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Transforming Knowledge into Action through Gaming and Simulation

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A three person chess game: Coalition formation and strategic behavior

RALF HANSMANN, HELMUT W. CROTT, MAURUS GAMPER, MARTIN HAAF & ROLAND W. SCHOLZ

The conventional chess game represents a classical model of the conflict situation of two players engaged in a zero-sum game. It appears challenging to use a modified variant of the game for the investigation of conflict and cooperation in small groups. Accordingly, a chess game played by three players was developed to analyze coalition formation and strategic behavior in three-person groups (see http: www.hexenspiel.de). In an exploratory study (N = 27), nine games were played under controlled conditions. Similar to previous studies analyzing mixed-motive games such as, for example, the prisoner's dilemma, tit-for-tat (Axelrod, 1984; Crott, 1985) reciprocity was the most observed strategy amongst players. In all nine games, reciprocal strikes were more frequent than non-reciprocal strikes ($p < .01$). On average, the corresponding percentages were 78.4% vs. 21.6%. Resource power of the players was operationalized via strength of figures using a calculation scheme similar to the common chess game. Contrary to observations in mixed motive games, there was no general tendency for the two weaker players to form a coalition against the strongest. The strongest player was attacked significantly less frequently than the weakest and the second weakest player. It is argued that certain characteristics of the game and dynamic processes corresponding to the reciprocity norm account for this result.

1. Introduction

Coalitions are "temporary, means-oriented alliances among individuals or groups (Gamson, 1961, p. 374)", which affect a wide range of social processes ranging from politics and economics to every day life. In many three-person games, two-person coalitions can be formed whereby two persons combine their forces to their subjective advantage (Thibaut & Kelly, 1959). This possibility also entails the risk for each player of finding him- or herself opposed by a coalition of two, which is often related to 1) a high probability of losing the game, and 2) psychological costs caused by social exclusion from the coalition (Baumeister & Leary, 1995; Leary, 1990; Van Beest, 2002; Van Beest, Wilke, & Van Dijk, 2003; Williams, 1997). In typical games, such as the political convention game or the Pachisi game, the strongest party appears particularly attractive as a coalition partner because of the strength of the resulting coalition (Gamson, 1961; Crott, Scholz, Ksiensik, & Popp, 1983; Vinacke & Arkoff, 1957). If only three persons participate in such a game, then the formation of a two-person coalition including the strongest player enhances the probability of winning the game. Nevertheless, there exists a tendency for the two weaker parties to form a coalition in these games if such a coalition is strong enough to achieve victory (c.f. Minimum Resource Theory, Minimum Power Theory; Gamson, 1961, 1964). The aspiration levels of the members of a winning coalition with respect to the division of the gains partly depend on the power of the coalition members (Komorita & Chertkoff, 1973; Komorita & Parks, 1995). Thus, for any player a higher share of the gains can be obtained when building a coalition with a weak party, as compared to a strong party, when the resulting coalition is strong enough to make a victory probable.

2. A three-person chess game

Substantial psychological research has been devoted to analyzing the cognitive processes and strategic behaviors of the players in the classical two-person chess game (e.g. Chase & Simon, 1973; de Groot, 1965). The present study uses a three-person chess game to analyze strategic behavior and coalition formation under dynamic conditions, namely when the strength of the various parties is constantly changing and when it is always possible to end a coalition and form an alternative one. For this, a new chess game, similar to the original but played by three players on a hexagonal board, was developed (for a summary of the vast number of previous modifications of the chess game, including hexagonal chess variants by Glinski, 1936, and McCooey, 1978, see http://www.chessvariants.com/).

2.1. Game board, figures and possible movements

A hexagonal board appears optimal for a three-person chess game, because it allows for the symmetric arrangement of the three parties, in which every party is separated from the two other parties by one unoccupied corner. Thus, a hexagonal board composed of 81 hexagonal fields arranged in honeycomb form was used (Figure 1). The honeycomb pattern of the field necessitated adaptations being made to the paths the chess figures follow when making a move. However, the moves of the different figures were determined in such a way that they resembled, as closely as possible, the figures' permitted moves in the conventional chess game. The chess figures were also renamed in such a way as to maintain the close analogy to the conventional chess game while at the same time indicating that the possible movements and the game rules are to some extent different. The use of fairytale figures connected to witches was suggested by a word-play: the German word for a hag, namely Hexe, somewhat corresponds to hexagon.

At the beginning of the game each party possesses one queen (witch), one king (raven), two bishops (besoms), two knights (bats), and 7 pawns (toads). The possible movements of these figures are depicted in Figures 2 – 7.

Pawn	= Toad
Bishop	= Besom
Knight	= Bat
Rook	= Tower
Queen	= Witch
King	= Raven

Figure 1: The hexagonal three-person chessboard and the positions of the figures of the three parties at the beginning of the game.

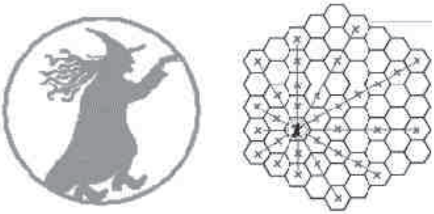

Figure 2: The witch (queen) can move diagonally, like the bishop, and forward like the rook.

Figure 3: The raven (king) can move forward, like the rook, but only one field. Analogous to the Rochade in conventional chess, the raven also has the possibility of changing the position with the tower (rook) one time during the game, if both figures have not previously been moved.

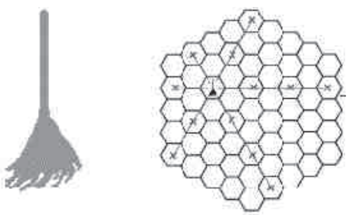

Figure 4: The besoms (bishops) can only move diagonally, which means that they always remain on fields of the same color. Their path can only be blocked by figures standing on fields of the same color.

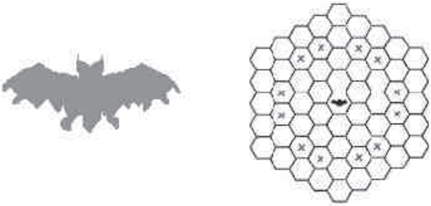

Figure 5: The bats (knights) can enter the fields surrounding a circle with a radius of two fields distance from the original position, excluding the fields reached by moving three steps forward. Thus, when positioned near the centre of the board, the bat can reach 12 fields. In contrast to other figures, the path of a bat cannot be blocked by other figures.

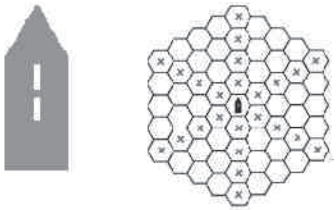

Figure 6: The towers (rooks) can move forward in any of the six directions corresponding to the 6 neighboring fields.

Figure 7: The toads (pawns) can move exactly one field forward in the direction of the corner (i.e., the two sides of the hexagonal board or the nine fields) opposite to the corner in which the toads' raven (king) stands. However, they cannot move to the field if it is occupied by another figure. The pawns can hit, however, the figures occupying the fields that are situated on the left and right hand side of the field that is directly in front of the toad. There are no extra rules concerning this movement pattern, nor are there any exceptions to this movement pattern. However, as in the conventional chess game, it is possible to change pawns into other figures when reaching one of the nine fields of the opposite side of the board.

2.2. Course and objective of the game

Firstly, the colors (red, black and white) are randomly assigned to the three players. The party with the red figures starts the game, followed by black, then white, then red again, and so on. A party makes one movement per turn. The game rules are similar to those of the conventional chess game.

A figure is not allowed to move to a field occupied by a figure of the same color. If a figure moves to a field occupied by a figure of a different color (i.e., party), then the other party's figure is hit and removed from the board. A party is eliminated when its raven is hit or, eventually, if it is not possible for the party to move any figure on its turn. If the first party is eliminated because of the inability to make a movement then all figures of that party are removed from the board. If the party is eliminated because the raven (king) was hit by another party's figure, then all remaining figures of the party, whose raven has been hit, come under the control of the hitting party for the remainder of the game. When one party is eliminated, the remaining two parties continue playing against each other until a winner is determined. Hence, the overall game consists of two phases, in which the second phase is equivalent to a two-person chess game being played on a hexagonal board.

In contrast to the conventional chess game, the ravens (kings) are not protected by any special rules. This means that there is no obligation for any party to hit a king, if indeed possible, and nor is it forbidden for a king to move to a field that can be attacked by figures of the other two parties. Moreover, when a party is not able to move any figure it has lost the game. In the second phase, the overall game can be won by hitting the opponent's king or through forcing the remaining opponent into a situation where he or she is unable to make any move. Finally, the game is won by the player having the strongest power in figures, if no figures are hit for ten consecutive rounds (for a more detailed description, see http://www.hexenspiel.de/engl).

2.3. Strategic and game theoretic considerations

As described, the game has two distinct phases, a first phase with three players, and a second and final phase with only two players. It follows, therefore, that coalition formation is only possible during the game's first phase. Hence, the present paper concentrates on the analysis of the players' behavior in game phase 1.

In the second phase of the game, the stronger of the two remaining players has a profound advantage against the weaker player. Thus, the two weaker players should form a coalition in phase 1 of the game and try to eliminate the strongest player thereby, to some extent, ensuring that they do not find themselves opposed by a highly superior party in the final game phase. In this respect, the situation during the first game phase is similar to the Pachisi and voting games, where the two weaker players often form a coalition to ensure a profitable split of the gains.

Focusing on game phase 1, but considering the consequences of the results of the first phase for the subsequent final game phase, the elimination of the first player corresponds to victory in the Pachisi game. Moreover, the probability of each of the two remaining parties winning the final phase corresponds to a split of the gains that are connected to the victory in phase 1. Thus, if victory has the utility value V = 1, and if the utility values obtained by the three players Pi (i = 1, 2, 3) at the end of the second, final and decisive part of the game are given by

$$V(Pi) = \{ (1 \text{ if } Pi = WP) \wedge (0 \text{ if } Pi \neq WP) \} \sum_{i=1}^{3} V(Pi) = 1 \quad (WP = \text{Winning Person}),$$

- which means that there exists only one winner and two losers at the end of the overall game -, then the interim utility value of the elimination of the first party is equal to the probability of winning the second phase of the game, with p(draw) ≈ 0, because of the game rules, which nearly exclude a draw. As the probability of winning against the second remaining player tends to increase with decreasing strength of this opponent, the value of eliminating the stronger of the two other players is higher than that of eliminating the weaker of the two other players. This difference is even greater when taking into consideration the fact that the figures of the party that is eliminated in the first phase come under the control of the party that has hit the raven of the eliminated party. This makes the elimination of the raven of the strongest party particularly attractive.

Previous research has shown that in mixed motive games, such as the prisoner's dilemma, a kind of reciprocity norm has a profound impact on the strategies used by players. The cooperation of an opponent induces cooperative behavior, whereas non-cooperation induces non-cooperation (Crott, 1985). Such a strategy was named tit-for-tat, and indeed proved to be particularly successful in obtaining high pay-offs in a larger series of the prisoner's dilemma game (Axelrod, 1984). Accordingly, it was assumed that the players of a three-person chess game would use an analogous strategy of contingent retaliation to 1) avoid being sequentially weakened by one party without any defense, and 2) signal to both other parties that attacks would be retaliated.

According to the considerations outlined above, it was expected that functionality in the sense of attacking the stronger of the two other players, as well as a retaliatory and reciprocal strategy resembling tit-for-tat would strongly influence player strategies in coalition formation.

This leads to the hypotheses that:

1) A player will tend to attack the stronger of the two other players rather than the weaker of the two other players.

2) As a result of the tit-for-tat reciprocity norm, a player will tend to attack the player who has recently attacked him, rather than the other player who has never attacked him or attacked him a longer time ago.

The first hypothesis is also in line with equity motivations and with the do-no-harm principle (Baron, 1993, 1994) insofar as both could serve to protect the weakest of the three players from being attacked. However, there also exist unpredictable interpersonal motivations such as, for example, those based on sympathy. Therefore, it was not expected that all moves made by players would correspond to hypotheses 1 and 2. In addition to unpredictable, interpersonal or social motivations, a game strategic source of error variance is connected to the possibility of hitting a raven, thereby acquiring the figures of the corresponding party. If, for example, the player who is neither weakest nor strongest has the opportunity of hitting the weakest party's raven (king), then choosing this option is apparently functional if the resulting increase in the player's strength makes him stronger than the second remaining opponent. Similarly, it always appears reasonable for the strongest player to defeat the raven of the weakest party, if possible. Accordingly, the final moves of the first game phase, namely the attacks directly eliminating a raven, were analyzed separately. In some cases, however, corresponding tactical considerations might also be operative and influential during previous moves in preparation for the direct attack on a raven. This might also account for some moves that are not in line with our hypotheses. However, as has already been mentioned, from a strategic viewpoint, the possibility of acquiring the figures of the eliminated party should particularly increase the motivation to attack the strongest party.

In the hexagonal chess game coalitions can only exist for certain phases and the commitment to a coalition cannot be formally assured by binding contracts. Only verbal statements of intent concerning the commitment to a coalition are possible during the game. As these statements of intent might be bogus, coalition formation was analyzed using the actual behavior during the game. It was assumed that a person attacking a particular party was to some extent involved in a coalition with the third party.

3. Method

3.1. Participants and procedure

Altogether, 27 males and females aged between 18 to 54 years took part in the study. Participation was voluntary. The 9 groups were formed in such a way as to avoid closely related people being assigned to the same three-person group. In this way, coalition formation on the basis of a priori friendships was minimized. All participants were informed of the game rules in the same way. The experimenter welcomed the participants and verbally explained the basic principles of the game using an analogy to the common chess game. However, the experimenter explicitly stated that, contrary to conventional chess tournaments, verbal communication during the game was permitted. Subsequently, the participants received a small brochure with the game instructions and were given 10 minutes in which to learn the rules. Following this, the three persons assigned to a chess match had 45 minutes in which to try and test the game together. After this test was finished, the experimental game started. The experimenter recorded, in writing, the moves made by the three players and any communication between them. There was no restriction with respect to the duration of the game. The winner of the game was promised a small award.

3.2. Calculation of the strength of each party

The permitted movements for each of the figures are similar to the common chess game. Thus, we estimated the relative strength of the figures referring to existing weighting schemes in the chess literature (e.g. Tarrasch, 1957), but with slight changes. Table 1 gives the corresponding strength values assigned to the figures. These values were used to calculate the current strength of the three parties at any point during the game.

Conventional Figure	**New Name**	**Strength value**	**Number of figures at game start**	**Sum of strength values**
Pawn	Toad	1	7	7
Bishop	Besom	3.5	2	7
Knight	Bat	4	2	8
Rook	Tower	5.5	2	11
Queen	Witch	7	1	7
King	Raven	2	1	2
Overall strength of each party at the beginning:				42

Table 1: Strength Values of the Figures

4. Results

Contrary to what was expected according to Hypothesis 1, there was a nearly significant tendency for a player to attack the weaker of the two other players (58% of all hits) more often than the stronger opponent of the two other players (42%; compare Table 2). As revealed in separate analyses, this tendency was principally due to the significant preference of the weakest player to attack the player of intermediate strength rather than the strongest player. It was only for the strongest player that a (non-significant) tendency in line with Hypothesis 1 was observed, namely that he attacked the player of intermediate strength more frequently than the weakest player.

Relative strength of hitting player	Hits on figures of the player with ... x … strength			Sum of Hits	Chi-Square value (d.f. = 1)	Significance p
	Strongest	Intermediate	Weakest			
Strongest	---	21 (3)	15 (3)	36 (6)	1.00	0.32 (n.s.)
Intermediate	17 (1)	---	25 (1)	42 (2)	1.52	0.22 (n.s.)
Weakest	15 (1)	32 (0)	---	47 (1)	6.15	0.01
	Stronger of the two other players		Weaker of the two other players			
All players	53		72	125	2.89	0.09 (n.s.)

Table 2: Frequency of Hits on Figures of the other Parties by Relative Strength of the Parties

Notes: Significance of the Chi-Square values have to be regarded with some caution as they are based on the assumption of mutual independency of the included moves. The final hits eliminating a raven are given in parentheses, but are excluded from the Chi-Square tests. Strikes in situations, where the strength of both other opponents was absolutely identical are excluded. In the case of equal strength of the hitting player with any of the two opponents the hitting player's strength (column 1) was assigned to the intermediate level.

All hits of players which have previously been attacked at least one time, were classified into retaliate strikes that attack the opponent, who ultimately attacked the player *versus* non-reciprocal strikes hitting the other opponent. In line with Hypothesis 2, there were 98 (78%) retaliatory hits and only 27 (22%) non-retaliatory strikes (Chi-Square Test, $p < .001$). In addition, there were 13 "first strikes" by players who had not previously been attacked and 9 strikes leading to the elimination of a raven. Of the latter strikes, 8 were retaliatory and only 1 non-retaliatory. Thus, Hypothesis 2 was clearly confirmed by the data.

In a final step of the analysis, those hits for which the tit-for-tat strategy could not account, namely the unprovoked "first strikes", along with the non-retaliatory hits, were analyzed separately with respect to Hypothesis 1. Here, out of 39 hits, a total of 18 (46%) were directed against the stronger opponent and 21 (54%) against the weaker of the two opponents ($p = .63$). Separate analyses for the different strength levels of the attacking player were also not significant. However, an analysis considering only the retaliatory or tit-for-tat strikes showed a nearly significant tendency in line with Hypothesis 1 for the strongest player to attack the player of intermediate strength rather than the weakest players (12 times vs. 5 times, $p < .1$). In contrast, the weakest player and the player of intermediate strength, when taken together, attacked their weaker opponent (46 times) significantly more often than the strongest player (23 times, $p < .01$).

5. Discussion

Hypothesis 2 was confirmed. Players tended to retaliate when they had been attacked. This speaks to some extent for the adequacy of the strategic behavior of the players. A tit-for-tat retaliation strategy helps to protect a player from being exploited and serves as a threat preventing others from attacking the player (Axelrod, 1984). However, Hypothesis 1 had to be rejected. No tendency for the two weaker parties to form a (winning) coalition against the strongest player was observed. Instead, the strongest party was attacked less frequently, as compared to the remaining parties. This seeming inappropriateness might, however, be related to the apparent reciprocity strategy of contingent retaliation. The reason for this suggestion is that the two strategies of "retaliation" versus "attacking the strongest party" are frequently aimed at opposite targets. At the beginning of the game it was often observed that when the first figure had been hit, retaliation followed, with this retaliation, in turn, also being retaliated, resulting in further retaliation, and so on. Thus, the player excluded from the tit-for-tat battle became the strongest player. Accordingly, one reason as to why the strongest player was rarely attacked seems to be that this player did not provoke the retaliation of either opponent. This suggests that a neutral strategy avoiding initiating any attacks on other parties might be particularly successful in a three-person chess game. Moreover, as the deviations from our Hypothesis 1 were particularly large with respect to the retaliatory strikes of the two weaker parties, the results indicate that the contingent retaliation strategy might be applied by the players to a larger degree than would be functional. However, this finding might also be due to threads exerted by the strongest party. An analysis using a greater number of groups, and taking into consideration the protocols of verbal communication, and the exact strength levels of the parties would be necessary for an in-depth analysis and understanding of players' behaviors and strategies in the game.

References

Axelrod, R. (1984). *The Evolution of Cooperation*. Basic Books, New York.

Baron, J. (1993). Heuristics and biases in equity judgments: A utilitarian approach. In B. A. Mellers & J. Baron (Eds.), *Psychological perspectives on justice: theory and application* (pp. 109-137). New York: Cambridge University Press.

Baron, J. (1994). Blind justice: Fairness to groups and the do-no-harm principle. *Journal of Behavioral Decision Making, 8*, 71-83.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*, 497-529.

Chase, W. G., & Simon, H. A. (1973). Perception in chess. *Cognitive Psychology, 4*, 55-81.

Crott, H. W. (1985). Theorien des interpersonellen Konflikts. In D. Frei & M. Irle (Eds.), *Theorien der Sozialpsychologie.* Band II: Gruppen- und Lerntheorien. Bern: Hans-Huber Verlag.

Crott, H. W., & Albers, W. (1981). The equal division kernel: An equity approach to coalition formation and payoff distribution in N-person games. *European Journal of Social Psychology, 11,* 285-305.

Crott, H. W., Scholz, R. W., Ksiensik, M. I., & Popp, M. (1983). *Koalitionsentscheidungen und Aufteilungsverhalten in Drei-Personen-Spielen: Theoretische und experimentelle Untersuchungen zu Konflikt, Macht und Anspruchsniveau*. Frankfurt am Main: Verlag Peter Lang.

de Groot, A. D. (1965). *Thought and choice in chess*. The Hague: Mouton.

Gamson, W. A. (1961). An experimental test of a theory of coalition formation. *American Sociological Review, 26*, 565-573.

Gamson, W. A. (1964). Experimental studies of coalition formation. *Advances in Experimental Social Psychology, 1,* 81-110.

Komorita, S. S., & Chertkoff, J.M. (1973). A bargaining theory of coalition formation. *Psychological Review, 80*, 149-162.

Komorita, S. S., & Parks, C. D. (1995). Interpersonal relations: Mixed motive interaction. *Annual Review of Psychology, 46,* 183-207.

Leary, M. R. (1990). Responses to social exclusion: Social anxiety, jealousy, loneliness, depression, and low self-esteem. *Journal of Social and Clinical Psychology, 9*, 221-229.

Tarrasch, S. (1957). *Das Schachspiel*. Berlin: A. Seydel Druck und Buchbinderei G.m.b.H..

Thibaut, J., & Kelley, H. H. (1959). *The social psychology of groups*. New York: Wiley.

Van Beest, I. (2002). *The social psychology of coalition formation*. Paper presented at the ECPR conference in Turin, Italy. Amsterdam: Faculty of Social and Behavioral Sciences, Communication Sciences Departement.

Van Beest, I., Wilke, H., & Van Dijk, E. (2003). The excluded player in coalition formation. *Personality and Social Psychology Bulletin*, 29(2), 237-247.

Vinacke, W. E., & Arckoff, A. (1957). An experimental study of coalitions in the triad. *American Sociological Review, 22*(1), 406-414.

Williams, K. D. (1997). Social ostracism. In R. Kowalski (Ed.), *Aversive interpersonal behaviors* (pp. 113-170). New York: Plenum.

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