviewer watching a monitor, and a data entry operator. Traditionally, AFL statisticians had only captured the numbers of kicks, marks, handballs, and scores for each player. The system introduced in 1996 imposes a structure on the flow of play, so that every disposal or use of the ball must be preceded by a "possession".

We need to be able to say which player is in possession, in which circumstances he got the ball, where he was on the field, how much time he had to think once he got it, a rough idea of what his options were, which option he chose, and whether he successfully executed his choice. Each of these events has to be put in context, with respect to what happened before and after the ball was in his control. The data capture software executes a model of the sport, which only allows certain events to take place in certain circumstances. Every statistic is time-coded, and since 2004 all possessions are given a position on the field by an independent operator whose sole responsibility is to pinpoint the location of the ball on a map of the field for each of these 1000 data points per match.

Testing has shown that the quantity of statistics for each player is logged at better than 99% accuracy, time is accurate to within about five seconds, and position to within approximately 5-10 metres.

AFL Phases of Play

Possession of the football has been qualitatively stratified to become the descriptive framework of AFL's Phases. Phases of Play with a team in possession include:

- Mark. The player has caught the ball from a kick and according to the rules is entitled to consider his options without being tackled.
- Handball Receive. The player has received a handball from a teammate, uncontested.
- Loose Ball Get. The ball has indiscriminately spilled loose and a player has been in the right place to pick it up.
- Hard Ball Get. The player has taken usable possession of the football while under direct physical pressure from an opponent.

Play can also be in an active neutral phase, after a smother of the ball or a similar random collision. There are also passive neutral phases where the umpire holds the ball, before launching it back into play. Lastly there are a couple of set-play phases such as a kick-in after a behind.

For the purposes of this paper we will consider five Phases of Play, which experience and analysis have shown cover most important facets of AFL:

- "Set" (approximately 35% of possession is granted this way). A player has taken a mark or received a free kick, or has been given another set-play role. He has an optimal amount of time to consider options and make the right choice. We will ignore kick-ins from goal in this paper.
- "Directed" (approx 38%). The ball was directed into the player's possession by a teammate, either via a handball, a kick to the player's advantage without achieving a mark, or a knock-on or hit-out intended for the player. Generally the player has space to run onto the ball and some time to make a good decision.
- "Loose" (approx 17%). The player won a virtually random ball via a loose ball get, and while he is not yet under physical pressure there is not a lot of time to evaluate the situation.
- "Hard" (approx 10%). The player won the ball under direct physical pressure and often must take the quickest option available to avoid being caught with the ball.
- "Umpire". The umpire has the ball and will restart play with equal chances for both teams.

We have ignored quasi-possession states like knock-on, hit-out and kick off the ground for this paper. A full description of Phase of Play would also include extra dimensions such as: how fast the ball travelled to where it is (catching the defence napping, for instance); who is currently on the field (is it the best 18 players available?); what formation the team is playing (flooding the backline to reduce the odds of uncontested ball near the opposition's goal).

Assumptions

AFL is regularly played at a dozen different venues, each with slight variations from the ideal oval shape and various lengths and widths. The shortest ground is the SCG at 148.5 metres, meaning that the 50m-wide centre square touches the 50m arcs at each end of the ground. At Subiaco in Perth, on the other hand, there are 175.6 metres between the goal-lines and therefore 12.8 metres of territory between the top of the arc and the centre-square. When plotting locations, it is important to note that some areas of the ground simply don't exist at some grounds, and that the wings are much wider at the SCG (length:width ratio of 1.09:1) than Geelong (1.47:1).

The positional capture software assumes that every ground is a perfect ellipse, and only the lengths of the axes vary, so the operators can accurately pinpoint play. For analysis, we use the MCG (160 × 138 metres) as the standard ground and transform the other venues into this shape to utilise their data. This transformation preserves fixed areas of the ground such as the centre-square, boundary and the corridor leading to goal, while distorting distances and angles in other regions.

We will always show teams attacking the goal to the right of the page. Contour maps have been generated using ComponentOne Chart3D v8. Other diagrams have been designed by the author.

An implicit assumption in the equity model is that the expected value of the next score is a good measure of the current phase of play, no matter how many minutes in the future that score may be. This has advantages over a Markov Model in that we do not assume that future states are exactly classifiable, instead there may be subtle repercussions of actions which are evident further down the track and should not be washed away by repeated normalising. Coaches value the players who can see three or more moves ahead, and don't just look for an easy option in front of them. The disadvantage of the equity approach is that the further we go from the source phase, the less relevance it has to the developing play, as more randomness floods in. Standard error measurements are quite high because of the number of data points ignored.

Method of Calculating Estimated Equity

For each data point, the value of the next score has been noted. This could be +6 (a goal for this team), +1 (a behind for this team), -1 (a behind for the opposition), or -6 (a goal for the opposition). Data points are excluded from analysis if there is no further scoring in the quarter. An example appears in Tables 1 and 2 at the start of the RESULTS section below.

It has been assumed that left/right and north/south biases are inconsequential, so the standard ground has been folded down the spine and data points from each half are analysed together.

We have used two different positional filters in this paper. The contour graphs are generated using a six metre square grid. All points within a six metre radius of the vertex are taken into account in the calculation, meaning that each point appears in roughly three map points – this is an attempt at smoothing, knowing the natural sampling error in the data. Parts of the map with insufficient data (fewer than ten points in the disc or an equity standard error of greater than 0.5) are shown blank.

Where we want to measure true statistical deviations and start to develop a model, the zones must not overlap. The semi-ellipse (remembering that the ground has been folded along its spine) is divided into 200 zones of equal area. First the length-wise (X) axis is divided into 25 sections to segment the ellipse into 25 equal areas. Then seven curves are drawn equidistant from each other, between the spine and the boundary to cut each strip into eight zones.

Error figures presented are two standard errors (95% confidence) except where noted.

RESULTS

Table 1 has a simple example of how to estimate the scoreboard value of two well-defined phases: after a goal, and after a behind.

Table 1: How to Calculate Estimated Equity

	Team Scored a Goal, Centre Bounce follows	Team Scored a Behind, Opposition will Kick-In
Event Count	31236	26160
Discard (no further score)	2376	2064
Team Goal (+6)	8340	7045
Team Behind (+1)	6823	5803
Opposition Goal (-6)	7435	6065
Opposition Behind (-1)	6262	5183
Sum of Next Scores	5991	6500
Sum of Squares	580985	482946
Equity Mean Estimate	0.208	0.270
Standard Error in Mean	0.026	0.029

Summarised in Table 2.

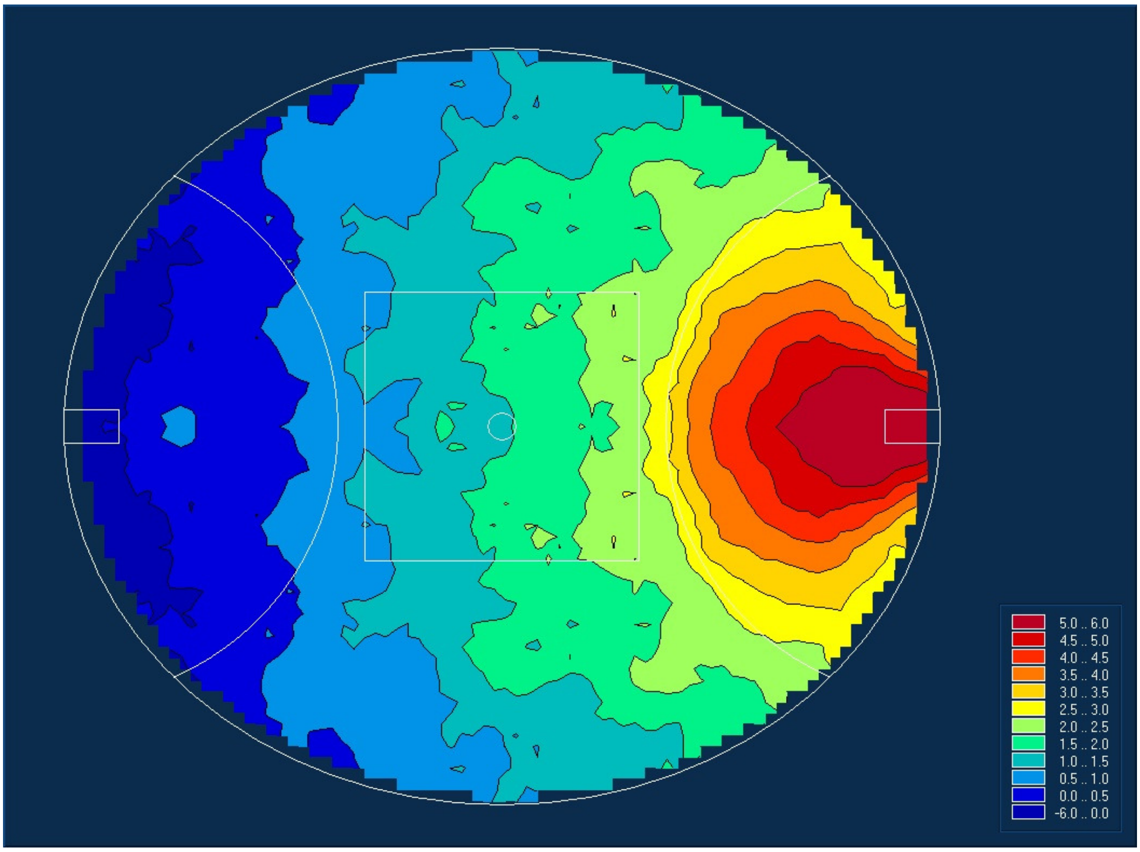
Table 2: Residual Equity in Restart Phase as measured in seasons 2000-2005

After scoring a goal	Measured E_F	+0.21(5)
After scoring a behind	Measured E_F	+0.27(6)

The measured residual equity in real matches is non-zero since the stronger team is more likely to be the scorer of both the previous and the next score. It appears irrelevant whether the restart is via the umpire in the centre of the oval, or via a player kick-in at the end of the ground (95% confidence interval for the difference: [-0.02, +0.14]).

Equity Maps

Figure 1: "Set" Phase Contour Map



The value of taking a mark and having a set shot at goal directly in front can be seen in this map, with an expected value of more than four points extending all the way out to about 40 metres from goal. A free kick within 25 metres makes the goal a virtual certainty. The tight bunching of contour lines from 40 to 60 metres out along the spine shows the natural limit of an AFL footballer's kick, being about 50-55 metres. To get within one kick of goal, and have the time to execute it, is extremely valuable.

Figure 2: “Directed” Phase Contour Map

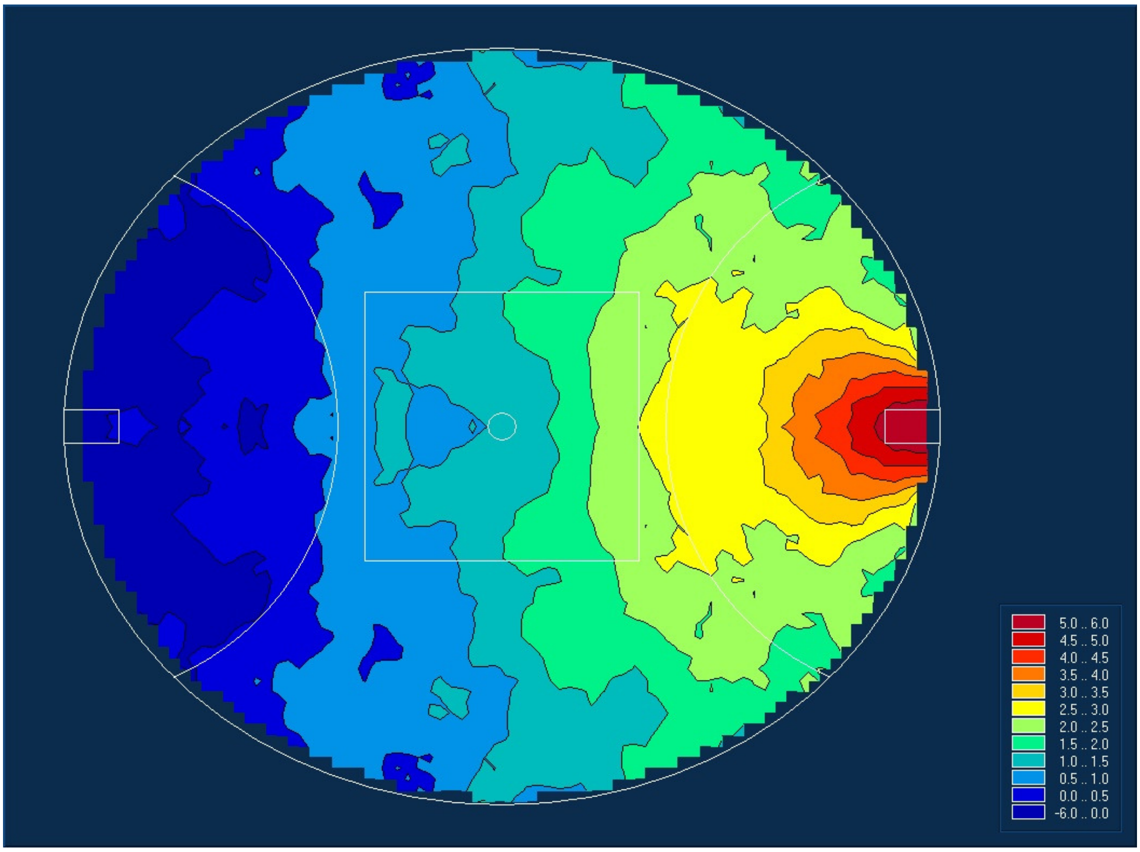
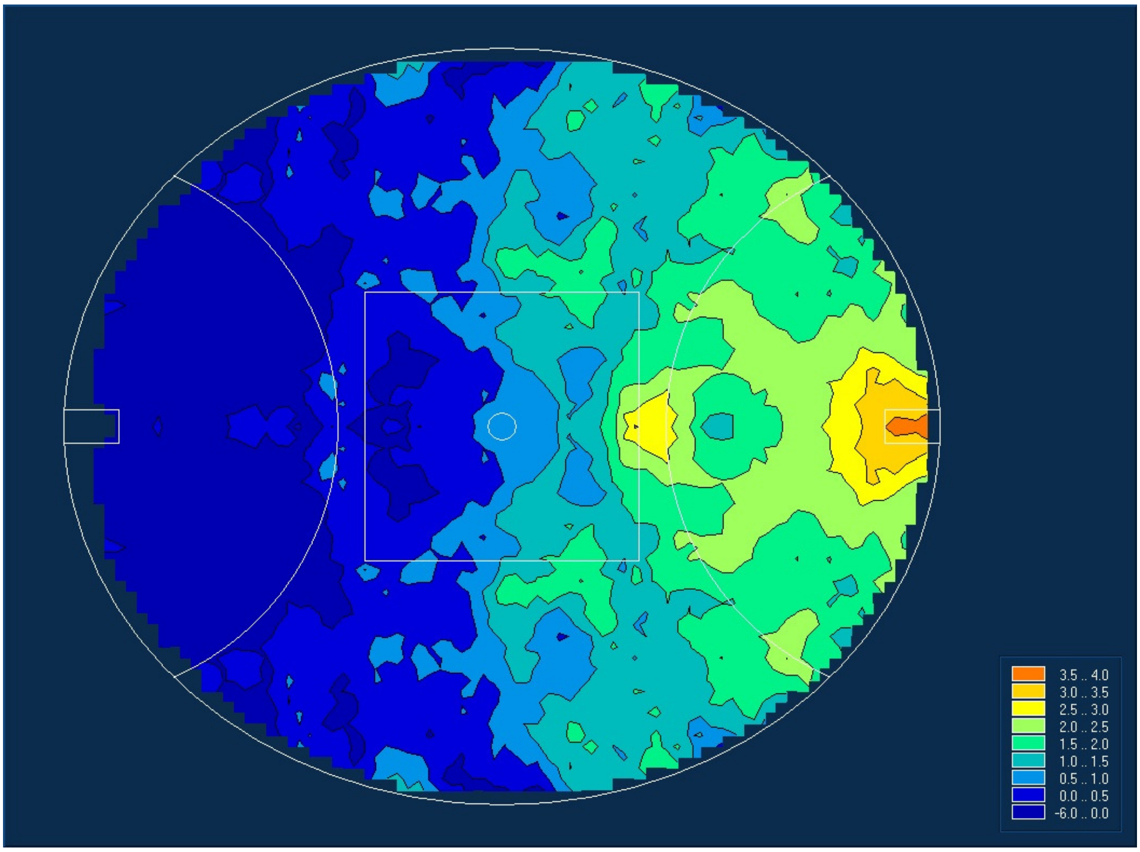


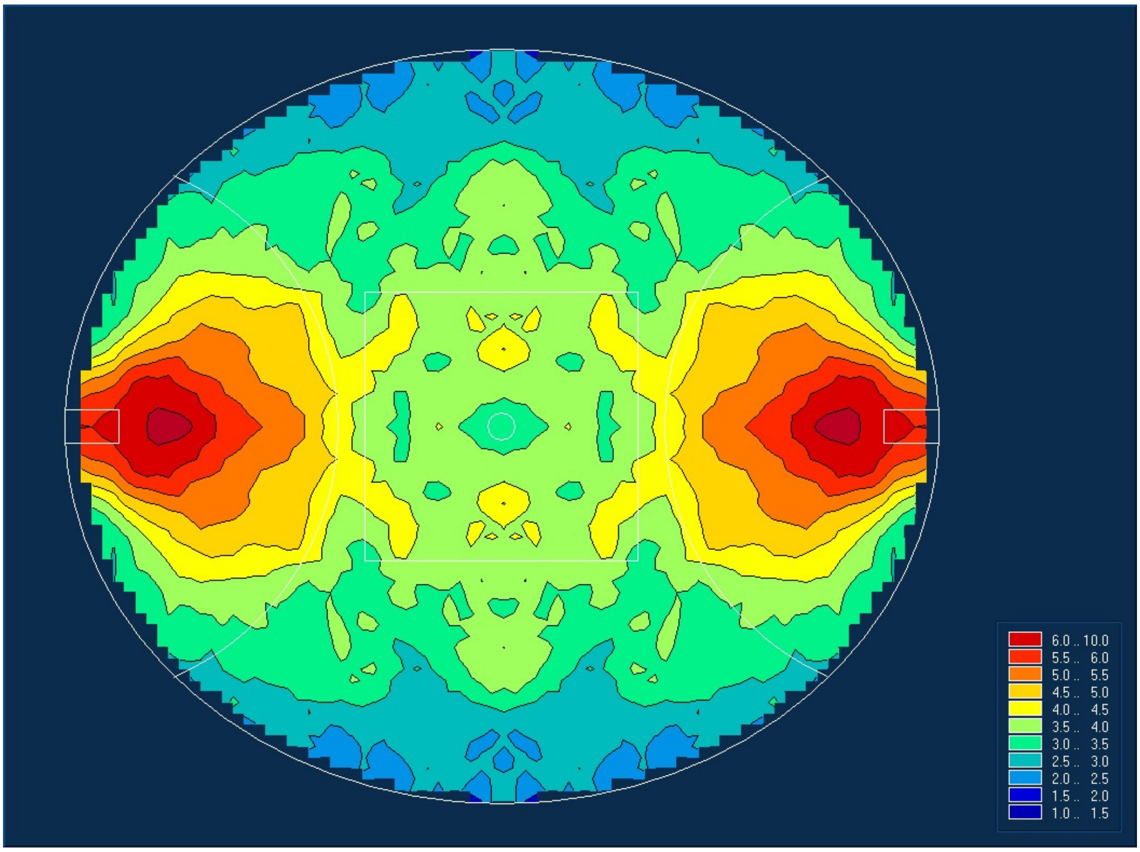
Figure 3: “Hard” Phase Contour Map



“Directed” (Figure 2) is the second-best phase for a footballer to receive the ball in. Usually he has received a handball in some space and should be able to execute his preferred option. But often he will have to take critical time to swivel as the defence closes in, and it’s only within ten metres of goal that the maximum six points can almost be assumed. The gradient we saw at 40-60 metres in Figure 1 is completely missing here, showing the greater difficulty of a snap shot on the run – the attacker wants to be within 30 metres.

An utterly different picture (Figure 3) awaits the player who faces the extreme pressure of a hard ball get. Even within ten metres of goal the expected scoreboard outcome is just 3.5 points. Equity is below zero for the entire defensive zone, but interestingly there is a peak at the top of the forward arc, indicating that perhaps this is one place on the ground where he has two reasonable areas either side of him to shoot out a handball and find a teammate who suddenly has options within range of goal. This circumstance often happens after the centre bounce when a quick kick lands at the congested top of the arc with the opposition still rushing the centre square.

Figure 4: Advantage of “Set” over Opposition “Set”



This shows clearly the “hot spot” favoured by AFL coaches. There is volatility of more than six points in contesting a mark or winning a free kick twenty metres out directly in front of goal, rather than letting your opponent have the same. Also of interest is how cool the wings are – an equity swing of less than 2.5 points for taking a mark over his opponent, as neither player can directly make use of the extra time. A kick from a set shot near the boundary will often travel straight down the boundary to a settled pack, which is very low in volatility.

Figure 5: Advantage of “Set” over “Directed”

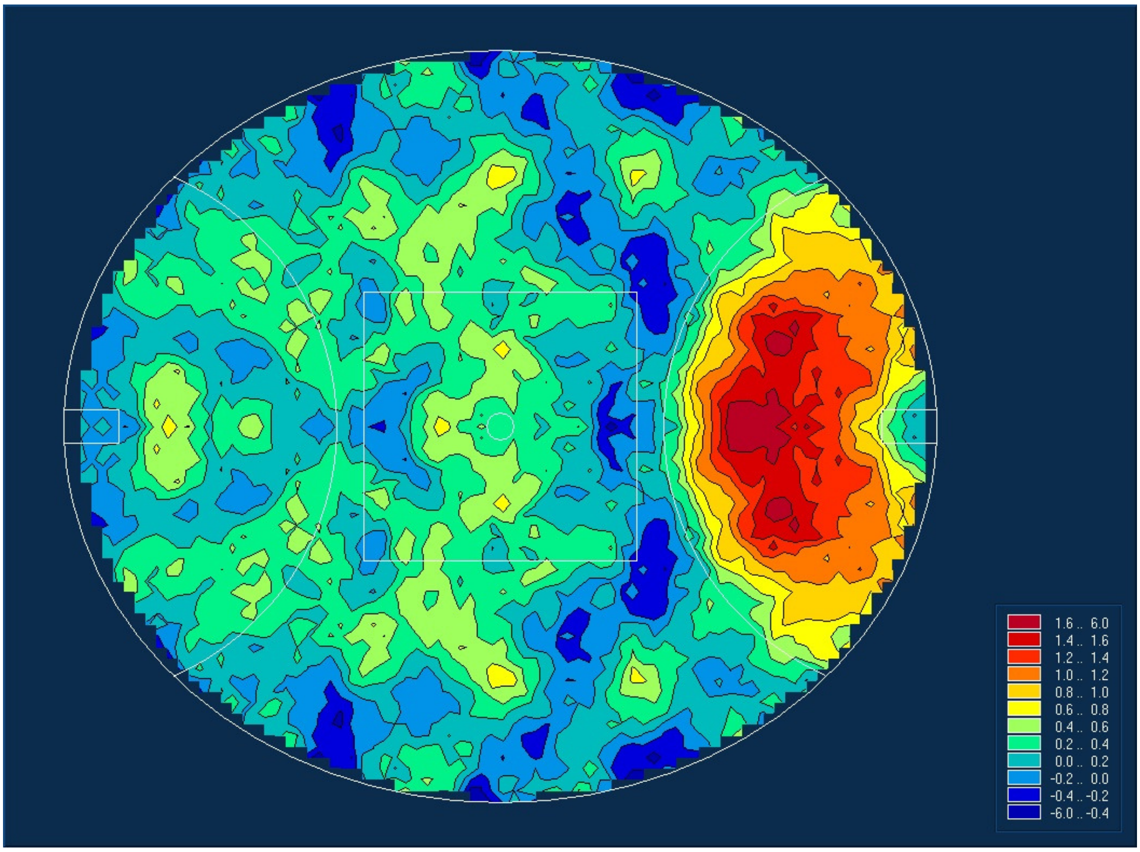
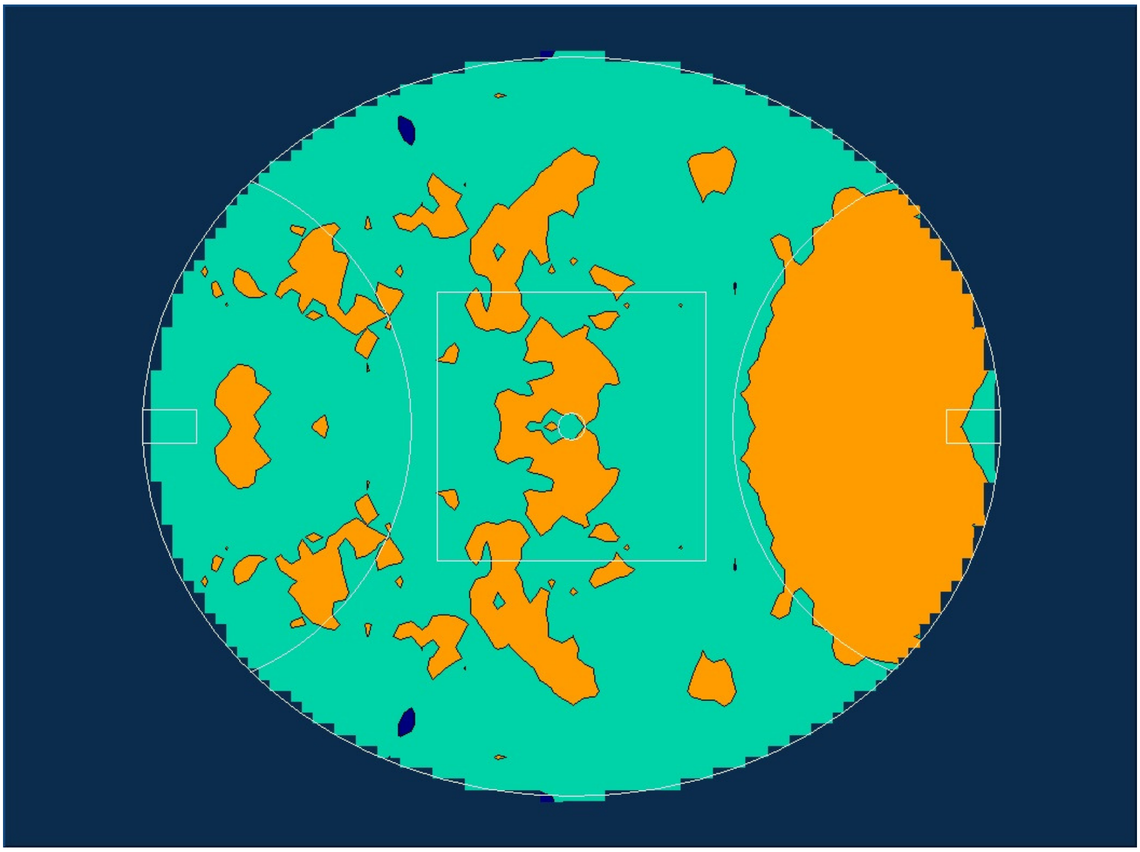


Figure 6: Significance Test: “Set” versus “Directed”



Calculated as an average over the ground, there is only a boost of 0.3 points to be gained by taking a mark instead of receiving a handball. In modern football uncontested marks across the half-back-line are cheap, with the opponent barely interested in forcing the man to go back and take the set shot. But the advantage is wholly concentrated in the forward-50 arc, with an extra 1.5 points available on the scoreboard for having a set shot rather than a running shot at goal between 25 and 45 metres out.

The light areas on Figure 6 show the regions where it is significantly better, at the two-sigma level, for a player to take a mark rather than gather it uncontested.

Average Phase Equity

The mean net value of each of the phases was calculated by averaging over the 200 zones on the field. This works as a "standard candle" to investigate deviations by teams or in certain situations.

Table 3: Equity of Possession Phases, Averaged Over Field

Phase	Mean Equity	Comments
Set	+1.61(2)	Being awarded a free kick in the centre circle is worth more than 1½ points on the scoreboard
Directed	+1.32(2)	About half-way between Loose and Set, this Phase tends to show up the good decision makers
Loose	+1.11(2)	Even if the options aren't great, it's still worth more than two points on the scoreboard to be in the right place instead of his opponent
Hard	+0.80(3)	Half the value of a set shot, compared to a 50/50 Phase

A Player's Choices: What Happens Next

Imagine a player who has just taken a mark 70 metres out from goal, on about a 40°-45° angle. It's unlikely he can score himself, and he faces an unenviable choice between bombing it long in hope of improved field position without turning the ball over, or picking out a nearby teammate to do the dirty work for him. This scenario – within six metres – has played out 822 times over the seasons 2004-2005. On average, a team in this position can expect to convert to about two points on the scoreboard (2.06(14)).

It's immediately obvious from Figure 7 below that if the player passes short and keeps it near the boundary, he almost always finds a teammate. Even more encouragingly, the team scores from there virtually every time. On the other hand, directing the ball long into the central corridor seems to be about a 50/50 proposition to hold onto the ball. Is it worth the risk? And should he play on, relinquishing the set shot time to gain some ground by running?

Figure 7: Mark on the MCG Half-Forward Flank

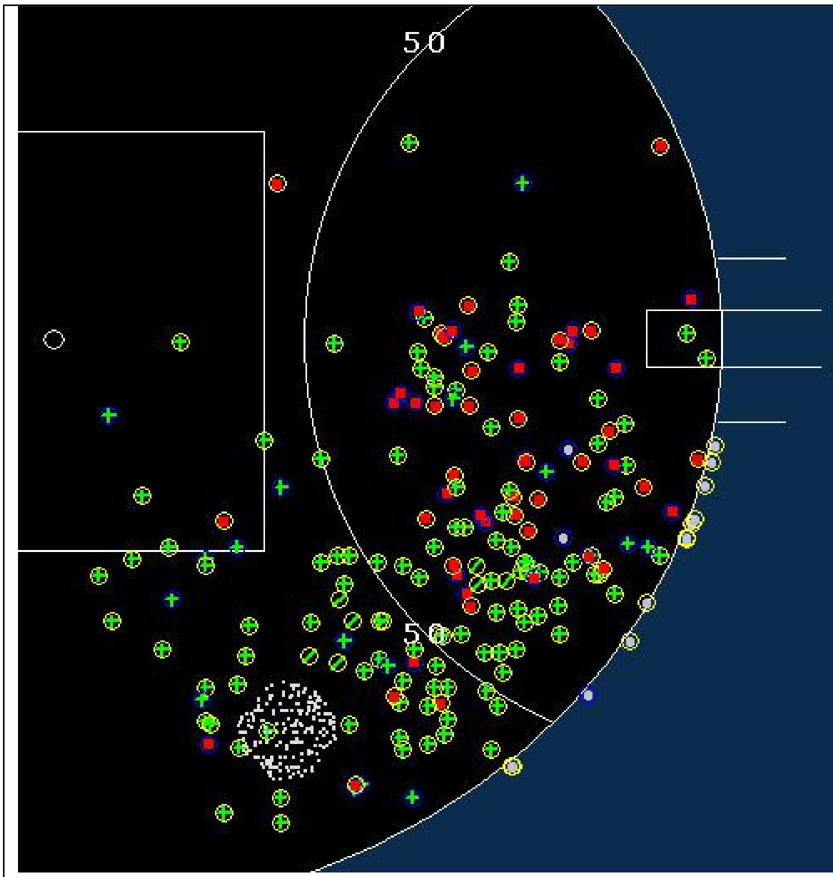


Figure 7 shows the results of the 195 marks at the MCG from this position. Showing all venues made the picture too crowded. The grey speckle in the lower left is the collection of points where a player marked. The plus signs (+) show where he managed to get the ball to a teammate, while the red squares are immediate turnovers. The grey circles indicate the ball went into the umpire's control. A ring around the marker means that the next score was to the opposition – no ring indicates a score for the marking player's team. The nine diagonal slashes are the rare occasions that the player managed to run to this point and scored for himself.

Table 4: Choices from a Mark (All Venues), 70 metres out on a 40-45 degree angle

Choice:	Handball	Kick 35m+	Kick <35m	Play On	Wait
N (%)	116 (14%)	382 (47%)	319 (39%)	347 (42%)	475 (58%)
Teammate	97%	48%	78%	73%	62%
Umpire	1%	14%	5%	8%	9%
Turnover	3%	37%	17%	19%	29%
Next Score	78%	77%	80%	81%	76%
Equity	2.08(35)	2.15(21)	1.96(21)	2.21(20)	1.95(18)

(All errors are one standard error)

The results are inconclusive, but they do highlight the dilemma. By choosing to handball, his team keeps the ball 97% of the time. With a short kick (gaining less than 35 metres or not moving closer to goal), the retention rate is 78%, but just 48% with a long kick. And yet the improved position gained from the long kick is worth the risk: a slightly higher equity as more of the scores are goals.

Players who waited rather than played on saw the defence coalesce around their options and could only find a teammate 62% of the time, for a slightly lower equity result. It should be noted that some of these would not have had the choice to play on, due to a close opponent or falling to ground after the mark.

DISCUSSION

Players and fans understand the scoreboard. Telling them that giving the won ball to the opponent at this point on the field is effectively taking three points off the scoreboard is a strong message, and should foster a new way of thinking about the game.

It has long been noticed that defenders have higher "kicking effectiveness" percentages, a measure of how often they find a teammate as a percentage of total kicks. The pictures in this paper make it obvious why – there is little pressure on them, and a wealth of options to hit. There is an implicit "funnel" in many team sports due to the location of the goals – trying to kick into the neck of the funnel at centre-half-forward is very risky, but as seen by the equity gradient also very rewarding if the team has strong marking forwards in the corridor. It is much easier to advance along the gentle equity gradient in the back half of the ground, the funnel gaping open as teammates have more space to run to.

The next step is to identify clubs' equity signatures, and find out where they are breaking down compared to the league standard. Where do they mostly direct the ball? Sydney are known to hug the boundary, but can this tactic be exploited?

CONCLUSION

This is just a first look at a huge body of data which is ready for exploitation by AFL researchers. Even these preliminary results are informing AFL coaches about the risks and rewards associated with some patterns of play. Future directions include looking at the effect of speed of play on equity – how much of an advantage is it to be able to advance the ball quickly? Or should the players switch play across the ground to exploit open space?

A semi-Markov approach as advocated for ice hockey (Thomas, 2006) could also be useful, to reduce the number of data points needed for conclusive evidence of strategic advantage.

Following the lead of baseball, an application to player ratings would be a significant opportunity. Identifying which players consistently increase equity for their team is a major goal.

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