Journal of Mathematical Sociology
1971, Vol. 1, pp 119–132

THE CHECKERBOARD MODEL OF SOCIAL INTERACTION†

JAMES M. SAKODA
Brown University

The checkerboard model is a computer simulation of social interaction among members of two groups. The checkerboard represents a social field on which two groups of checkers move on the board on the basis of positive, neutral or negative attitudes toward one another assigned to them. The resulting pattern of positions of the pieces represents the social structure. The theoretical basis for the checkerboard model is explained and the rules for operating the model are outlined. This is followed by illustrative runs named Crossroads, Mutual Suspicion, Segregation, Social Climber, Social Worker, Boy-Girl, Couples and Husband-Wives, showing intermediate and final positions on the board for each. It is concluded that the checkerboard model is capable of demonstrating the intimate connection between attitudes of group members toward their own group and toward others to a continuous social interactional process and to the resulting social structure.

One of the persistent problems of social psychology is the adequate conceptualization of the relationship between individual members and the group. Psychologists can be content to study, for example, the perceptual process of a single member or explore his personality. Sociologists can likewise study the social group as an entity. For the social psychologist the desire is to study the interaction among two or more members and to understand how this interaction is related to such group concepts as social stability and group structure. The checkerboard model provides a concrete means of portraying social interaction as an ongoing process among members of groups. The resulting pattern of distances among individuals can be interpreted as the social structure resulting from the interactional process. Conceptually, the model may represent a breakthrough in the wall separating psychological concepts from sociological ones. A computer program has been written in FORTRAN to operate the model. In this paper the underlying theoretical concepts are discussed, the rules under which the model operates are given, and examples of applications of the model provided.

†This study is partially supported by National Institutes of Mental Health Grant MH–08177–05, Computer Utilization for Behavioral Sciences. The help of the following in making runs of the model and in writing computer programs for the model is gratefully acknowledged: Paul J. Woods, Leslie Hyman, James Bruce, Robert Munck, Elliot Perlman. The most recent program was written by William J. Sakoda. Those interested in a listing of the FORTRAN program written for the IBM 1130 should write to the Department of Sociology and Anthropology, Brown University, Providence, R.I. 02912.

Social Attitude

Social attitudes or definition of the situation, terms coined and used extensively by W. I. Thomas (1927, and Volkart, 1951), are basic concepts employed in the checkerboard model. Each participant adopts an attitude or defines the situation and then moves on the board in accordance with this definition. The importance of the concept lies in its ability to express a relationship between a person and the environment in which he operates. It is a very general term since the definition can be general or particular, momentary or lasting. It is also a term which can be applied to groups as well as to individuals as in the expression social or cultural definition of the situation. The concept of attitude differs from a term such as trait, which has no situational referent. W. I. Thomas expounded the notion that social attitudes manifest themselves in the social activities of individuals and are the bases for social organization and societal values. However, he did not concretely illustrate this interactional process.

Psychological Field or Life Space

Kurt Lewin (1951) made use of a concept very similar to definition of the situation which he called psychological field or life space. The psychological field also has both a subject and object referent. Lewin went farther than W. I. Thomas in analysis of the internal structure of the psychological field and in diagrammatically illustrating it. He used concepts such as field force, valence, goal, paths to goals. The single most important property of a psychological field is its valence—i.e., the degree to which it is positive, neutral, or negative.

Difficulty of the Subjective Approach

The difficulty of analyzing the interaction of two or more individuals through the concept of attitudes or psychological fields is that there are as many psychological fields as there are participants in the social situation. For example, in illustrating the social interaction of a husband and a wife who are drifting apart, Lewin (1951, Chapter IX, *Frontiers in Group Dynamics*, pp. 188–237), shows five diagrams, the life space of husband at Time 1, of wife at Time 1, and a social field at Time 2. This is followed by the life spaces of the husband and wife at Time 2. At Time 1 the individual life spaces indicate the husband moving toward the wife thinking that the wife is also moving toward him. The wife, to the contrary, is moving away from the husband. The objective social field shows what is actually happening: the wife is moving away from the husband and the latter is in pursuit. Individual life spaces at Time 2, however, show the pattern reversed. The husband is moving away, seeing that the wife is not moving toward him as he had supposed. The wife, on the other hand, now moves toward the husband, seeing that he was approaching her.

Lewin's suggestion is that the analysis proceed from separate life spaces to the social field and then back again to individual life spaces. What is needed is a less cumbersome means of relating individuals with subjective attitudes to one another.

Development of the Checkerboard Model

The checkerboard model grew out of an attempt to portray the social interaction in a relocation center during World War II (Sakoda, 1949 and Thomas 1946). On

one side there were administrative personnel, only some of whom were favorably disposed toward Japanese evacuees from the West Coast. On the other hand, there were evacuees, who were withdrawn into their own barrack apartments. In between were evacuee leaders, some of whom adopted positive attitudes toward the administration and others who showed negative attitudes. It occurred to the writer that social interaction might be well portrayed on a checkerboard with two different kinds of pieces moving about on the board. The board represented an objective social field. The pieces on the board were participants who could be assigned attitudes toward one another, either positive, neutral or negative. Each individual was assigned two sets of attitudes—one toward other members of one's own group and the other toward members of the opposing group. Changes in patterns of attitude showed interesting changes in patterns of pieces on the board.

At first the model was operated by moving pieces on the board, and rules were set up so that the closest pieces were given consideration first in making moves, if unique moves could be made. Otherwise, more and more pieces were taken into consideration in deciding the place to which a piece could be moved. When a piece had two attitudes, one toward its own group and another toward the opposing one, each attitude was allowed to operate independently of the other, in order to make the calculation easier. This separation of attitudes also helped to add flexibility to the moves. Several, computer programs were then written to operate the model and at this point distances from a piece to every other was calculated, prior to making a move. Two of the programs displayed the model in operation on a graphical display screen. In the most recent model, distances from both attitudes were combined resulting in a single combined move. This helped to make the patterns less subject to chance variation, but also increased the inflexibility of moves. To overcome this tendency pieces which were not able to make a move one space away were allowed to search farther another space for a possible jump. This provided a desired degree of flexibility. Throughout the variations in mode of operating the model the general pattern of moves of pieces on the board had basically not varied greatly so that the results reported here can be considered to be representative of several variations of the model.

The Model and Its Function

The checkerboard model in its present form is more of a basic conceptual framework than a model of any given social situation. It has potentiality for further elaboration to fit particular situations. As it now stands, it can be used as a visual representation of the social interactional process, relating attitudes, social interaction and social structure. It should be particularly useful in introductory courses, not only in illustrating the relationship among these concepts, but also in discussing the function of models. A model is not necessarily used to predict behavior in a real situation. Model building is useful in clarifying the definition of concepts and the relationship among them. Left in verbal form, concepts can be elusive in meaning, whereas computerization require precision in definition of terms. Models can be used to gain insight into basic principles of behavior rather than in finding precise predictions of results for a given social situation, and it is this function which the checkerboard model in its present form provides.

The Social Field Concept

In this model the checkerboard represents a social field. It is a socially or culturally defined field whose properties are accepted by the participants. These properties are codified in rules of play, which governs the movement of pieces on the board. The importance of the social field concepts lies in allowing participants with subjective attitudes to interact on it, thus overcoming the dilemma of social psychologists who were reluctant to give up the subjective factors which were crucial to the analysis of the dynamics of behavior. It also avoids the dilemma of the psychologist who feels he must deal with the total personality of the individual, since the social field is allowed to select out only those attitudes which are pertinent to a given social situation.

The two-dimensional space of the checkerboard can be most easily conceived of as physical space, but probably should not be confined to that. Distance can be social in nature. Closeness can be thought of in such terms as communication between individuals. Two neighbors, for example, can physically live close to one another without social interaction and hence maintain a large social distance between them. Two individuals living far apart can still maintain a close social distance through identification, imitation, and communication. The center of the board represents a point of convergence of individuals; the periphery locations of withdrawals. Individuals attracted by one another tend to converge toward the center of the board, while those who are escaping from others generally move away from the center to the periphery of the board.

Locomotion or movement of individuals within the social field represents social behavior—i.e., behavior which is affected by the presence of others in the social field. An individual with neutral attitudes toward everyone would not move and hence would not exhibit social behavior. In the initial model movements are defined grossly as approach or withdrawal and it is not possible to distinguish, for example, aggression from withdrawal or approach. One of the advantages of the social field concept as represented by the checkerboard is that it is possible to allow continuous process of social interaction to take place, and to observe the change of position of each individual on the board during the interactional process.

Finally, the pattern of positions of individuals on the checkerboard can be used to define the existing social structure. Individuals attracted to one another will move close to each other and will form a cohesive group. Mutual repulsion will result in wide separation between individuals, indicative of social distance between them. Two cohesive groups which repel each other will gravitate to opposing corners, forming a segregated pattern. Couples made up of one person from each of two groups can be dispersed over the board, indicating a pattern of cohesion between individual members of two groups. Some patterns of relationship will be stable and not be subject to further change once they are reached. Others are unstable, and are subject to continual change over time. The checkerboard model provides students of social structure with a possible explanation of its dynamics.

The Rules of the Game

The checkerboard model of social interaction, like other models, is a simplified version of a more complex social situation. It cannot be expected to represent the full

complexities of actual social situations, but rather is used to explore the effects of a few variables. There is no assurance, of course, that the rules which are devised are the most appropriate ones. They have been devised to produce effects which appear to be applicable to social situations. Some of the restrictions such as the size of the board, the two-dimensional quality of the social field, the rule that a position can be occupied by only one piece are arbitrary and restrictive and it is possible to explore the effects of varying them. Here the rules are given as they are followed by the most recent computer program.

1. An 8×8 checkerboard represents the field of social interaction. The rows are numbered from top to bottom, 1–8, and columns from left to right, 1–8. Each of the 64 cells is identified by its row number followed by its column number. (The board can be varied in size from 2×2 to 12×12.)

2. Two sets of six pieces each are used, Squares and Crosses. The two sets represent two groups and the pieces members of groups. Each piece is assigned a number from 1 to 6. (The number in each group can be varied.)

3. Unless otherwise stated the starting positions on the board is determined by a random process. This produces a social structure in which groups are indistinguishable and members of both groups are scattered throughout the board. The user provides an odd random number to specify a starting position. (He can also specify a preset pattern of pieces, if he so desired.)

4. Each checker is assigned a positive, neutral or negative valence or value. There are two sets of such values, one toward members of one's own group and another toward members of the other group. These represent attitudes toward members of one's own or the opposing group:

	Toward Own Group	Other Group
Attitude of Squares	+1, 0, or −1	+1, 0, or −1
Attitude of Crosses	+1, 0, or −1	+1, 0, or −1

(The weight of the attitude can be varied by specifying larger weights, such as 2 or 4.)

5. Members of each group make their move in a random order. A completion of one turn for all members of both groups represents a cycle and during a cycle each piece gets one turn each.

6. Normally each piece takes one step on each move. A step can be up, down, or to the side one square or to one of the four diagonal cells, provided the cell in question is not occupied by another piece. If there is no advantage to making a move a piece stays where it is. To overcome a tendency of cohesive groups not to move after it is solidified, pieces which are unable to move are allowed to search a distance of two squares in all directions to find the most advantageous position. This, therefore, permits a jump over one square.

7. The choice of a move is based on the inverse of the distance of each piece from every other toward whom it has a positive or negative attitude, and closer pieces are given greater weight than distant ones. The distance is calculated by summing the squares of the distance on the X and Y coordinates:

$$D = (X_i - X_j)^2 + (Y_i - Y_j)^2$$

The inverse of this distance is weighted in two ways. First it is weighted positively or negatively by the valence of the attitude of the *i*th piece toward the *j*th. Secondly, a distance weight is applied by taking the *n*th root of the distance. If the distance weight is 2 the square root is taken; if 4 the fourth root is taken. The greater the distance weight the greater the relative weight given to the distance pieces. With a distance weight of 2 the influence of several pieces a distance of 7 or 8 squares away would be overcome by a single adjacent piece. With a distance weight of 4, however, several pieces on the other side can overcome the influence of a single adjacent piece. The runs reported here have been made with a distance weight of 4, thus allowing several distance pieces to carry some weight. The formula for calculation of the sum of the weighted distance can be written:

$$f = \sum \left(\frac{V}{D^{1/w}} \right)$$

where V is the valence of the attitude, D is the square distance between two points on the board, w is the distance weight. The summation is over all other individuals. Whenever it is the turn of a piece to move it checks all possible positions to which it is allowed to move and selects the move which has the highest positive value of f.

8. The maximum number of cycles can be specified. The number of cycles which should be run is dependent upon the degree of stability of a social pattern. When a stable pattern is reached and no further change occurs, the run can be terminated. Unstable patterns which do not terminate but change slowly must be run longer to detect the pattern of change involved.

9. After each cycle the position of each piece is shown in a printout.

10. The following descriptive measures are calculated and printed out at the end of a run.

a. Number of cycle.

b. For each group the mean X and Y coordinated, $\bar{X}$ and $\bar{Y}$, indicating the positions of the group centroids.

c. The distance between the centroids of the two groups.

d. For each group the index of dispersion, which is calculated as:

$$\text{Dis} = \sqrt{\frac{\sum (X_i - \bar{X})^2 + \sum (Y_i - \bar{Y})^2}{N}}$$

Illustrative Runs

At least three runs of several combinations of attitudes were made to study the nature of the social interactional process and social structure associated with different combinations of attitudes. These are named Crossroads, Mutual Suspicion, Segregation, Social Climber, Social Worker, Boy-Girl, Couples, Husband-Wives. All of them are started from random positions. For each run several cycles from a typical

run are shown. Some of the runs end quickly in a stable pattern, others continue to change and do not stabilize. Comments are made to show the types of situations to which one can apply the particular model.

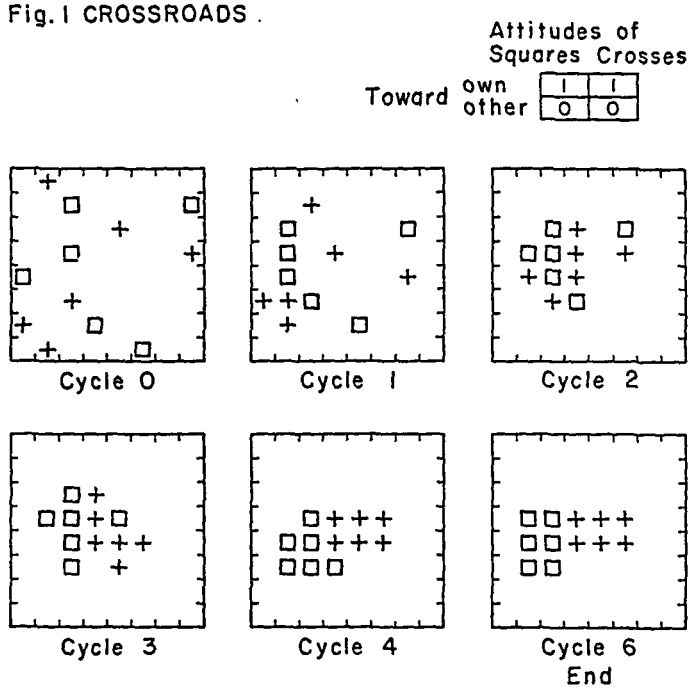

FIGURE 1 *Crossroads* (Squares: 1 to Own, 0 to Other; Crosses: 1 to Own, 0 to Other).

The simplest situation is one in which one group is attracted by one's own group and is neutral toward the other, and the other group does likewise. It is sometimes said that a group, by sticking together, alienates itself from other groups. Minority groups, for example, frequently are accused of being withdrawn and clannish, instead of associating with members of the majority groups. Some will therefore predict that this pattern of positive attraction to one's own group will result in a segregated pattern, with the two groups widely separated on the board. In Figure 1 is shown a typical sequence for this combination of attitudes.

Each group moves toward the center of the board, and in the process contacts members of the other group. At the end the two groups disentangle themselves into two separate groups, sitting side by side near the center of the board. This stable state was reached in six cycles. To meet other members of one's group the movement in general is from the periphery of the board to the center. The periphery of the board represents a state of isolation. An analogy would be between widely scattered farms in the countryside and crossroads where a few stores are located and people congregate. In a hotel individual rooms would represent locations of social isolation, while the lobby would represent the crossroads where people are likely to meet one another. Mobility in the form of attraction to other members of one's own group is

more likely to bring one in close contact with members of other groups. It is the stay-at-home, unattracted by anything else, who is not likely to make new contacts.

Another simple situation is one in which members of both groups have neutral attitudes towards their own group and negative attitudes toward the other. One might suppose that movement away from each other will lead to isolation of each group in opposing corners, forming segregated groups. With the jumping option this does happen: without it, it generally did not happen. In Figure 2 is shown every other cycle of a run. Initially, each group breaks up into weak clusters, as can be seen in Cycle 3, but eventually after nine cycles a stable segregated pattern is reached.

Fig. 2 MUTUAL SUSPICION

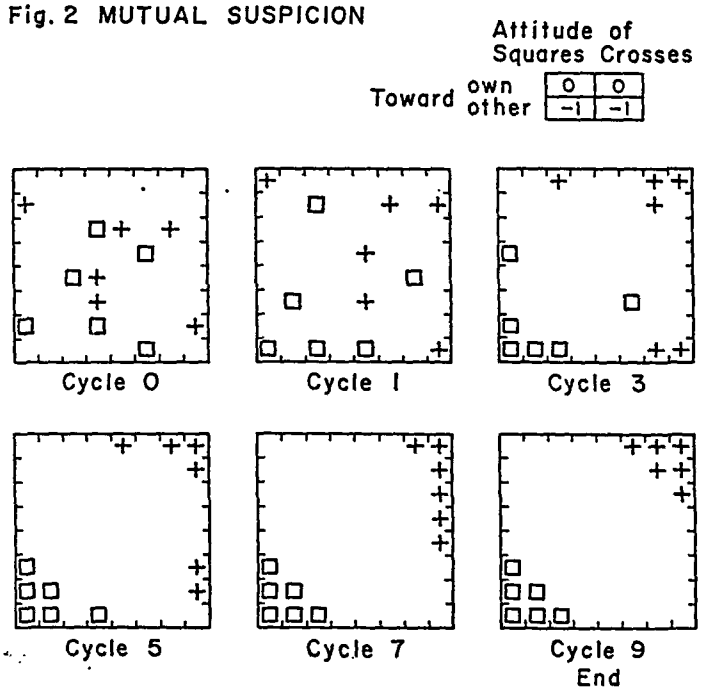

FIGURE 2 *Mutual Suspicion* (Squares: 0 to Own, −1 to Others; Crosses: 0 to Own, −1 to Others).

Initially, mutual suspicion creates fragmented and weakly clustered subgroups, and cannot be counted upon to form strong in-groups. In a police state, for example, there can be a tendency for people to be secretive and not communicate with members of one's own group. The lack of solidarity within a group would make communication between groups difficult also. The pattern is unstable until segregated groups are formed.

When both positive attitudes toward one's own group and negative attitude toward the opposing group are in effect, the typical pattern is withdrawal of both groups into opposing corners (Figure 3). Initially, however, there is a tendency for both groups to move toward the center in order to form in-groups and then as groups to move out to opposing corners.

When one finds segregation, one can assume the existence of both a positive attitude

Fig. 3 SEGREGATION

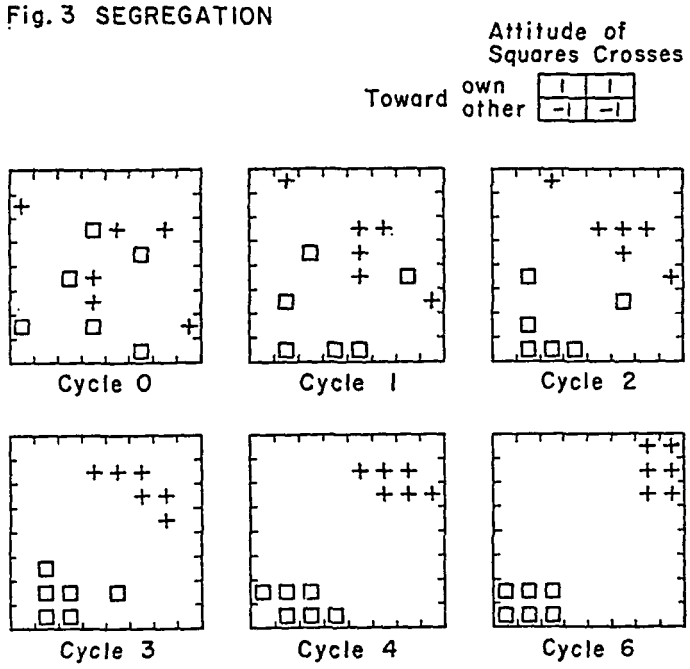

FIGURE 3 *Segregated Groups* (Squares: 1 to Own, −1 to Others, Crosses: 1 to Own, −1 to Others).

toward one's group and a negative one toward the other group. Racial groups, for example, seek residential areas where others of their kind are already living. At a party of couples, frequently men and women get together in different rooms. This is particularly true when the main activity is conversation. Men dislike the small talk of women about babies and clothes, and prefer to discuss business matters, sports or politics. Likewise, women are repelled by men's conversation, and seek other women. The pattern would be different, of course, if men and women were seeking sexual stimulation.

While the end patterns for Mutual Suspicion and Segregation are quite similar, the intermediate configurations are different. The greater cohesiveness within groups and the initial closeness between groups in the segregation patterns would, it seems, enhance communication between the two groups.

The social climber situation is essentially a pursuit situation, in which the Squares, disliking one another, spread out and chase the Crosses, who form an in-group, which attempts to elude the pursuers. In Figure 4 every third cycle from 0–15 is shown. One might suppose that the Crosses would form a tightly-knit group in the center and would be surrounded by the Squares. In order to avoid the pursuer, however, the Crosses seek refuge on the periphery of the board. When it is surrounded by the Squares, it attempts to break away and usually does so to another part of the board, and in the process breaks up into subgroups. The situation is unstable, since the Squares again close in on the Crosses, and move to another part of the board is again necessitated. Occasionally, the Squares manage to trap the Crosses in a corner.

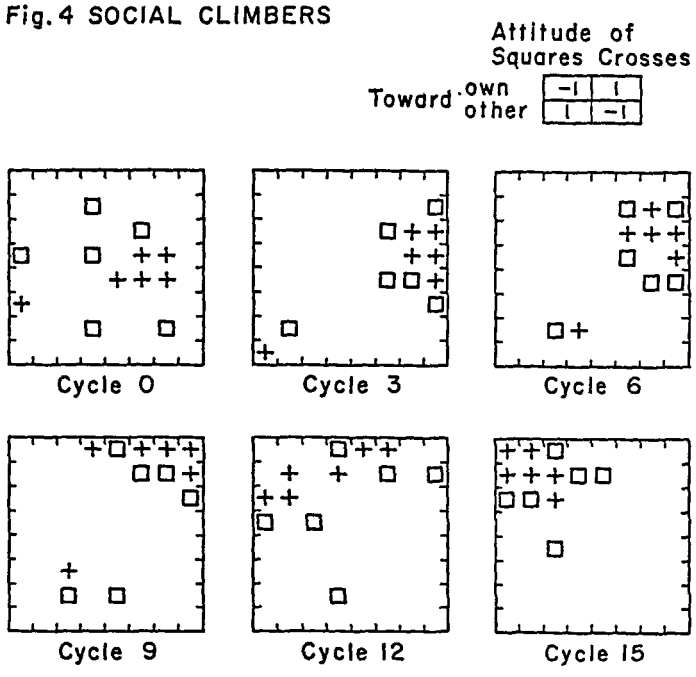

FIGURE 4 *Social Climber* (Squares: −1 to Own, 1 to Other; Crosses: 1 to Own, −1 to Other).

There are a number of social analogies to this situation. The upper class needs to move away from an area when it deteriorates and lower classes begin to move into it. Such movement can occur a number of times until some means is found to keep the lower classes away. Fashions follow a similar pattern. The fashion setters seek a new design. As soon as the fashion spreads to the run-of-the-mill crowd, fashion needs to be changed. The change is mandatory even if the trend is reversed from short skirts to long ones, from big cars to small ones, etc. To escape pursuit it is frequently necessary for the Crosses to split up. The more tightly a group sticks together the easier it is for them to be surrounded by the pursuers or imitators. The isolated Cross has the best chance of being left alone.

The social worker pattern is like the social climber situation with the roles of the pursuer and pursued reversed. The Squares have positive attitudes toward both its own group and others. The Crosses have negative attitudes toward both its own groups and the Squares. The Crosses scatter throughout the periphery of the board while the Squares group together and slowly pursue one or two Crosses around the edge of the board. In Figure 5 every other cycle from Cycles 8 to 18 is shown. The pursuit is inefficient because only a limited contact with one or two Crosses is possible at any one point, and the movement around the board is extremely slow.

The situation resembles some social work situation in which a well-organized group pursues unorganized individual delinquents who are scattered in the neighborhood. It is also reminiscent of missionary work which involves an organized group in pursuit of individual 'lost souls' who have little interest in having their souls saved. An alternative is to encourage the organization of the pursued group under a leader,

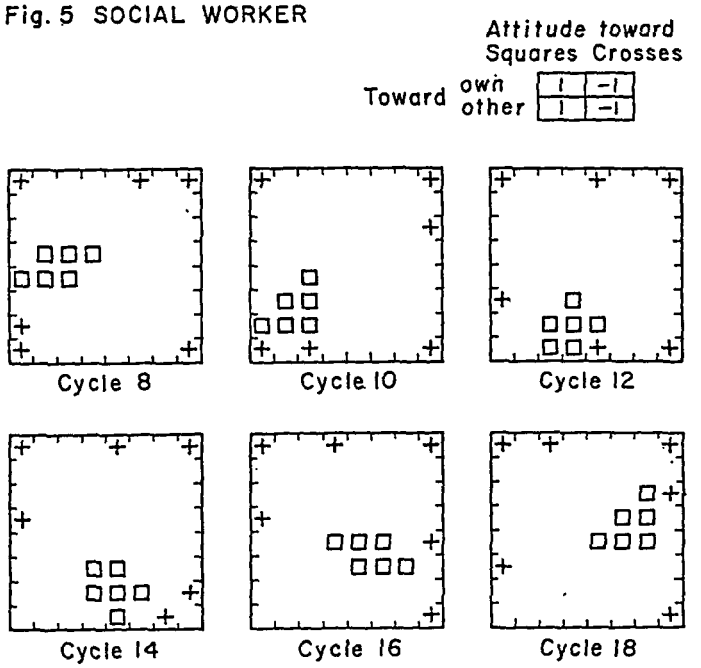

FIGURE 5 *Social Worker* (Squares: 1 to Own, 1 to Other; Crosses: −1 to Own, −1 to Other).

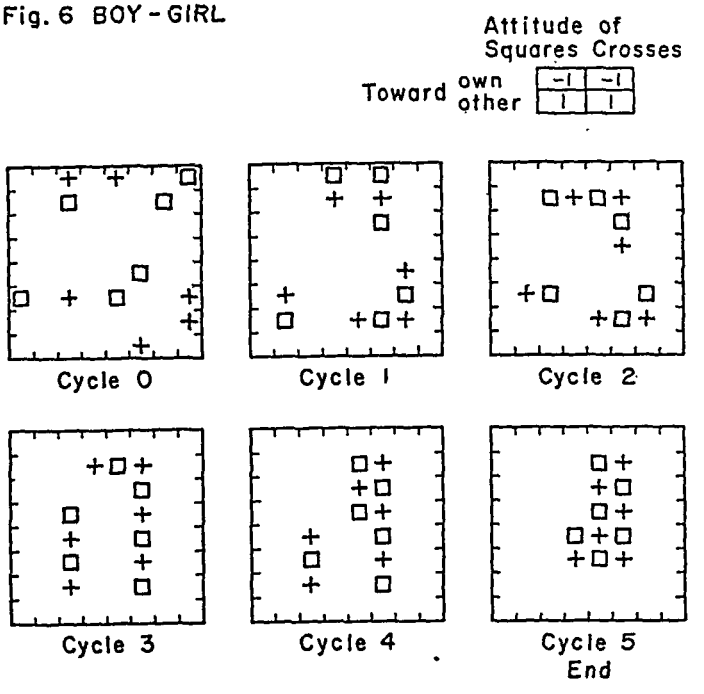

FIGURE 6 *Boy-Girl Situation* (Squares: −1 to Own, 1 to Other; Crosses: −1 to Own, 1 to Other).

which would facilitate group to group communication. Another is to set up a soup kitchen or a medical center which meets needs of the group and will attract them to a central location. Still another is for pursuers to disperse and seek out lost souls individually.

In the boy-girl situation both groups are repelled by members of one's own group and attracted by members of the other group. One might suppose that this pattern of attitudes would end up with couples scattered throughout the board. As can be seen in Figure 6, there is some tendency initially for couples to form between pairs which happen to be close to one another. There is an additional tendency for couples to move close to another to form a circle of alternating Squares and Crosses; as can be seen in Cycle 2. The circle eventually collapses into a stable checkerboard pattern.

Given the pattern of attitudes, the most satisfying position is not that of isolated couples, but rather one of a party situation in which one has a partner on more than one side. Under this pattern it is possible not only to share a partner, but also to change them when moving from one part of the board to another, so that the association between pairs is not in any sense permanent. The hostess who plans to seat men and women alternately around the table, avoiding pairing husbands and wives, is attempting to carry out the logical pattern for the boy-girl situation. One of the interesting questions in this situation is what it would take to form couples scattered throughout the board.

Strong attachment to a particular partner, for example to the one one meets first, can help to form couples on the board. A similar device would be a marriage vow which would hold couples together as a unit. Such individual choices, however, are

Fig. 7 COUPLES.

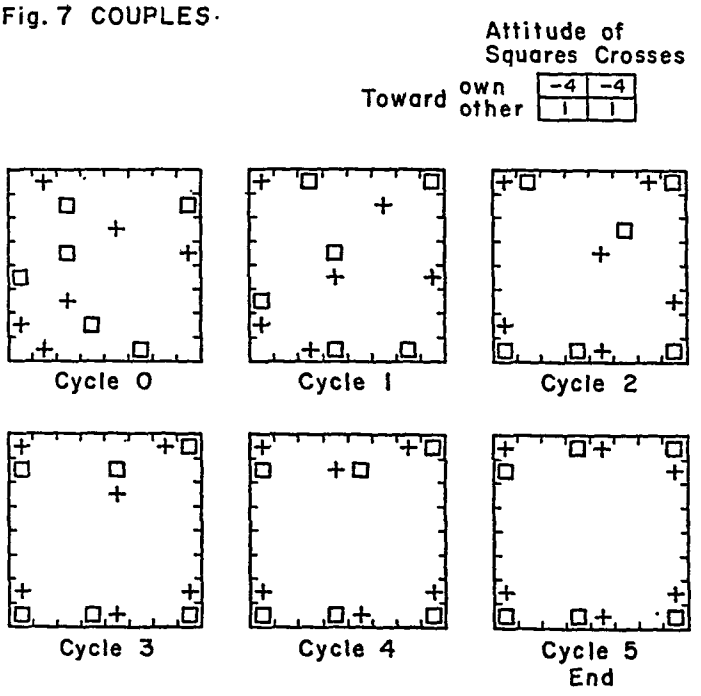

FIGURE 7 *Couples* (Squares: −4 to Own, 1 to Others; Crosses: −4 to Own, 1 to Others).

not part of the program yet, and a different method has been found to form couples. This consists of increasing the strength of the negative attitudes of both Squares and Crosses to their own kind from −1 to −4. This increase in negative attitude keeps individuals within a group widely spread out on the board—the result of which is that the positive attitude across the group will form couples, as shown in Figure 7. Hence, one method of preserving the separated couple arrangement is to develop negative attitudes within sexes.

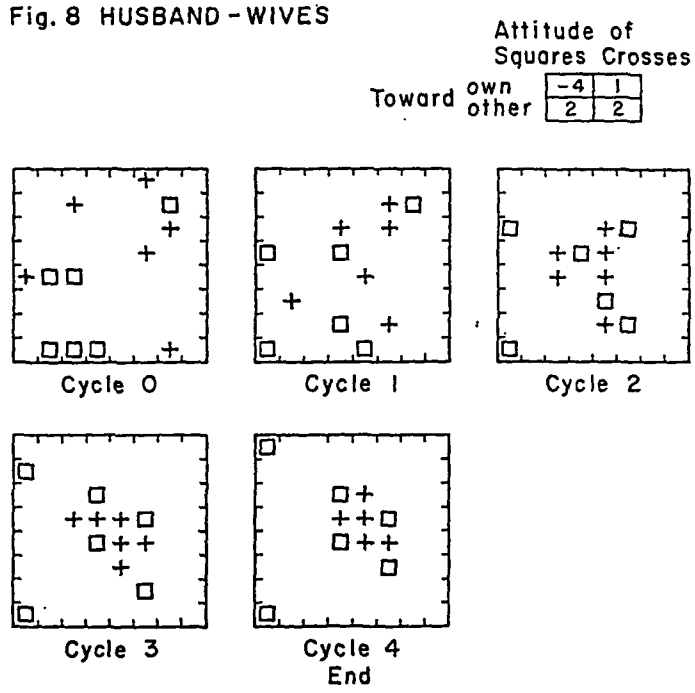

FIGURE 8 *Husbands and Wives* (Squares: −4 to Own, 2 to Others; Crosses: 1 to Own, 2 to Others.)

In American society females probably have greater negative attitudes toward other females than do males, and they represent the force toward keeping the couples apart. The males, on the other hand, frequently desire male companionship, fishing and hunting, golfing, playing poker or attending the Playboy Club. This situation is simulated by a +1 attitude of males for males, +2 for males for females, and also females for males, and a −4 attitude of females for females. The resulting pattern, shown in Figure 8, is one of males (Crosses) grouped together in the center of the board surrounded by four females. Two of the females find no room in the center and withdraw into corners. The result appears to represent some typical situations. The isolated females represent both women who do not get married and those who are married but are temporary widows while the men have their night or afternoon out. The women with the men are on the periphery. Some of the women are shared by two men, a situation which would have been avoided by the couples only situation. The attraction of men for one another, even though weaker than attraction between sexes, destroys the couple arrangement.

Some Variations

A number of variations have been tried out, and these demonstrate that minor differences in pattern can occur with change in parameters. Particularly affected is the extent to which pieces are scattered or become immobilized. The use of the 12×12 board generally has the effect of scattering pieces and giving the distance pieces less weight. In the social climber situation three separate clusters rather than two appeared. In the social worker situation the cohesive Squares were not attracted sufficiently by the Crosses to move from a central position on the board. In the boy-girl situation greater scattering resulted in four subgroups, two of them couples. Changing the distance weight from 4 to 3 and 5 made only slight changes in pattern. Changing the weight to three had an effect similar to expanding the board since it gave the distance pieces less weight. Changing the valence of attitudes from 1 to 2, for example, did not change the general pattern very much, but again, had an effect similar to changing the size of the board. The distance between two pieces could be compensated for by stronger attitude. Hence, in the case of the social worker situation in which a positive weight of 1 of Squares toward Crosses was not sufficient to move them from the center of the board where they were clustered together they could be made to pursue the Crosses as a group by increasing the weight to 2. These interdependences are inherent in the manner in which distances, distance weights and valences are combined into a single measure.

Conclusion

It would appear from these examples that the checkerboard model is capable of demonstrating the intimate connection between attitudes of group members toward their own group and toward others to a continuous social interactional process. While the social structure, as an end product, may appear to be rigid, they can be viewed as a resultant of the social interactional process, which is in turn governed by social attitudes. When the social structure is unstable or in a state of flux, the social interactional process is visible. Even when a social structure appears to be stable—as when a socially elite group is caught in a corner by a social climbing group—forces may be at work to change the structure, given the proper opportunity.

REFERENCES

Lewin, Kurt. *Field Theory in Social Science.* New York: Harper and Brothers, 1951.

Sakoda, James M. *Minidoka: An Analysis of Changing Patterns of Social Interaction* (Doctoral Dissertation). Berkeley: University of California, 1949.

Thomas, Dorothy Swaine and Nishimoto, Richard S. *The Spoilage.* Berkeley: University of California Press, 1946.

Thomas, W. I. *The Polish Peasant in Europe and America.* New York: Alfred A. Knopf, 1927.

Volkart, Edmund H. (editor). *Social Behavior and Personality.* New York: Social Science Research Council, 1951.