DO FIRST MOVER ADVANTAGES EXIST IN COMPETITIVE BOARD GAMES: THE IMPORTANCE OF ZUGZWANG

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ABSTRACT

The ability to move first in competitive games is thought to be the sole determinant on who wins the game. This study attempts to show other factors which contribute and have a non-linear effect on the game's outcome. These factors, although shown to be not statistically significant, because of their non-linear relationship have some positive correlations to helping determine the winner of the game.

INTRODUCTION

In Allis's paper "A Knowledge-Based Approach of Connect-Four: The Game is Solved: White Wins", the author states that the player of the black pieces can follow strategic rules by which they can at least draw the game provided that the player of the red pieces does not start in the middle column (Allis, 1992). This would tend to indicate that position alone is the sole determinant of whether one won or lost the game, with red or the player going first always winning. Allis in his paper goes on to state that, although many people know the rules of the game, most of them know little about the way the game should be played. Inasmuch as he admits that his paper tries to fill that gap, the purpose of this paper is to try to increase the level of understanding.

Therefore, the purpose of this study is to look more closely at various aspects in a game of Connect-Four and try to determine the effect each has on its outcome, and to provide additional insight into the game and how it is played. Additionally, an attempt will be made to draw some comparisons between the strategies taken by the players and those listed/developed in Allis's analysis of the game. The result, it is hoped, will shed some additional insight as to when is execution of a particular course of action most relevant and does position alone determine the final outcome. Additionally, an attempt will be made to provide a match between the various strategies described by Allis and those reported and described by the players.

THEORETICAL FRAMEWORK

In competitive board games a player's initial strategy comes from their ability to move first. The ability to move first is important in that it gives that player the opportunity to set the tempo of the contest between the players. It is the opposing players' strategy to wrest that tempo or initiatives from their opponent. Therefore, a competitive board game is one which requires players to form strategies that are diametrically opposed to the other player(s) in the game (Zagal, et.al., 2006) Examples of such games are chess and Connect-Four. The players try to secure some sort of first-mover advantage in trying to attain some advantage of position from which a lethal attack can be mounted. The ability to move first in competitive board games has thought to have resulted more often in a situation where that player, the one moving first, being victorious. The person moving first will normally try to take control from the outset and force their opponent into making moves that they would not otherwise have made. This is a strategy which Allis refers to as "Zugzwang", which is the principle of having to play a move one would rather not.

To be able to ensure that victory through a gained advantage is attained, a position must first be determined. SunTzu in the "Art of War" described position in this manner: "this position, a strategic position (*hsing*), is defined as 'one that creates a situation where we can use 'the individual whole to attack our (the rival's) one, and many to strike a few' – that is, to win the war before joining the battle." (Ames, 1993). This is to mean where effort is either concentrated in the area or to broaden ones' attack base to gain position on several/many areas. He continues; "from this strategic position, one can gain a strategic advantage (*shih*). This advantage is described as the full concentrated release of that latent energy inherent in ones' position, physical and otherwise" (Ames, 1993). Moving first gains position from where one can execute an advantage from that position. However, the attainment of position alone cannot be the sole determinant of whether one wins the game. It is here where the principle of Zugzwang can be held throughout the game. There are other factors involved.

Some strategies depend on Zugzwang, some do not. Allis lists several variations on his basic strategies which affect the influence of Zugzwang. There are also some that are limited by an opponent's moves and therefore do not exert a significant influence (positively or negatively) on the situation. If this is not the case, Zugzwang changes and a problem occurs (Allis, 1992). It is in these instances where strategy goes completely wrong and something must change. Therefore it should not be surprised that there is a way to win against someone using the rules (Allis, 1992).

This is especially true when a given set of rules, when played, will guarantee that one will never lose (Allis, 1992), this occurs when the player who captures or controls the necessary squares (position) needed to ensure victory. It should also be noted that although many people know the rules to the (a) game, most of them know little about the way the game should be played, hence; the importance of the control of Zugzwang in attaining a desired position from which to move. To put forth the initial notion of control as it relates to chess, Bill Roberti in

his book "Winning Chess Openings" lists twenty-five (25) essential chess openings. In it he states, "we have two strategic goals in mind when playing the opening of a chess game, the first is development – the opening is the time to get our pieces into play. The second is pawn structure – we want a favorable formation of our center pawns, which will be the foundation on which we'll build our middle game attack (Robertie, 1995). What is common to both of these games are these general rules; 1) take control of the center, 2) win the exchange (the exchange can be material or position depending on the game) and lastly, 3) attack.

The determination of who wins and loses in competitive-collaborative games cannot, in all cases, be reduced to a set of mathematical formulas or a set of pre-described strategies (a set of If-Then statements). Although, it is admitted, that used in a mathematical order, one can win. A problem arises when we try to force prescribed computer generated alternatives (mathematical) into a non-mathematical (behaviorally influenced environment, (similar to IBM's computer "Big Blue" playing chess against one of the masters) such that it is only what we choose to execute, but also when.

The individual executing a Zugzwang type of strategy on their opponent would first seek some type of advantage either by moving first and being able to hold that advantage, or by occupying a superior position and exploiting it. If unable to hold or control that position, a victory looms for the opponent. In reality, each player is trying to wrest control from their rival. This is one important part of competitive games, one that leads to a desired winning position, and hence the win (which will be further defined later). The question then becomes, what are the various relationships that are formed along the course of the game which gives rise to a given situation and what are the strengths of those relationships.

THE GAME OF CHESS

CHESS: INDIVIDUAL GAMES

In chess, like other competitive board games, there exists the possibility of three types of outcomes: 1) Checkmate, where there is an outright win for one player and loss for the other; 2) Resignation, where a position exists for one of the players such that it will lead to a loss, and 3) Draw, where neither side has a winning or losing position. The game is played with white moving first and then through a series of moves, alternating with the player of the black pieces, secures a win, loss, or draw. The main objective is to take control of the center of the board and the game by forcing your opponent into moves that they would not have ordinarily made, to attain the desired (hopefully winning) position to either checkmate, force a resignation by the opponent or force a draw to the game. It should be noted that when a variability of experience exists, such as when a master plays an amateur, the master is normally confronted with a different type and greater number of inferior moves and errors tan he would find in master's play (Euwe, 1971).

This is no more evident than in the game of chess. Every player has at sometime or other reflected with wonderment on the remarkable co-ordination of brain, eye, and hand. The player studies the position – visually and mentally. He decides on a move; his brain sends a message to the hand, which accordingly plays the indicated move. The automatic perfection of this process fills us with awe. Suppose the process were to someday fail? What might be the cause for this breakdown – excitement, fatigue, time, pressure – all are possible explanations.

There are reasons for this oversight and they are as follow: 1) the player becomes deeply absorbed in a certain possibility that he quite overlooks something which is all to obvious, 2) calculates accurately just what he wants to do and yet as he reaches out his hand to move, he capriciously decides on some other totally unexpected move, 3) the player sees that a given move is bad, forgets why it is bad, and eventually plays it. Soon after he plays the move, he immediately recollects why it is inferior! Many an important game has been decided in this unfortunate manner. But in these cases, the hand cannot evaluate the moves, it can only make them as instructed – be they good, bad, or indifferent (Chernev and Reinfeld, 1949). Similarly, as we shall see, moves in Connect-Four are also governed by such actions where a misplaced chip can cause the influence and control of Zugzwang to shift.

Thirty-eight (38) games of chess were listed in the "Fireside Book of Chess" which were played by masters and grandmasters from 1892 to 1946. In these games the players of the white pieces won 28 games; six by checkmate and 22 by the virtue of the player of the black pieces resigning. The games and types of strategies are seen in Exhibit 10 where white won 73.68% of the time. It should be noted that within this series of games, at no time did opponents play each other more than once and playing the same pieces. This can be looked at in contrast to the 1972 World Chess championship between Bobby Fisher and Boris Spassky. In this monumental matchup, the player of the white pieces won only 5 games out of 21 all by resignation, there were 11 draws. This could be attributed to a number of factors such as familiarity of moves and strategies, pressure to win, amongst other things.

CHESS: TEAM PLAY

Team play is not very common at the championship level and those that are listed have the player of the white winning fifty percent (50%) of the time (once by checkmate).

THE GAME OF CONNECT FOUR

Connect-Four is a vertical checkers game where one player alternating with their opponent attempts by dropping checkers into columns, connects four checkers in a row either horizontally, vertically, or diagonally. There are four basic (as opposed to chess) strategies to the game of Connect Four (Exhibit 1). The following of these strategies can help ensure that the controller of Zugzwang has the best possibility of securing the win. In the game of Connect-Four, the winner is usually determined by either the person (or team) who takes control of the board at some time during the game and does not relinquish it. The desired outcomes here are to either win the game by connecting four checkers in a row, making the opponent concede or resign, or to force a draw to the game. A loss is described as an undesirable outcome.

In Exhibit 1 we show not only the basic strategies but also the self-described ones, which clearly resemble the basic ones. These basic strategies are a result of computer generated

Exhibit 1
Connect-four Basic Strategies

Strategy Name	Strategy Description	Self-described Strategy
Baseinverse	If two squares are directly playable and both squares are part of the same group, one player can prevent the other from completing that group by playing one square as soon as the opponent plays the other.	Blocking strategy Defensive Spread the board
Claimeven	One player can find answers to all of the rivals threats. They can claim an even numbered square. The concern is with two squares, an odd and an even, both empty, lying directly above each other.	Anticipating your rival responses Looking for openings/ opportunities Spread the board
Vertical	A pledge cannot play two men in the same column in one turn, the square above that then becomes immediately playable. The vertical rule is only used if the upper square is odd.	stacking; working the center
Lowinverse	Control of the Zugzwang will be forced to play the lowest, even square of a column which contains an odd number of empty squares. Based on the fact that the sum of two odd numbers is Even. It consists of two verticals.	

strategies via the program VICTOR. It is useful to show this comparison because there is at least at some level an understanding of the games' rules/strategies outside of those generated by the computer. The rules which govern play, although looking perfectly reasonable, do not always commit that the best result possible can be reached as seen through the above chess illustration. Looking at Exhibit 10, we can see when a strategy employed can result in a win just as much as a loss.

In this study teams were used instead of individuals. In doing so, there is an issue of the existence of cooperation between individual members or whether there was the existence of a degree of collaboration. It should be noted that collaborative board games are ones where all the participants work together as a team, sharing the payoffs and outcomes; if the team wins or loses, everyone wins or loses. The team is an organization in which the kind of information each person can have differs, but the interests and beliefs are the same (Marshak, 1972). The difference occurs in that cooperative players may have different goals and payoffs, where collaborative players have only one goal and share rewards or penalties of the decision (Zagal, 2006). In games such as Connect-Four and chess where teams can be formed to play against one another, it is important that the distinction be made between collaborative and cooperation. Additionally, you will find that the characteristics between individual and teams when playing competitive-collaborative games are very similar.

Connect-Four teams in this study are collaborative teams in that every team member received the same reward or penalty as every other team member. As stated above, the purpose of this study is to determine what other factors, in addition to moving first, come into play and their effect in determining if that player who moved first has definite advantages not realized in subsequent plays. These questions are formulated into the following hypotheses:

a) The ability to move first has no effect on the final outcome of the game. Therefore, H_0 = moving first has no effect on the final outcome of the game and H_1= moving first has an effect on the final outcome.
b) The effect of the timing of a particular strategy within the context of the overall game. Therefore, $H_{0,2}$=strategy at a particular point will have no effect on the game's outcome. Alternatively, $H_{1,2}$ that the strategy has an effect on the outcome.

Additionally, other variables will be investigated as their effect on the above relationship.

METHODOLOGY

Seventy-one (71) games of Connect-Four were played in a round-robin style tournament consisting of nine (9) teams of 3-4 members each. After each game, each team was required to provide answers to questions designed to capture the following data: who won the game (wongame); who made the first move (fmove); was this move seen as an advantage (advan); the reasoning behind it (reason); the type of strategy used to start the game (sstrategy); the type of strategy used in the middle game (mstrategy); the type of strategy used in the end game (strategy); and, were they playing to win or to tie (ggoal).

The respondents were asked to list the types of strategies they undertook in the different phases of the game. Each of the various types of strategy were then coded separately for each phase or type of game; starting, middle, and ending. These are shown in Exhibits 2 through 4. In order to provide some sense of zugzwang in qualitative terms, a number of these strategies were identified in the various phases with a couple of them also

Exhibit 2
Starting Strategies

Value	Strategy
1	Conservative
2	Defensive
3	Horizontal
4	Aggressive
5	Make them go where we want them to go
6	Reactive – copy cat
7	Look for openings/opportunity
8	Gain control: stacking, working the center
9	Form Diagonals
10	Blocking
11	No Strategy

Exhibit 3
Middle Game Strategy

Value	Strategy
1	Conservative
2	Defensive
3	Horizontal
4	Aggressive; Offensive
5	Avoid placing in the "Hot Spots"
6	Prolong game
7	Spread out board
8	Set trap and force them to move
9	Diagonals
10	Blocking Strategy
11	No Strategy

Exhibit 4
End game Strategies

Value	Strategy
1.	Conservative
2.	Defensive
3.	Horizontal
4.	Aggressive; Offensive
5.	Try to dictate where they move; set trap
6.	Wait for right spots; try to dictate where they come from
7.	Follow them; copycat strategy
8.	Diagonals
9.	Blocking Strategy
10.	Being forced to take a spot
11.	No strategy

being classified as a type of "reverse zugzwang". A reverse zugzwang is identified as an instance where control is trying to be wrested from an opponent. These are shown in Exhibit 5.

A regression analysis was performed on the data with the dependant variable being who won the game (wongame). The results from this analysis are shown in Exhibits 6 and 7. As you can see from the regression line in Exhibit 6, that the correlation coefficient (R=.329) indicates that relationship among the variables is weak in predicting who won the game. From the data in Exhibit 6, we can also see an overall negative effect in the influence or correlation among the variables. With respect to the first hypothesis/issue concerning the effect of moving first on the final outcome of the game, it can be seen that there is no high degree of correlation between these two variables.

In this case, the correlations start out as a negative relationship and would tend to suggest an acceptance of H_o, however since it cannot be proven that H_o is in fact true, it can be concluded we don't have enough evidence to reject H_o as being false.

The second issue this analysis addresses is the effect of strategy at a particular point in the game as having no effect on the game's outcome. While the data show no overall linear relationship and hence would tend to reject this notion, there is the existence of clusters within the data that suggest a non-linear relationship may exist. A partial correlations analysis was conducted controlling for the variable "wongame" to see if this correlated with what was shown in the regression correlations. Looking at Exhibits 8 and 9, there is evidence of "pockets" of positive, although low and not statistically significant, correlations among the variables reason, sstrategy, msstrategy, and estrategy in relation to the perception of moving first was seen as an advantage. It appears that in this instance that the middle strategies influence/effect only appears to increase as it appears to be more of an advantage to moving first.

Looking closer at the data in Exhibits 8 and 9, we can identify three pockets which may offer at least some information as to the effect of these variables on the outcome of the game. A low degree correlation exists between the stages of strategy, i.e. the different "games" being played. It is suggested that there is

Exhibit 5
Zugzwang – Game Type Strategies

Type Game	Zugzwang Type
Starting Game Strategy	Make them go where you want them to go Gain control
Middle Game Strategy	Avoid playing in the "Hot spots".* Set trap and force them to move
Ending Game Strategy	Try to dictate where they move: set trap Try to dictate where they come from Being forced to take a spot*

*possible case of reverse zugzang

Exhibit 6
Model Summary (b)

Mode	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F change	Df1	Df2	Sig F Change	Durbin-Watson
1	.326a	.106	- .096	.57808	.106	.536	7	31	.808	1.264

a. Predictors: (Constant), final goal, final goal, Advantage, Reasoning, Ending Strategy, First Move, Middle Strategy, Starting strategy
b. dependant variable: Winner of the Game

some relationship and degree of correlation among starting or beginning strategy, middle strategy, and end-game strategy. We can also see the data suggesting the existence of some relationship between moving first and the reasoning behind it with middle to end-game strategy. This is probably due to those stages of strategy being far removed from the beginning of the game.

Additionally, we can identify a third pocket between the different games, first move, and the perceived advantage. It is here were increases in the correlation coefficient might suggest that the middle game is the more important part of the overall strategy. This would tend to support what Roberti stated when he cited the second strategic goal of building a foundation from which to build a middle game attack. Even though the relationships are low and not statistically significant, given the existence of "pockets" of positive correlations, a case can be made to not accept H_o, that there is no effect of a particular "game" strategy on the outcome. This effect, again, is the result of a non-linear relationship.

CONCLUSION

This study has attempted to show the existence and significance of other factors other than a player moving first, which contribute to the outcome in competitive games such as Connect-Four. Although there was very little evidence of a linear relationship to assist in predicting the eventual winner, it has been determined that non-linear relationships also have an effect on the outcome by the "pockets" of small but positively correlated variables. The importance of moving first to employ strategy giving one a strong beginning cannot be discounted in total. However we find that it is the middle part of the game which allows one to have a positive effect in both in position (hsing) and competitive advantage. These effects are greater as they extend both backward to the beginning strategy and forward to the end-game strategy. These correlations suggest that the interaction and result of smaller games or "games within games" may have more to do with determining the eventual winner than who moved first to start the game.

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Exhibit 7
Regression Correlations

		Winner of Game	First Move	Advantage	Reasoning	Starting Strategy	Middle Strategy	Ending Strategy	Final Goal
Pearson Correlations	Winner of Game	1	-0.151	-0.098	-0.186	0.11	-0.03	0.095	0.122
	First move	-0.151	1	0.003	-0.051	-0.17	0.074	-0.104	-0.134
	Advantage	-0.098	0.003	1	0.046	0.011	0.096	0.005	0.045
	Reasoning	-0.186	-0.051	0.046	1	0.105	-0.038	0.074	0.063
	Starting Strategy	0.11	-0.17	0.011	0.105	1	0.382	0.339	0.192
	Middle Strategy	-0.03	0.074	0.096	-0.038	0.382	1	0.284	0.158
	Ending Strategy	0.095	-0.104	0.005	0.074	0.399	0.284	1	-0.092
	Final Goal	0.122	-0.134	0.045	0.063	0.192	0.158	-0.092	1
Sig. (1 tail)	Winner of Game		0.18	0.276	0.128	0.252	0.429	0.283	0.229
	First move	0.18		0.494	0.379	0.15	0.327	0.264	0.207
	Advantage	0.276	0.494		0.391	0.474	0.28	0.488	0.392
	Reasoning	0.128	0.379	0.391		0.263	0.41	0.328	0.352
	Starting Strategy	0.252	0.15	0.15	0.263		0.008	0.017	0.121
	Middle Strategy	0.429	0.327	0.28	0.41	0.008		0.04	0.169
	Ending Strategy	0.283	0.264	0.488	0.328	0.017	0.04		0.288
	Final Goal	0.229	0.207	0.392	0.352	0.121	0.169	0.288	

Exhibit 8
Partial Correlations – Controlling for Winner of Game - A

Control Variables	First Move	Advantage	Reasoning	Starting Strategy	Middle Strategy	Ending Strategy	Final Goal
Move First - Correlation Significance	1.000						
Advantage - Correlation Significance	.003 ,987	1.000					
Reasoning - Correlation Significance	-.051 .757	.046 .782	1.000				
Starting Strategy - Correlation Significance	-.170 .301	.011 .948	.105 .526	1.000			
Middle Strategy - Correlation Significance	.074 .654	.096 .560	-.038 .821	.382 .016	1.000		
Ending Strategy - Correlation Significance	-.104 .527	.005 .075	.074 .657	.339 .035	.284 .079	1.000	
Final Goal - Correlation Significance	-.134 .415	.045 .785	.063 .704	.192 ,242	.284 .079	-.092 .576	1.000
Winner of Game - Correlation Significance	-.151 .359	-.098 .553	-.186 .256	.110 .504	-.030 .856	.095 .565	.122 .459

Exhibit 9
Partial Correlations – Controlling for Winner of Game – B

Control Variables	First Move	Advantage	Reasoning	Starting Strategy	Middle Strategy	Ending Strategy	Final Goal
First Move - Correlation Significance	1.000						
Advantage - Correlation Significance	-.012 .942	1.000					
Reasoning - Correlation Significance	-.082 .626	.028 .867	1.000				
Starting Strategy - Correlation Significance	-.156 .349	.022 .897	.128 .443	1.000			
Middle Strategy - Correlation Significance	.071 .674	.094 .575	-.044 .794	.388 .016	1.000		
Ending Strategy - Correlation Significance	-..092 .585	.015 .931	.093 .578	.332 .042	.289 .079	1.000	
Final Goal - Correlation Significance	-.118 .480	.058 .730	.088 .600	.181 ,277	.163 .329	-.105 .530	1.000