The communication of messages of the impending impact of some natural disaster agent can play a key role in averting natural catastrophe. This article examines the social processes involved in disaster warnings which function to elicit evacuation in such threat situations. These processes and the role of the mass media in forming situational definitions requisite for evacuation are examined in reference to data gathered in Rapid City, South Dakota where on June 9, 1972 a flash flood produced a major disaster.

COMMUNICATION IN CRISIS
Explaining Evacuation Symbolically

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Warnings connected with the impact of some natural hazard agent, for example, tornadoes, hurricanes, or flash floods, have been conceptualized as a social process comprised of three basic elements: evaluation, dissemination, and response (Williams, 1964; McLuckie, 1970). Evaluation encompasses those processes taking place from the time of detection of the environmental hazard to the point at which some means are employed to convey a message to the endangered community of the probable impact of the natural agent. Conveying such a message to the community is

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dissemination. Response is defined as that behavior on the part of warning recipients which follows warnings heard.

The process of warning, then, is not seen as limited solely to the dissemination of a threat message. Rather it includes all behavior connected with the evaluation of threat, warning dissemination, and public response to it. The message itself functions primarily as the mechanism whereby individuals and groups within an endangered community may perform adaptive behavior to anticipated stress input into the social system by some natural agent.[1] Such adaptive behavior to negative short-term changes in the natural environment are accomplished as consequences of varied community-specific organizational and technological mechanisms which allow for such anticipatory adaptive behavior. For example, the use of river gauges and radar by the National Weather Service may provide the means whereby a potential flash flood can be detected. Community decision points, typically within organizations, then provide the means whereby the information is conveyed to the media or other dissemination agents within a community. Community preparedness plans may then specify the procedures to be followed whereby warnings are issued to the community in general.[2]

It is the purpose of the paper, on the basis of existing research and theory, to generate a formulation of individual response to short-term natural hazard warnings. Short-term natural hazard warnings may be conceptualized as any public warning of the immediate, or imminent, impact of some natural hazard agent (see Mack and Baker, 1961; Williams, 1964). They differ from warnings in general only in terms of the shorter amount of time they allow for response. Such was the nature of the warnings issued to the residents of Rapid City, South Dakota prior to the flash flood which struck that community on June 9, 1972. Response to those warnings is the focus of this study. Tornado and flash flood warnings are typical examples of natural hazard warnings of quick impact. Warnings of long-term or progressive floods, in that they may be issued over a period of several days, exemplify a natural hazard of long-term impact in which warnings do not require immediate response.

In an effort to explicate the consequences in response to differences in the warnings themselves, a model based upon, but not solely limited to, warning-specific variables is advanced. Emphasis is placed on the characteristics of the warnings themselves, as well as on the interpretation given to those warnings by recipients. The model, then, is assessed in terms of data gathered from a random sample of the June 9th residents of Rapid City's flood plain.

THE EVENT

On Friday, June 9, 1972, Rapid City was hit by a flash flood in which over 230 persons lost their lives. It had been raining most of the day and as a consequence most people were in their homes that evening. At 7:30 p.m. the mayor was advised of a flood warning by the National Weather Service, and thirty minutes later the city and county civil defense emergency operations center had opened. At 9:30 radio and TV stations were advised that heavy rains would continue to fall until about midnight. Radio broadcasts at 10:00 spoke of the continuation of the heavy rains, and by 10:30 evacuation advisements went out over the media for the low-lying areas of the city. By that time, however, the canyons above the city were already flooded and residents upstream along Rapid Creek had already begun to lose their lives. At 10:45 Canyon Lake Dam, a recreational dam on the upstream western margin of the city, ruptured. By 12:15 a.m. the flood crest reached the downtown area. (For further details of the actual events, see U.S. Department of Commerce, National Oceanic, and Atmospheric Administration, 1972.)

A WARNING-SPECIFIC MODEL

This research seeks to answer the question of how, on the basis of differences in the warnings received, does the social process function whereby evacuation takes place. Response to warnings is seen as a consequence of the interaction between the transmitter of a message and its recipient. The key to this interaction is seen as meaning, the subjective interpretive response by the warning recipient to the warning received. Hence, response develops out of the interpretation of the warning or out of the ascribed meaning of the warning by the actor. The question of how someone comes to evacuate his home, on the basis of short-term warnings, is, then, approached essentially through the symbolic interactionist perspective. This perspective has been persuasively stated by Blumer (1966: 537) where he notes, "symbolic interaction involves interpretation, or ascertaining the meaning of the acticns or remarks of the other person, and definition, or ccnveying indications to another person as to how he should act." An interpretation of a natural hazard warning which is conducive to evacuation proceeds in the midst of a somewhat unaccustomed situation in which the same "object" may mean different things to different persons. Gillespie (1972: 245) has shown that in circumstances of this type it is the definition of that situation which must be seen as the intervening mechanism between the stimulus and behavioral response.

Explaining warning belief. If it is to be argued that the definition of a situation is requisite for action, it follows that a definitional requirement for evacuation is warning belief. Past research has shown warning belief to be a function of four communication-related variables: communication mode, content, perceived certainty, and confirmation.[3] The manner in which the warning is communicated, including messages received through the media, telephone, in face-to-face conversation, and so forth, can be labeled "communication mode." Williams (1964) has shown that different channels of communication have different degrees of authoritativeness, credibility, and legitimacy for warning recipients. Belief, as a function of communication mode, has also been shown to be greater for warnings delivered in a personal manner than those communicated by some impersonal medium (see Clifford, 1956; Moore, 1963). It was therefore postulated that warnings directed at specific individuals rather than warnings for some general aggregate, e.g., "person-specific" warnings, will be believed to a greater extent than warnings delivered in any other mode.

The literature also suggests that warning-belief is a function of two components of the content of the warning (see Mack and Baker, 1961; Clifford, 1956). The first is the subjective interpretation of "perceived warning certainty." That is, belief has been shown to be higher in instances when warning recipients perceive a high degree of certainty in the transmission of the warning issued, than in those cases when certainty is perceived as not that great. This, then, was advanced as another postulate. The second aspect of warning content makes a distinction between general and specific information. The actual "warning content" or information contained in the warning was also postulated to foster greater belief when it consisted of specific information rather than general information. Hence, the degree of warning specificity represents another important dimension in the model.

A number of authors (Mack and Baker, 1961; Withey, 1962; Drabek and Boggs, 1968; Drabek, 1969; Drabek and Stephenson, 1971) have suggested that warning belief is in addition a function of "warning confirmation." Here the focus is upon the act of obtaining additional information concerning the information obtained in the original warning. As Mack and Baker (1961) have stated, "interpretation of the meaning of the signal depends . . . upon . . . validation." It was, therefore, postulated that warning belief is also a function of the confirmation process.

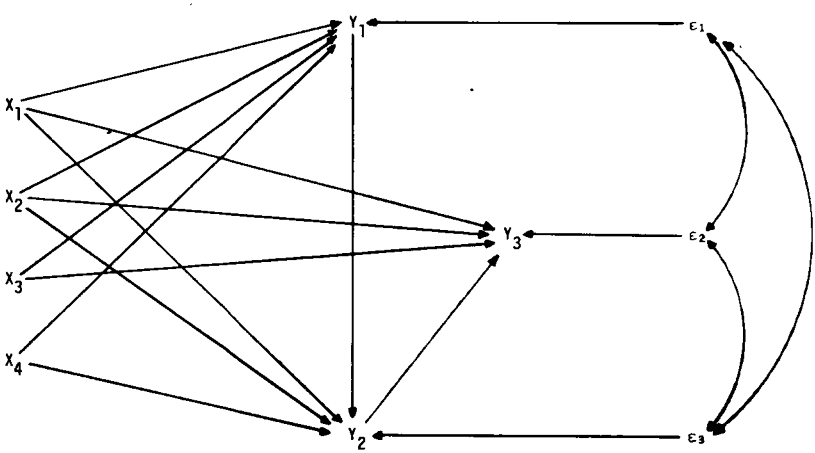
Explaining warning confirmation. Warning confirmation is, itself, a function of several relevant variables. For instance, Drabek and Stephenson (1971) found that families which are separated at the time a warning is received seek to confirm the message more so than do united families. It was postulated that "situational context," defined as whether or not the nuclear family is together at the time a warning is received, is related to warning confirmation. It was also proposed that confirmation is a direct function of perceived warning certainty. Danzig et al. (1958) have shown this to be the case. Furthermore, communication mode has been determined to be a predictor of confirmation (see Drabek, 1969; Drabek and Stephenson, 1971). We postulated that person-specific warnings would have a higher probability of being followed by confirmation than warning obtained in some other manner. It was also postulated that specific warnings issued for a recipient's own location would foster an attempt at confirmation more than would general warnings. It is argued that such warnings would create a greater motivation for action and a consequent disposition for seeking a definition of the situation.

Explaining warning response. Four additional relationships were included in the model. The first of these is that specific own-area warnings would invoke evacuation to a greater extent than general warnings. A direct relationship was postulated then between area-specific warnings (warning content) and evacuation (see Moore et al., 1963; Wilkinson and Ross, 1970). In addition, a relationship was seen between the communication medium carrying the warning and evacuation. Moore (1963) found that evacuation has a greater probability of occurring after person-specific warning than after warning communicated in some other way. It was postulated, therefore, that such is the case.

Repeatedly, although not in studies of short-term warning, it has been shown that families evacuate as units and not individuals (see Danzig et al., 1958; Moore et al., 1963; Spiegel, 1964; Drabek, 1969). Situational context, as here defined, was postulated in addition to be a predictor of evacuation. Specifically, it was hypothesized that warnings received in the context of a united nuclear family would have a greater probability of being followed by evacuation than those received when the family unit was separated. Returning to our original assumption that the definition of a situation is requisite for action, it was postulated that evacuation is also a direct function of warning belief, that is, belief in the threat of impending disaster.

The preceding relationships constitute the model on which the analysis was based. The exogenous, or explanatory, variables are: warning content (X_1), communication mode (X_2), situational context (X_3), and perceived warning certainty (X_4). The dependent, or endogenous, variables are: warning confirmation (Y_1), warning belief (Y_2), and warning response (Y_3). The interrelationships among these variables are displayed diagrammatically in Figure 1. The model, then, is a composite of those communication variables which past research has shown as central to disaster warning situations (warning content and communication mode); those social-psychological variables which stand as key factors in such situations (perceived warning certainty and belief); warning confirmation and situational context (two key sociological variables as revealed by past research); and warning response. The model, which is designed to have applied import, is therefore a composite of intrapersonal, contextual, and behavioral variables. However, in a theoretical sense the model adheres to the symbolic interactionist perspective: the communication variables are central to both definitional situations and behavior and that the former are predictive of the latter.

The structural equations linking the exogenous and endogenous variables in the model are:



Where X_1 = warning content; X_2 = communication mode; X_3 = situational context; X_4 = perceived warning certainty; Y_1 = warning confirmation; Y_2 = warning belief; and Y_3 = warning response.

Figure 1: NONRECURSIVE MODEL OF RESPONSE TO SHORT-TERM NATURAL HAZARD WARNINGS

$$Y_1 = \beta_{10} + \beta_{11}X_1 + \beta_{12}X_2 + \beta_{13}X_3 + \beta_{14}X_4 + \epsilon_1 \qquad [1]$$

$$Y_2 = \beta_{20} + \beta_{21}X_1 + \beta_{22}X_2 + \beta_{24}X_4 + \Gamma_{21}Y_1 + \epsilon_2 \qquad [2]$$

$$Y_3 = \beta_{30} + \beta_{31}X_1 + \beta_{32}X_2 + \beta_{33}X_3 + \Gamma_{32}Y_2 + \epsilon_3 \qquad [3]$$

where the β_{ij}'s are the effects of the exogenous variables, the Γ_{ij}'s represent the effects of the endogenous variables on each other, and the ϵ_j*'s are disturbance terms. In the absence of any theoretically compelling rationale for preferring one* functional form over another, we use linear relations as a first approximation for our model. No assumptions are made concerning the independency of the disturbances in the model, and while relaxing this assumption increases the complexity of the estimation technique needed to solve for the model's parameters, we gain the advantage of recognizing that our model may exclude important unidentified variables which may influence confirmation, belief, and response. In other words, what we lose in ease of computation is more than compensated for by gains in conceptual rigor.

It is argued, then, that warning confirmation is a compound function of the effects of warning content, communication mode, situational context, and perceived warning certainty. Warning belief is a function of warning content, communication mode, perceived warning certainty, and warning confirmation. And lastly, evacuation is a function of warning content, communication mode, situational context, and warning belief.

MEASUREMENT

The population was defined as adult heads of households and their spouses, living in the June 9th flood plain, within the city limits of Rapid City. A population of 1,958 preflood dwelling units was enumerated by a review of tax records and mobile-home park-registration lists. A systematic 8 to 1 random sample was drawn yielding a sample of 244.[4] Of these, 11 were occupied by persons not in town at the time of the flood, and 10 were vacant at the time of the flood. The sample size was, therefore, reduced to 223. Of these, interviews were completed with 188, or 83.3% of the sample.[5]

In reference to each warning which respondents received, variables were measured with the following questions. Warning content (X_1) was ascertained by the question "What did they say?" Pretesting revealed the categories of response which were used. These were: heavy rains; water rising, not sure how serious; river flooding, possible danger; river flooding in some other place; dam broke; river flooding, approaching your area; and other. Aside from the "other" category, the last three possible choices for this analysis were coded as "1: specific own-area warnings," while all others were coded as "0: general or other-area warnings." In this way warning content was dichotomized for analysis.

Communication mode (X_2) was measured by the question "How did you get this message?" Responses were dichotomized into "1: person-specific" which included telephone and face-to-face interaction, and "0: mass communicated" which included TV and radio communications. Situational context (X_3) was measured by the question "Were all the members of your immediate family, who were living with you at that time, with you when you received the warning or message?" Responses were, of course, dichotomous, with "1: yes," and "0: no." Perceived warning certainty (X_4) was measured by showing the respondent a card on which was displayed a scale of 1 to 6. The question asked was "How certain did they seem about the information they were giving, on a scale of 1 to 6, where 1 represents 'they were very uncertain,' and 6 represents 'they were very certain.' " Although "certainty" is conceptually a continuous variable, preliminary analysis demonstrated little variance across this 6-point scale with roughly 50% of the respondents scoring in the highest category. As a result the scale was dichotomized between those with complete certainty in the warning, a score of 6, and those with less certainty, a score of 5 or less. The former was coded "1" while the latter was coded "0."

Warning confirmation (Y_1) was measured by the question "Did you make any attempt to obtain additional information after you heard that message?" Responses were recorded as no, or in terms of behavior constituting confirmation, whether it was calling a relative, continuing to listen to the radio for more information, and so forth. For analysis—in that in no one warning was a confirmation attempt unsuccessful, except in fewer than 4% of the cases—responses were dichotomized as "1: yes," or "0: no."

Warning belief (Y_2) was measured by showing the respondent, once again, the scale card, and asking "How would you rank the extent to which you believed this warning, on a scale of 1 to 6, where 1 represents 'totally disbelieved' and 6 represents 'totally believed.' " Empirically the scale failed to adequately discriminate its entire range. Since approximately 50% of the respondents fell into the "totally believed" category, this scale was dichotomized between 5 and 6 so that respondents are categorized "1: total belief" as represented originally by a code of 6, versus "0: less than total belief" represented originally by codes 1-5. Warning response (Y_3) was measured by the question "What were your first actions immediately thereafter?" Responses were recorded verbatim and for this analysis were dichotomized as "1: evacuated," and "0: no evacuation."[6]

ESTIMATION

The structural model presented in Figure 1 does not make the assumption of the independency of the disturbance terms; that is, the possibility that the unknown factors, represented by the ϵ_i's, influence the endogenous variables is allowed for in this research. Unless the disturbances are independent, the application of ordinary least squares (OLS) estimating techniques to the structural equations will result in estimators which are biased and inconsistent. To avoid this possibility, indirect least squares (ILS) were used to estimate the structural equations of our model. (For a simplified discussion and further details on ILS, see Wonnacott and Wonnacott, 1970.)

To arrive at the ILS estimates it was first necessary to express the model in terms of the reduced form equations. This is to say that equation 1 is substituted into equation 2, and then solved so that only the exogenous variables appear on the right-hand side of the equation. Likewise, the reduced form of equation 2 is substituted into equation 3 and solved for the exogenous variables. The resulting reduced form equations are:

$$Y_1 = \gamma_0 + \gamma_1 X_1 + \gamma_2 X_2 + \gamma_3 X_3 + \gamma_4 X_4 + V_1 \quad [4]$$

$$Y_2 = \pi_0 + \pi_1 X_1 + \pi_2 X_2 + \pi_3 X_3 + \pi_4 X_4 + V_2 \quad [5]$$

$$Y_3 = \lambda_0 + \lambda_1 X_1 + \lambda_2 X_2 + \lambda_3 X_3 + \lambda_4 X_4 + V_3 \quad [6]$$

where

$$\gamma_0 = \beta_{10} \quad [7a]$$

$$\gamma_1 = \beta_{11} \quad [7b]$$

$$\gamma_2 = \beta_{12} \quad [7c]$$

$$\gamma_3 = \beta_{13} \quad [7d]$$

$$\gamma_4 = \beta_{14} \quad [7e]$$

$$V_1 = \epsilon_1 \quad [7f]$$

$$\pi_0 = \beta_{20} + \Gamma_{21}\beta_{10} \quad [7g]$$

$$\pi_1 = \beta_{21} + \Gamma_{21}\beta_{11} \quad [7h]$$

$$\pi_2 = \beta_{22} + \Gamma_{21}\beta_{12} \quad [7i]$$

$$\pi_3 = \Gamma_{21}\beta_{13} \quad [7j]$$

$$\pi_4 = \beta_{24} + \Gamma_{21}\beta_{14} \quad [7k]$$

$$V_2 = \Gamma_{21}\epsilon_1 + \epsilon_2 \quad [7l]$$

$$\lambda_0 = \beta_{30} + \Gamma_{32}\beta_{20} + \Gamma_{32}\Gamma_{21}\beta_{10} \quad [7m]$$

$$\lambda_1 = \beta_{31} + \Gamma_{32}\beta_{21} + \Gamma_{32}\Gamma_{21}\beta_{11} \quad [7n]$$

$$\lambda_2 = \beta_{32} + \Gamma_{32}\beta_{22} + \Gamma_{32}\Gamma_{21}\beta_{12} \quad [7o]$$

$$\lambda_3 = \beta_{33} + \Gamma_{32}\Gamma_{21}\beta_{13} \quad [7p]$$

$$\lambda_4 = \Gamma_{32}\beta_{24} + \Gamma_{32}\Gamma_{21}\beta_{14} \quad [7q]$$

$$V_3 = \Gamma_{32}\Gamma_{21}\epsilon_1 + \Gamma_{32}\epsilon_2 + \epsilon_1 \quad [7r]$$

Since with the reduced form disturbances, the v_i's, are uncorrelated, we may estimate the reduced form equations employing OLS techniques. Using the OLS estimates of these questions, one may then solve by substitution for the ILS estimates of the structural equations. Denoting the OLS estimates with a caret and the derived ILS estimates with an asterisk, we have

$$\overset{*}{\beta}_{10} = \gamma_0 \quad [8a]$$

$$\overset{*}{\beta}_{11} = \gamma_1 \quad [8b]$$

$$\overset{*}{\beta}_{12} = \gamma_2 \quad [8c]$$

$$\overset{*}{\beta}_{13} = \gamma_3 \quad [8d]$$

$$\overset{*}{\beta}_{14} = \gamma_4 \quad [8e]$$

$$\overset{*}{\beta}_{20} = \pi_0 - (\pi_3\gamma_0/\gamma_3) \quad [8f]$$

$$\overset{*}{\beta}_{21} = \pi_1 - (\pi_3\gamma_1/\gamma_3) \quad [8g]$$

$$\overset{*}{\beta}_{22} = \pi_2 - (\pi_3\gamma_2/\gamma_3) \quad [8h]$$

$$\overset{*}{\beta}_{24} = \pi_4 - (\pi_3\gamma_4/\gamma_3) \quad [8i]$$

$$\overset{*}{\Gamma}_{21} = \pi_3/\gamma_3 \quad [8j]$$

$$\overset{*}{\beta}_{30} = \lambda_0 - (\lambda_4\pi_0/\pi_4) \quad [8k]$$

$$\overset{*}{\beta}_{31} = \lambda_1 - (\lambda_4\pi_1/\pi_4) \quad [8l]$$

$$\overset{*}{\beta}_{32} = \lambda_2 - (\lambda_4\pi_2/\pi_4) \quad [8m]$$

$$\overset{*}{\beta}_{33} = \lambda_3 - (\lambda_4\pi_3\gamma_3/\pi_4\gamma_4) \quad [8n]$$

$$\overset{*}{\Gamma}_{32} = \lambda_4/\pi_4. \quad [8o]$$

All of the exogenous and endogenous variables in the model are binary, with all variables being coded as either 1 or 0. Therefore, unstandardized coefficients, in that they have a straightforward probabilistic interpretation, are given as the estimated parameters of the model (Goldberger, 1968). The standardization of the estimated coefficients for the structural equations, as is the usual practice in such an analysis, would not have contributed to the interpretation of the model. While the structural parameters have a clear interpretation as contributions to the linear probability function, it can be shown that in binary variable regression, when the dependent variable is dichotomous, the homoscedasticity assumption concerning the disturbance variance is untenable. Hence, the OLS estimates of the reduced form equations do not have the minimum variance property normally associated with OLS estimates (Beck, 1972; Theil, 1970; Goldberger, 1964). However, even in the face of heteroscedasticity the OLS estimates are unbiased, and there is no substantial loss of information concerning the model's parameters, although they are somewhat less efficient.

In recursive models the adequacy of a structural equation can be assessed by the magnitude of the squared multiple correlation coefficient. The interpretation of this coefficient, however, when applied to models such as ours is inherently ambiguous. Hooper (1959) has suggested using the mean square canonical correlation, or trace correlation, as a desirable measure of the association between the exogenous and endogenous variables.[7] The trace varies between −1.0 and 1.0, and can be interpreted as the proportion of the variance in the endogenous variables accounted for by the nonrandom variance in the exogenous variables. The trace (ρ) is defined as

$$\bar{\rho}^2 = \frac{1}{k}\sum_{i=1}^{k}\rho_1^2 \qquad [9]$$

where p_1 is the ith of k canonical correlations, and there will be as many canonical correlations as there are endogenous variables in the model.[8] Whereas p^2 is the population trace coefficient, a consistent estimator, r^2, can be derived by utilizing the sample analog to equation 9.

FINDINGS

The ordinary least squares estimates of the reduced form equations for the first, second, third, and fourth warnings received were obtained, and these estimates were substituted into equations 8a through 8o to obtain the ILS estimates of the structural equations.[9] Analysis ceased with the fourth warning because the sample size became too small for analysis.

Table 1 tabulates the sample means for our seven variables by warning number which refers to the frequency and sequence of respondent-specific warnings received, and not to any particular set of warnings issued in the pre-impact community. If the fourth warning is ignored, we find that there is an increase in the degree of perceived warning certainty, warning belief, and proportion of families evacuating as the number of warnings received increases. It would appear, then, that families who received multiple warnings tend to believe these communications, perceive greater

TABLE 1
SAMPLE MEANS BY WARNING NUMBER

Variable		First Warning	Second Warning	Third Warning	Fourth Warning
Warning content	(X_1)	0.294	0.458	0.493	0.441
Communication mode	(X_2)	0.356	0.356	0.471	0.529
Situational context	(X_3)	0.582	0.612	0.631	0.545
Perceived warning certainty	(X_4)	0.500	0.610	0.567	0.529
Warning confirmation	(Y_1)	0.544	0.513	0.552	0.546
Warning belief	(Y_2)	0.405	0.605	0.642	0.588
Warning response	(Y_3)	0.201	0.250	0.261	0.242
Number of respondents		160	118	68	34

NOTE: The sequence of warnings received varied for each respondent. That is, respondents received different warnings from different sources at different times. Warning number, as it is used here, therefore, refers to the number and sequence of respondent-specific warnings, and not any specific set of warnings issued in the pre-impact community.

certainty in them, and act upon these beliefs in so far as evacuation is concerned.

The trace correlations, average intercorrelations among the exogenous variables, and ILS estimates of the parameters for the first, second, third, and fourth warnings are presented in Table 2. To summarize the degree of multicollinearity we computed the average of the six bivariate correlations among the four exogenous variables.[10] As can be seen from Table 2, in no case did this average exceed .3597 from which we concluded that our analysis is not confounded by a high degree of correlation among the exogenous terms. No trace for the warnings was as high as hoped.

As ascertained by the trace correlations, the exogenous variables in the model accounted for 15%, 11%, 10%, and 21%, respectively, of the variance in the endogenous variables. However, this is not as discouraging as it may seem when considered in light of some of the estimated coefficients within the model.

Situational context and perceived warning certainty were, for all practical purposes, of no predictive value for warning confirmation on any of the warnings examined. The relationship between warning content and warning confirmation did not hold either, except for the second warning, and then it was only of marginal magnitude and in the opposite direction of that predicted ($\overset{*}{\beta}_{11}$ = −.1631). From this one might impute a general attitude of "I'm safe, but I'll watch TV to see what's going on." However, because the relationship was relatively weak and appeared in only one of the four warnings examined, it was dismissed as being of no real theoretical significance. Communication mode, on the other hand, did emerge as a moderate predictor of warning confirmation. Warnings received over the media—rather than person-specific warnings as predicted—increased the probability that a person would seek warning confirmation. Respectively, for each of the four warnings examined, $\overset{*}{\beta}_{12}$ was −.1823, −.2401, −.1218, and −.4879. It appears that the effect of communication mode on warning confirmation

TABLE 2
INDIRECT LEAST SQUARES ESTIMATES OF STRUCTURAL PARAMETERS

Variables						
Endogenous	Exogenous	Slope	First Warning	Second Warning	Third Warning	Fourth Warning
Warning confirmation		β^*_{10}	.5696	.5671	.5657	.6820
	Warning content	β^*_{11}	–.0486	–.1631	–.0245	.0803
	Communication mode	β^*_{12}	–.1823	–.2401	–.1218	–.4879
	Situational context	β^*_{13}	.0377	.1011	.0891	.0612
	Perceived certainty	β^*_{14}	.0509	.0388	–.0110	.0716
Warning belief		β^*_{20}	–.1666	–.3384	–.3026	–.0956
	Warning content	β^*_{21}	–.0478	.0821	.0421	.2259
	Communication mode	β^*_{22}	.0212	.1081	–.0148	–.0624
	Perceived certainty	β^*_{23}	.3259	.2041	.3196	.1998
	Warning confirmation	Γ^*_{21}	.6585	.9352	.7205	.5311
Warning response		β^*_{30}	–.0563	.0596	–.0109	–.2381
	Warning content	β^*_{31}	.3021	.1118	.1000	–.1517
	Communication mode	β^*_{32}	.2392	.2294	.1757	.6941
	Situational context	β^*_{33}	.0633	.0243	.0630	.0063
	Warning belief	Γ^*_{32}	.1799	–.0330	.3403	.5604
Trace correlation			.1493	.1126	.0971	.2127
Average intercorrelation			.2323	.2322	.2545	.3597

is strong after several warnings have been received. The important issue, however, is what this means in relation to warning belief.

Consistently, warning confirmation was a strong predictor of belief. Respectively, by warning number, $\overset{*}{\Gamma}_{21}$ was .6585, .9352, .7205, and .5311. If mass-communicated warnings have a high probability of being followed by confirmation, this suggests an interesting function which the media provide. Confirmation can be the result of two different phenomena, both of which accomplish the same end. An overt behavior may be made to obtain confirmatory information by continuing to watch or listen to the media with the specific intent of seeking confirmation. However, confirmatory information may be obtained by involuntary means, e.g., "involuntary confirmation," if you will, by a lack of change in behavior by continuing to use the media, but not in response to warnings and without the intent of obtaining additional information. In either case confirmation will result which is, in itself, a strong predictor of belief.

In and of itself, however, communication mode had no predictive value for belief regardless of warning number. Perceived warning certainty, on the other hand, did have a fair degree of predictive value for warning belief across warnings. Coefficients were of moderate magnitude; respectively, by warning number, $\overset{*}{\beta}_{24}$ was .3259, .2041, .3196, and .1998. Estimates of the relationship ($\overset{*}{\beta}_{21}$) between warning content and belief were, respectively, –.0478, .0821, and .2259. It appears, therefore, that specific own-area warnings gain marginal predictive value for warning belief only after several warnings are heard.

The variable, response, we dichotomized as "evacuation" versus "nonevacuation" and was, of course, the endogenous variable of prime concern in the analysis. As a predictor of evacuation, specific own-area warnings, e.g., warning content, had moderate value ($\overset{*}{\beta}_{31}$ = .3021) for the first warning. For all ensuing warnings, however, it was of minimal influence;

for the second through fourth warnings, respectively, $\overset{*}{\beta}_{31}$ was .1118, .1000, and −.1517. Communication mode, however, was of greater predictive value across warnings. $\overset{*}{\beta}_{32}$, respectively, for the first, second, and third warnings was .2320, .2294, and .1757. Whereas for the fourth warning, person-specific warnings had a .6941 probability of being followed by evacuation. The same increasing trend in predictive value was also true, for all practical purposes, of warning belief. Respectively, by warning number, $\overset{*}{\Gamma}_{32}$ was .1799, −.0330, .3403, and .5604. Surprisingly, situational context, e.g., whether the family was together or not, had no predictive value for evacuation, $\overset{*}{\beta}_{33}$ never exceeded .0633, just as it did not have any predictive value for confirmation.

CONCLUSIONS AND DISCUSSION

It was postulated that evacuation is a function of warning content, communication mode, situational context, and warning belief. Warning belief was postulated to be a function of warning content, communication mode, perceived warning certainty, and warning confirmation. In addition, warning confirmation was seen as a function of warning content, communication mode, situational context, and perceived warning certainty.

Although the explanatory power of the overall model was low, the findings of the analysis seem quite relevant to furthering our understanding of some of the social processes through which individuals evacuate in response to short-term natural hazard warnings.

Perhaps the most obvious conclusion which can be drawn from this analysis is that response to natural hazard warnings is a complex social process when a series of warnings is considered. Confirmation, belief, and response to warnings differ not only in terms of some of the exogenous variables introduced into the analysis, but also in terms of the number of warnings received. This is to say that what may constitute meaningful relationships between variables is very different for the first warning received than the second, and so forth. It was obvious that the predictive value of several exogenous variables changed over the number of warnings received. Specifically, own-area warnings were a strong predictor of warning belief only after several such warnings were heard. Likewise, mass-communicated warnings did not become a strong predictor of warning confirmation until several warnings had been heard. The differential predictive value of the exogenous variables over warnings was most obvious when evacuation was taken as the dependent variable. Warning belief increased its predictive value for evacuation as more warnings were heard. Person-specific warnings, over the first several warnings, moderately predicted evacuation; however, after several warnings had been heard, it demonstrated a strong predictive value for evacuation. Conversely, however, specific own-area warnings, in and of themselves, were only of moderate predictive value for evacuation only on the first warning; in subsequent warnings they became of marginal value. This suggests that evacuation is not merely a function of hearing a warning and responding. A portion of the populace evacuates in this stimulus-response manner; however, for the remainder of the population evacuation is a much more complex process. The implications of these findings will be discussed shortly.

Only two exogenous variables remained consistent predictors over all warnings; this was the case when warning belief was taken as the dependent variable. Perceived warning certainty was a consistent, although only moderate, predictor of warning belief, while warning confirmation was a consistent strong predictor of warning belief over all warnings. This, however, is not surprising. Past research has shown that interpretation of a warning as valid is a direct function of the certainty, or lack of ambiguousness, in the warning (Clifford, 1956; Mack and Baker, 1961). In addition, defining the situation as one of potential danger has been shown to be a gradual process which confirmation will accelerate (Drabek and Stephenson, 1971).

Several variables had no predictive value for one or several of the endogenous variables regardless of warning number. Situational context did not account for any of the variance in evacuation. Perhaps this was due to the urgency of the flash flood situation. Whether or not the family was united made no difference in terms of evacuation if evacuation had to be accomplished quickly. In immediate stress situations response patterns may be, therefore, quite different from situations where stress is slow in mounting. In the latter, situational context has explained response (see Drabek, 1969; Drabek and Boggs, 1968; Drabek and Stephenson, 1971); however, that it offered no explanatory power in this study of an immediate stress situation further illustrates the heterogeneity of threat across a variety of hazard types, and the influence this can have on differential response patterns.

Communication mode never attained predictive value for warning belief. It was postulated that warnings obtained in a face-to-face manner would be believed to a greater extent than mass-communicated warnings. However, this analysis does suggest that belief is more a function of the perceived certainty with which the warning is delivered and the confirmation of that warning, rather than how the warning is delivered.

Situational context, perceived warning certainty, and warning content were not related to warning confirmation as postulated. Again referring to the immediateness of the situation, perhaps the heretofore predictors of confirmation do not hold relevance when response must be almost immediate. It is a major conclusion, therefore, that the variable of time is of central importance in explaining behavior elicited by warnings in predisaster settings. Perhaps this variable may be a means whereby warning-related behavior may be integrated into some middle-range theory applicable across different general types of disasters.

In terms of all variables considered, however, this analysis has revealed the main process whereby warnings were cause for individuals to evacuate prior to Rapid City's June 9th flood. This is not to say that other variables and relationships were not important. Rather, on the basis of this analysis, a series of several relationships stand out as the main process.

After several warnings had already been received, person-specific warnings had a strong direct effect on predicting evacuation; for the fourth warning $\overset{*}{\beta}_{32}$ was .6941. Mass-communicated warnings, however, had their effect on evacuation through a series of relationships. After several prior warnings had already been received, mass-communicated warnings were a strong predictor of warning confirmation; the fourth warning $\overset{*}{\beta}_{12}$ was −.4879. Warning confirmation was itself a consistently strong predictor of belief; across all warnings, $\overset{*}{\Gamma}_{21}$ ranged from .5311 to .9352. Warning belief, after several warnings had already been received, was a strong predictor of evacuation, $\overset{*}{\Gamma}_{32}$ for the fourth warning was .5604.

This suggests that evacuation could have been maximized in Rapid City had more warnings been issued over the media. Such a process would have fostered warning confirmation either by voluntary means, where warning recipients purposefully sought additional information, or involuntary means (see Drabek, 1971), where confirmation took place not because of any concerted effort to obtain additional information, but simply because many persons continued to use the media for entertainment purposes. Either type of confirmation would have ultimately fostered belief, and eventually led to evacuation after the receipt of several warnings to evacuate. In other words, evacuation seems to be a function of warning belief which appears, itself, to be a function of confirmation. Confirmation, then, could have been maximized—either by voluntary or involuntary means—by continued warnings over the media.

It can therefore be stated that evacuation is a function of some additive process of internalizing warning information over a series of warnings. Further research is needed to specify such an additive model which considers such variables as time, warning number in reference to specific relationships between a greater variety of variables like those considered here, and type of disaster agent. Only after such a model is developed and tested can we hope to add any degree of closure to a theory capable of explaining and predicting response to warnings of impending disaster.

NOTES

1. It was Barton (1963) who conceptualized natural disaster as a segment of collective stress which he defined as large unfavorable change in the inputs of some social system.

2. It is not the purpose of this paper to review the organizational and technological mechanisms which comprise warning dissemination. See Anderson (1965, 1969, 1970), McLuckie (1970), and Yutzy (1964) for a discussion of these aspects of the warning process.

3. Warning source, e.g., whether the warning was from an official or nonofficial source, regretfully, had to be excluded from the analysis. Across all warnings analyzed, only an average of 5% were from official sources, e.g., police, fire department, mayor, national guard, and so forth. Warning source (Clifford, 1956; Moore et al., 1963; Williams, 1964; Drabek, 1969; Wilkinson, 1970) has been shown to be related to warning belief, confirmation, and evacuation.

4. Whether the household head or his/her spouse were interviewed was made to vary randomly. Interviewing was conducted through the inclusive dates of August 5 to August 22, 1972. It was completed by the principal investigator and a team of hired interviewers from a local college with a pretested interview schedule.

5. Of the 16.7% not interviewed: three refused to be interviewed, eight could not be located; four were never at home when interviewers called; two were on vacation at the time of the study; 13 had moved too far away to be interviewed; and five were dead.

6. The endogenous variable of evacuation was inherently dichotomous, as were several other exogenous variables, e.g., situational context. In addition several variables were natural response dichotomies, e.g., perceived warning certainty and warning belief. The analysis, therefore, is a linear probability function analysis which allows each estimated coefficient to be interpreted as a simple probability function.

7. A canonical correlation is a generalized multiple correlation. See Van de Geer (1971) and Hooper (1959) for a discussion.

8. More specifically, the total number of canonical correlations will be equal to the number of variables in the smallest set being correlated. Here the exogenous set contained four variables and the endogenous set was composed of three variates. There were, therefore, three canonical correlations entered in the computations for the trace correlation.

9. Copies of tables giving the OLS estimates of the reduced form equations and intercorrelations are available from the senior author.

10. The average intercorrelation was computed from

$$\text{ave} = \left(\frac{m(m-1)}{2} \sum r_{ij}^2\right)^{1/2} \quad i \neq j,$$

where m is the number of exogenous variables in the model and r_{ij} is the zero-order correlation between the ith and jth exogenous variable.

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