FILMING COLLECTIVE BEHAVIOR AND THE PROBLEM OF FORESHORTENED PERSPECTIVE: A CORRECTIVE METHOD

RONALD T. WOHLSTEIN

A number of critics (Blumer 1957; Milgram and Toch 1969:518; McPhail 1972:3; Fisher 1972:187; Berk 1974:15) note the lack of systematic descriptions of what is traditionally referred to as "crowd behavior." As Berk (1974:15) notes in summarizing the situation regarding descriptions of crowd behavior, "In contrast to the rich data on crowd preconditions and consequences, data on *crowd process* during collective behavior is sparse and largely inadequate." In addition, research strategies for filling this void have not been fully exploited (Pickens 1975:6).

Various suggestions have been offered for developing systematic descriptions of crowd behavior (Milgram and Toch 1969:518-536; McPhail 1972; Fisher 1972). The thrust of these suggestions, for students of collective behavior, concerns the observation and measurement of the elementary features of "crowds." We should observe and measure: (1) the spatial arrangement of participants across time and space; (2) the density of these assemblages with attention to its variation and change within and between events; (3) the frequency, initiation, and velocity of participants' locomotive behaviors which intermittently occur and changes in the direction of these locomotive behaviors; and (4) the growth and dispersal processes of such assemblages. In short, develop adequate descriptions of the formal and recurrent sequences of individual and collective behavior within assemblages (McPhail 1972:5).

Because these events may occur too rapidly (Berk 1972: 113; McPhail 1972:14) or involve numerous events going on simultaneously (Fisher 1972:201), filming "crowd" activity is one strategy which offers many advantages. First, by employing telephoto or zoom lens obtrusiveness is not a problem (see Smith et al. 1975). Second, film records are fairly permanent and can be repeatedly analyzed. Third, the film record can be accelerated or decelerated thereby controlling the velocity of the activity. Thus, the investigator has considerable control over the behavior under examination (McPhail 1972:14).

For illustrative purposes as well as making rough generalizations about "crowd" activity this strategy is adequate. However, students of collective behavior interested in making precise measurements directly from film records of such factors as the distance between crowd members or the velocity of their locomotive behaviors have found that filming these activities also has shortcomings—one of which is the problem of foreshortened perspective.

Ronald T. Wohlstein is Assistant Professor of Sociology at Eastern Illinois University. He is currently collaborating with Clark McPhail in a study of the production and measurement of various forms of collective behavior.

THE PROBLEM OF FORESHORTENED PERSPECTIVE

As Weick (1968:413) points out, one of the major difficulties with film records is foreshortened perspective. There are varying degrees of distortion evident in the film record. This is particularly true if the elevation of the camera position is low and a wide area is being filmed. When we view such film records, persons located closest to the camera may appear to be moving more rapidly than persons further away from the camera, when in fact they are moving at the same rate of speed. The same problem arises when trying to determine changes in the direction of locomotive behavior or the spacing between persons. For example, two persons may be located a considerable distance apart. But if one is a short person standing nearer the camera and the other is a taller person standing some distance to the rear, both may appear on the film record to be within touching distance. Obviously, if a small area is filmed, less distortion will be present in the film record. However, the larger the area filmed and the lower the camera elevation, the more the distortion in the film record.[1] Filming from directly overhead would probably correct this problem. However, this would generally be costly, it would be impractical in most situations, and some might consider it obtrusive as well.

To my knowledge, no method is currently available for correcting foreshortened perspective.[2] Thus, while filming collective behavior offers certain advantages, making measurements from film records of such factors as the velocity of participants' locomotive behaviors, the distance between members, etc., has not been feasible.

The purposes of this paper are threefold. First, I will present a method for correcting foreshortened perspective so that measurements of such factors as velocity, spatial arrangement, etc., can be made directly from film records. Second, I will indicate the procedures employed to verify this method. Third, I will discuss the practical implications of this method for students of collective behavior concerned with the task of precise measurement and description.

A CORRECTIVE METHOD FOR THE PROBLEM OF FORESHORTENED PERSPECTIVE IN FILM RECORDS

In order to establish comparable units of measurement for velocity or changes in direction of locomotive behavior, as well as the spacing of participants, the following set of procedures is advanced.

First, the following information must be recorded at the time of filming: (a) the zoom setting of the camera (i.e., the amount of magnification); (b) the angle of the camera with respect to the horizontal; (c) the distance from directly below the camera on the horizontal plane being filmed to some recognizable reference point within the observational field; (d) the height of the camera as measured from directly beneath the camera on the horizontal plane being filmed to the center of the camera lens; (e) it is also helpful to measure various distances within the observational field (e.g., the width of a sidewalk). This information is sufficient to establish the standardized units of measurement for correcting foreshortened perspective.

Second, once the film record has been made, the next step is to develop a matrix for standardizing units of measurement. This is accomplished in the following manner: (1) With black tape, mark out a matrix of one-foot squares on the floor approximately 15 by 20 feet. (2) Film the matrix at the same angle and zoom setting as was used to produce the original film record. The best procedure is to use the information that was gathered when the original film record was produced and determine the dimensions of the triangle created by the position of the camera with respect to the observational field. Then, reduce this triangle proportionately. How far away from the matrix the camera should be and how high it should be from the ground can, thus, be determined before attempting to film the matrix. Make sure to locate the point in the matrix which corresponds to the known observational reference point (the reduced distance of the base side of the triangle–point (c) above) so that the film record can be synchronized with the matrix. (3) Project the developed film image of the matrix on a large white sheet of paper and trace the projected matrix on the paper with dark pencil or a marking pen. (The projector must be level and the distance from lens to the floor and to the paper must be recorded.)

Third, cover the paper matrix with a clear sheet of plastic. This serves as (a) a screen onto which the original film record can be projected, and, (b) as a surface upon which participants' locations can be marked with grease pencil, measurements can be taken, markings erased, the film advanced and the entire process repeated. It is very important to maintain the same distance from the projector lens to the matrix screen during the film projection as when the matrix was constructed. Similarly the projector lens must be the same distance from the floor. These are imperative if the image of the matrix is to correspond to the dimensions of the observational field as retained on the film record.

The original film is then projected on the matrix (see Figure 1), and participants' positions are marked on the transparency covering the matrix at the beginning and end of a two second period (frame 1 and frame 37 at 18 frames per second).[3] Draw a line parallel to each proximate line of the matrix (as shown in Figure 1). The distance between any two

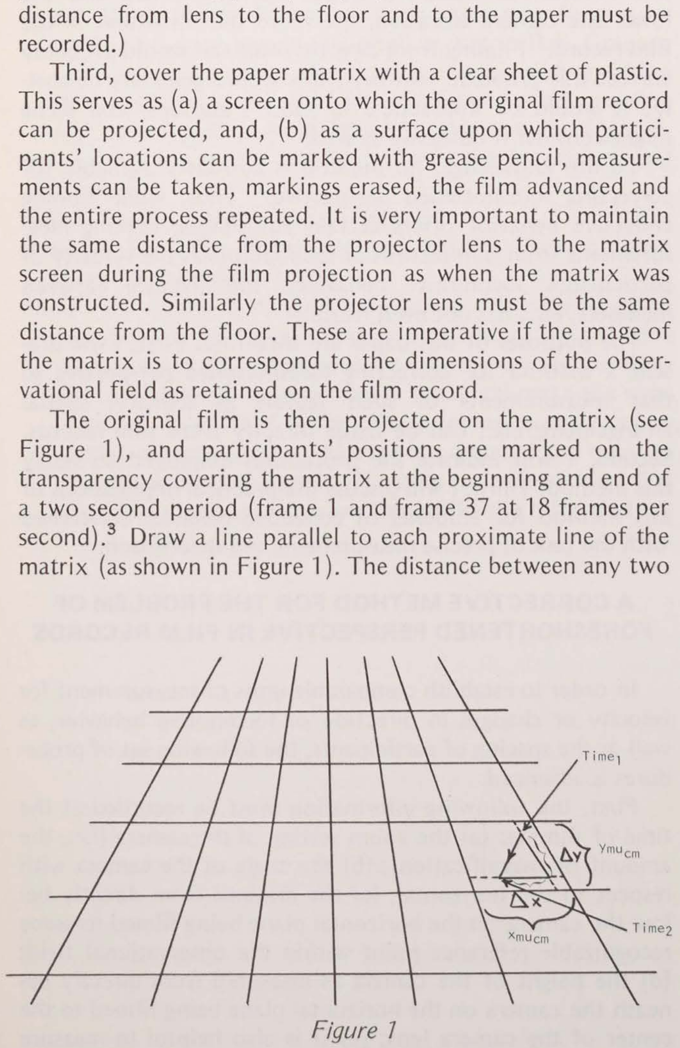


Figure 1

adjacent intersections of the matrix will be called a matrix unit (mu). The length of the vertical side of the triangle is called Δy. The length of the horizontal side of the triangle is called Δx.

The length of Δy and Δx in matrix units is determined by the ratio of Δy and Δx, as measured in centimeters, to the length of their respective parallel matrix unit lines in centimeters. This is accomplished by extending the sides of the triangle (as shown in Figure 1) and measuring the length of both Δy and Δx in centimeters and the total distance between the respective matrix lines and using this as the length of the matrix unit. This is expressed in the following scale transformations:

$$\Delta y_{mu} = \frac{\Delta y_{cm}}{y\ mu_{cm}} \qquad \Delta x_{mu} = \frac{\Delta x_{cm}}{x\ mu_{cm}}$$

Thus, both Δy and Δx can be determined, yielding a standard unit of measurement, regardless of the position of the participant's movement within the observational field on the film record, assuming there is no change in the position of the camera.

Given Δy_{mu} and Δx_{mu}, the total distance traveled in matrix units (d_{mu}) can be determined by the following Euclidean Distance formula:

$$d_{mu} = \sqrt{(\Delta x_{mu})^2 + (\Delta y_{mu})^2}$$

Distance between members can be determined in analogous fashion.

The velocity of movement is expressed as the distance in matrix units per unit of time, allowing rates of speed to be compared without reference to the actual distance covered by participants when they were filmed. Having determined the distance in matrix units, average velocity in matrix units is determined by the following:

$$velocity_{mu} = \frac{d_{mu}}{\text{time in sec.}}$$

The angle of the direction of locomotive behavior relative to the horizontal matrix lines is determined by the following formula:

$$angle = \tan^{-1}\left(\frac{\Delta y_{mu}}{\Delta x_{mu}}\right)$$

For determining changes in the direction of locomotive behavior a third measurement at time three is needed. Repeat the above to determine the angle of direction between time two and time three. Then, taking the difference of the angles yields the magnitude of the change in direction corrected for any distortion in the film record. This is illustrated in Figure 2.

Converting the distance traveled in matrix units and the velocity in matrix units to the actual distance and velocity of the persons in the observational field involves the following: the measurements have to be transformed proportionate to the actual dimensions of the original observational field which was recorded on film. The procedures for determining velocity, etc., once the conversion is made, are identical to those above since the principles of physics employed do not change. All that is being done is to convert the unit of measurement so that it is comparable to actual distances in

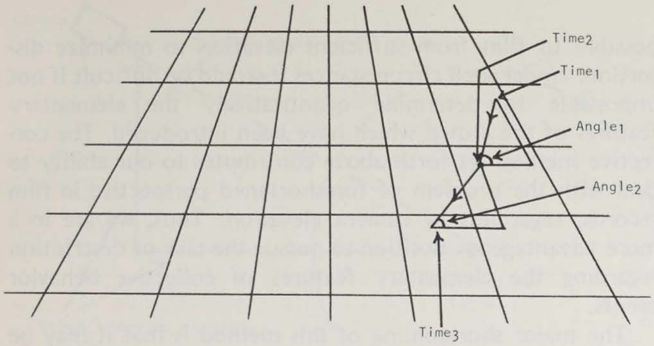


Figure 2

the observational field originally filmed.

Very simply, it is necessary to determine the multiplier which is a scale transformation constant (k) for converting matrix units to actual feet in the original observational field. For example, if you have the width of a sidewalk (d_{ft}) as measured from the observational field, determine the length of this in centimeters as it is projected on the matrix (d_{mu}). Divide the actual distance by the length in matrix units to get the multiplier. This is expressed as:

$$k = \frac{d_{ft}}{d_{mu}}$$

If the sidewalk was nine feet wide and it was 1.5 matrix units, then 9/1.5 = 6 feet. Each matrix unit is, thus, equal to 6 feet in the actual observational field. The measurements of distance and velocity can now be multiplied by the constant (k) to convert these measurements in matrix units to the actual distance in feet they were in the original observational field.

In sum, this set of procedures corrects the foreshortened perspective which may occur, especially, when filming a large area at low elevation. This distortion in the film record of the dimensions of interest can then be corrected and standard units of measurement developed with reference either to the matrix, or to the actual distances in the original observational field.

If any changes are made while filming, a tape recorder can be used to record the times when these changes occurred, and the changes in the parameters previously specified which are necessary to make the matrices for correcting foreshortened perspective in the film record. It should be noted that the key to this set of procedures is determining the dimensions of the triangle created between the position of the camera and a reference point within the observational field.[4]

VERIFICATION OF THE METHOD

Theoretically, the method advanced for correcting the foreshortened perspective in film records provides a means for accurately measuring such factors as the spatial arrangement of participants, the density of the assemblage, and the like. In order to verify the method one camera was positioned at high and another at low elevation. These two cameras were used to simultaneously film the same observational field. A number of reference points were established in the observational field. These were measured, producing a set of known coordinates. Employing the method for correcting foreshortened perspective, the same set of coordinates were estimated from the two film records. The verification of the method depended upon the degree of correspondence across these three sets of measurements, i.e., measurements of the observed field, of the film record from the high elevation camera, and of the film record from the low elevation camera. The details of the procedures employed in securing the information necessary for assessing whether or not this method is satisfactory will be presented followed by the results and an evaluation of the method.

One half of a basketball court was filmed simultaneously with the two cameras. Their exact positions in relation to the observational field are presented in Figure 3. The low elevation camera was mounted on a tripod at a height of 5′5″ above the court. This was measured by a perpendicular line from the court to the center of the camera lens. The camera was a distance of 59′3″ from the center of the court to the perpendicular height line. A clinometer attached to the camera was used to estimate the angle of the camera with the horizontal. An angle of 6° was registered. The high elevation camera was positioned on a tripod located on a balcony directly above and slightly to the rear of the low elevation camera. As indicated in Figure 3, the height from the court to the center of the camera lens was 16′8¾″. It was 62′1″ from the base of the perpendicular height line to the center of the court. The angle of the camera with the horizontal was approximately 16°. Thus, these two camera positions produced different visual records of the same observational field.

The layout of the observational field is presented in Figure 4. Each of the numbered positions was marked on the court with blue paper so they would be visible on the film records. These positions provided known reference points in the observational field. Connecting these various positions with positions labeled Center (C) and Left Center (LC) created a set of known angles as well. Comparisons were made between the known coordinates and angles and the estimates of these for both film records employing the method for correcting foreshortened perspective. The estimates were strikingly accurate.[5] For both film records, the greatest error in estimating angles was approximately three degrees. For both film records, the estimates of coordinates of positions were generally accurate within a foot. A few major errors of over three feet occurred, but these can reasonably be attributed to the grainy quality of the film, the size of the markings on the court (8x10 sheets of paper were

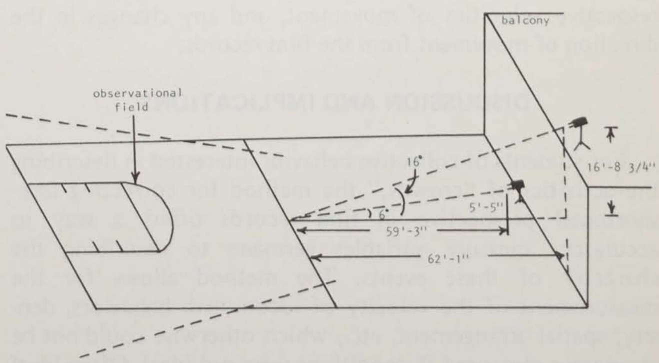


Figure 3

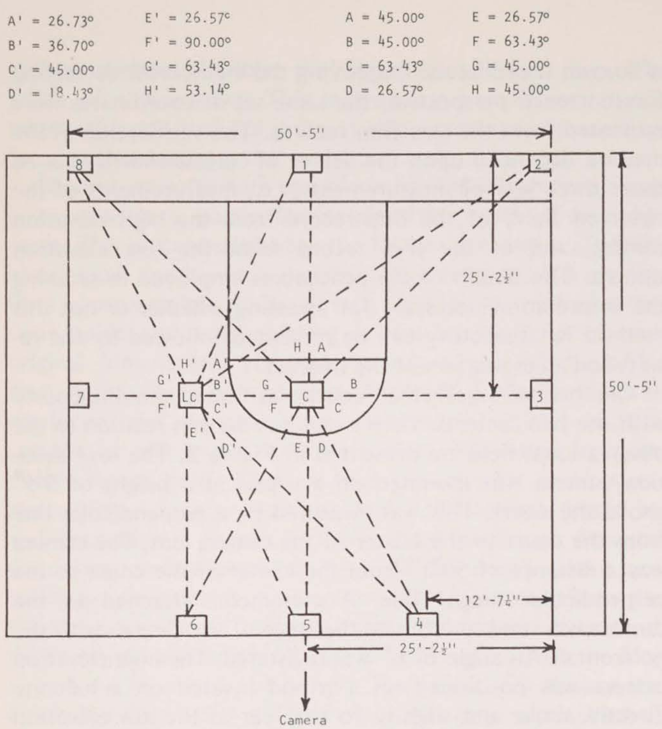


Figure 4

used), and the glare of the court surface itself (these factors made locating the markings on the film records difficult for a few positions). Thus, these errors are regarded as well within the range of precision necessary for making judgments of such factors as directional change in locomotive behavior, velocity, spatial arrangement, and the like.

In sum, the method is verified and these findings empirically substantiate the theoretical argument: Foreshortened perspective in film records can be corrected for and accurate measurements can be made corresponding to the dimensions of the original or actual observational field.

Elsewhere I have advanced a set of theoretical instructions for determining a person's location and employed the method with actual film records of locomotive behavior (see Wohlstein 1977). I have examined film records of three segments of the following types of locomotive behavior: a marching band, movement of simulated marching demonstrators, and the movement of pedestrians. The film records were generated from varying camera elevations. In all three conditions, the method worked extremely well for estimating the actual spatial arrangement of the participants, their respective velocities of movement, and any changes in the direction of movement from the film records.

DISCUSSION AND IMPLICATIONS

For students of collective behavior interested in describing the activities of "crowds," the method for correcting foreshortened perspective in film records offers a way to accurately measure variables germane to describing the character of these events. The method allows for the measurement of the velocity of locomotive behaviors, density, spatial arrangement, etc., which otherwise could not be accurately measured if conditions were not ideal. Often ideal conditions cannot be achieved in the field. That is, it is impossible to film from sufficient elevation to minimize distortion. Under such circumstances it would be difficult if not impossible to determine quantitatively the elementary features of the crowd which have been introduced. The corrective method set forth above contributes to our ability to deal with the problem of foreshortened perspective in film records, regardless of camera elevation. Thus, we are in a more advantageous position to pursue the task of description regarding the elementary features of collective behavior events.

The major shortcoming of this method is that it may be time-consuming to code from the film record depending on the time interval chosen, the number of participants, and the number of behaviors considered. In short, the more precision desired for description the more time-consuming the method becomes. I am exploring the possibility of using a digitizer system for recording the coordinates of a person's location on computer tape. However, the only feasible solution at present is to sample selectively portions of the film record or reduce the time interval used for coding.

As Milgram and Toch (1969:584) recognize, "In the end, there is no substitute for direct observation and measurement of authentic crowd behavior." It is to this end that this effort has been directed. Only when we begin to develop and fully explore direct observational techniques for measuring and describing collective behavior will we be in a position to know what goes on in "crowds" and to establish the patterns and regularities of behavior which must be explained.

NOTES

Acknowledgments. My thanks to Ray Mosely and P. Scott Smith for their help with developing the method and to Clark McPhail for comments on an earlier draft.

[1] For instance, filming half of the quadrangle at the University of Illinois from a first story window would produce more distortion in the film record than filming from the top of the same building.

[2] Harrison (1974) and Scherer (1974) offer methods which, in part, are related to the problem of foreshortened perspective. However, neither method adequately deals with the problem. Harrison (1974: 269-270) suggests superimposing a rectangular grid on a photograph or scale drawing of the observational field. Evidently this grid is not adjusted to correct for any distortion in the film record. In addition, it appears that the location of a person's coordinates on the film record is estimated by reference to landmarks in the observational field although how this is accomplished is not explained. Scherer (1974) was interested in determining the distances between members of a dyad in natural settings. However, the method developed for determining the distances between members of a dyad depends on knowledge of how far the subjects are from the camera or an estimate of this distance.

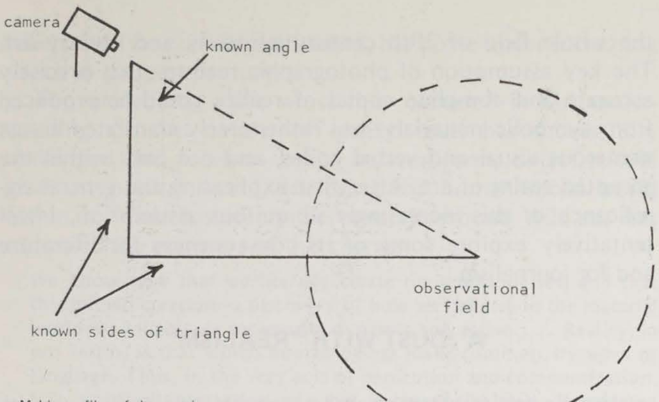
[3] I have developed an elaborate set of coding instructions for determining the location of a person elsewhere (Wohlstein 1977). Although in this presentation of the method I have chosen a two second interval for coding purposes this can be varied. It depends on the degree of precision desired and the length of time participants are retained on the film record.

[4] Having gathered the information necessary for correcting foreshortened perspective, the dimensions of the triangle of the camera with the observational field are known as diagrammed in Figure 5.

[5] Tables presenting this data are available upon request.

REFERENCES CITED

Berk, Richard A.
1972 The Controversy Surrounding Analyses of Collective Violence: Some Methodological Notes. *In* Collective Violence. J. Short and M. Wolfgang, eds. Pp. 112-118. Chicago: Aldine.



Making a film of the matrix involves reducing this triangle proportionately.

Figure 5

1974 Collective Behavior. Dubuque, Iowa: Wm. C. Brown.
Blumer, Herbert
1957 Collective Behavior. *In* Review of Sociology. Joseph B. Gittler, ed. New York: John Wiley and Sons.
Fisher, Charles
1972 Observing a Crowd: The Structure and Description of Protest Demonstrations. *In* Research on Deviance. Jack Douglas, ed. Pp. 187-210. New York: Random House.
Harrison, Patrick R.
1974 A Technique for Analyzing the Distance Between Organisms in Observational Studies. The Journal of General Psychology 91:269-271.
McPhail, Clark
1972 Theoretical and Methodological Strategies for the Study of Individual and Collective Behavior Sequences. Paper presented to the Collective Behavior Session of the Annual Meeting of the American Sociological Association.
Milgram, Stanley, and Hans Toch
1969 Collective Behavior: Crowds and Social Movements. *In* Handbook of Social Psychology, Vol. IV. 2nd ed. Gardner Lindsey and Elliot Aronson, eds. Pp. 507-610. Reading, MA: Addison-Wesley.
Pickens, Robert G.
1975 The Explananda of Collective Behavior. Unpublished Ph.D. dissertation, University of Illinois, Champaign-Urbana.
Scherer, Shawn E.
1974 Proxemic Behavior of Primary School Children as a Function of Their Socioeconomic Class and Subculture. Journal of Personality and Social Psychology 29:800-805.
Smith, Richard L., Clark McPhail, and Robert G. Pickens
1975 Reactivity to Systematic Observation with Film: A Field Experiment. Sociometry 38:536-550.
Weick, Karl E.
1968 Systematic Observational Methods. Handbook of Social Psychology, Vol. II. 2nd ed. Gardner Lindsey and Elliot Aronson, eds. Pp. 357-451. Reading, MA: Addison-Wesley.
Wohlstein, Ronald T.
1977 The Theoretical and Methodological Specification and Description of Collective Locomotion. Unpublished Ph.D. dissertation, University of Illinois, Champaign-Urbana.