MASS COMMUNICATION AND BELIEF CHANGE: A TEST OF THREE MATHEMATICAL MODELS

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Three mathematical models of communication and belief change were proposed and tested: a proportional change model, a belief certainty model, and an accumulated information model. A quick correlational check of the three models suggested that the accumulated information model was the superior with the belief certainty model being the most inferior of the three. Stronger support for the accumulated information model obtained using a more stringent test: a nonlinear bivariate regression which produced visual "plots" of empirical data that nearly duplicated the visual "plots" produced by the theoretical model. The accumulated information model states that belief change is proportional to the discrepancy between the original belief and the belief communicated in the message, and inversely proportional to the amount of information which the receiver has about the topic at the time the message is received. The belief certainty model was the most inferior of the three indicating that the degree to which a receiver is certain in conviction is unrelated to the communication-belief change relationship.

The relationship between communication and belief change has been of central interest to social scientists and communication scholars for decades. In an attempt to clarify the ways in which communication changes belief, this research tested three mathematical models of communication and belief change: the proportion change model, the belief certainty model, and an informational inertia model. In each model, the change variable is the original believe (b_0) in some claim such as: "The nuclear production of electricity is potentially more dangerous than the conventional methods of producing electricity." Belief is assessed as a subjective probability where 0=completely true, 50=uncertain, and 100=completely false; the change message (M) is a "factual" communication derived from a news source such as a popular news magazine. Thus, a message (M) which warrants the truth of a claim should cause the original belief to change in the direction of true, i.e., toward zero (0). Clarification of the cognitive-communication mechanisms responsible for the belief changes produced by communication was the central focus of this research.

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THE PROPORTIONAL CHANGE MODEL

The proportional change (or "message-belief discrepancy") model was first suggested by French (1956) and has since been elaborated by a variety of authors (Anderson, 1959, 1965, 1971; Anderson & Hovland, 1957; Hovland, & Pritzker, 1957; Hunter & Cohen, 1972, 1974; Whittaker, 1967; Woelfel & Danes, 1977). The recursive structure of this model as specified by Anderson and Hovland (1957) took the following form:

$$b_1 = b_0 + \alpha(M - b_0) \quad (1)$$

This model states that after the reception of a message (M), the new belief (b_1) is given by the original belief (b_0) plus the degree to which the belief changed: $\alpha(M-b_0)$. Belief change (Δb_0) after the reception of one message (M) may therefore be written as:

$$\Delta b_0 = \alpha(M - b_0) \quad (2)$$

Where α is a constant of proportionality that depends upon the discrepancy of the belief value communicated in the message and the original belief held by the receiver: $(M-b_0)$. This model gives the change in belief as the proportion α of the discrepancy $(M-b_0)$ between the receiver's original belief and the belief value communicated in the message M. If α equals zero, the receiver is unaffected by the message; as α assumes larger values, the receiver's original belief changes more so in the direction of the message M. With a message that warrants the truth of a claim, i.e., M=0, the proportional change model as expressed above becomes:

$$\Delta b_0 = \alpha(0 - b_0) \quad (3)$$

$$\Delta b_0 = -\alpha b_0 \quad (4)$$

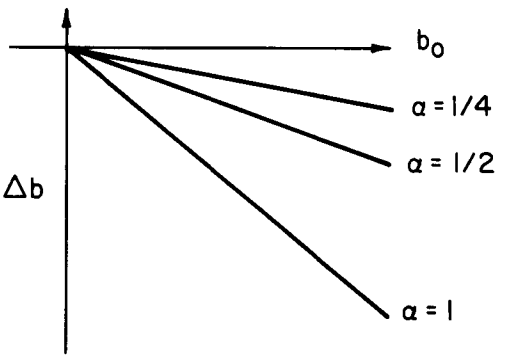
The parametric curves illustrating the theoretical relationships between belief change as a function of the original belief when M=0 are presented in Figure 1.

Nonlinear versions of this model have been proposed by Sherif, Sherif, and Nebergall (1965) in their social judgment theory; by Aronson, Turner, and Carlsmith (1963) in their version of dissonance theory; by Hunter and Cohen (1972); and by Fishbein and Ajzen (1975) in a model which they derive from McGuire (1968).

THE BELIEF CERTAINTY MODEL

For many years investigators have believed that people with extreme beliefs are more resistant to change than those with more neutral beliefs (Brim, 1955). This principle was dubbed the "polarity" principle by Osgood and Tannenbaum (1955) when they incorporated it into their congruity theory. The

FIGURE 1
Parametric curves for the proportional change model with α controlled. The curves graphically represent predicted change as a function of the amount of change requested.



polarity principle was used in conjunction with discrepancy theory in a version of "information processing" theory by Hunter and Cohen (1972) and the model presented below is adapted from theirs. The belief certainty hypothesis states that belief change is proportional to the message-belief discrepancy and inversely proportional to the certainty to which a receiver holds a particular belief. Thus, those who are uncertain in their convictions should be the most susceptible to change:

$$\Delta b_0 = \alpha(M - b_0)/(1 + c_0) \quad (5)$$

And with M=true=0, the model becomes:

$$\Delta b_0 = -\alpha b_0 / (1 + c_0) \quad (6)$$

With belief certainty (c_0) explicitly defined as the deviation from an uncertain response (maximum uncertainty=b_0=50), a precise operationalization of belief certainty becomes:

$$c_0 = \beta |b_0 - 50| \quad (7)$$

where β is a scale dependent parameter which governs the potential range of values; with $\beta=1$, the belief certainty scale runs from zero for minimum certainty (maximum uncertainty) to 50 for maximum certainty. With $\beta=2$, the scale runs from zero for minimum certainty to 100 for maximum

FIGURE 2
Parametric curves for the belief certainty model with α controlled. The curves graphically represent predicted change as a function of the amount of change requested, inhibited by belief certainty.

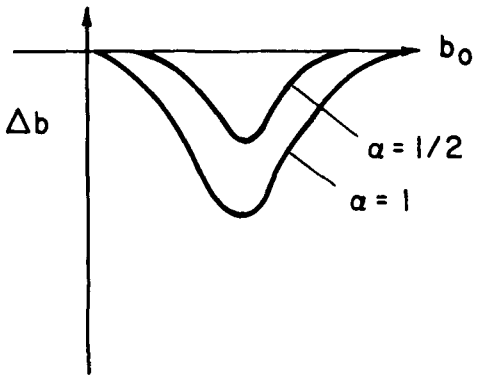
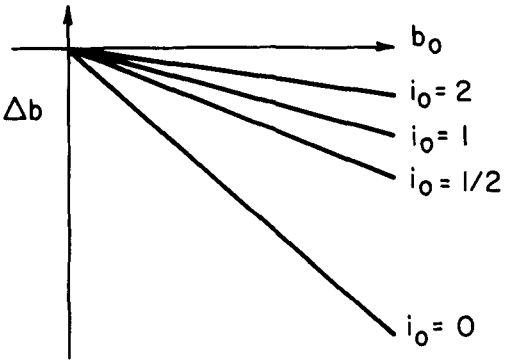


FIGURE 3
Parametric curves for the accumulated information model with α held constant at one; and accumulated information (i_0) controlled. The curves graphically represent predicted change as a function of the amount of change requested, inhibited by prior information accumulation.



certainty. Thus, in order to keep the belief and the belief certainty values equivalent, β was set to 2 for the parametric curves derived from Equation 5 (see Figure 2). Most importantly, however, the setting of $\beta=2$ enables the model to behave mathematically in a way that is consistent with the theoretical expectation: Those with extreme beliefs, regardless of whether the beliefs are true or false, should be more resistant to discrepant messages. Smaller values for β would not reflect this theoretical expectation and this is evident when $\beta \rightarrow 0$; for in this instance, when β is very small (.1 or .001), the belief certainty model would then more closely reflect the underlying theoretical expectation extant in the proportional change model as presented in Equation 4. Although larger values for β do produce the theoretical expectation, as $\beta \rightarrow \infty$, the resulting distributions become unrealistically leptokurtic.

THE ACCUMULATED INFORMATION MODEL

For some years communication researchers have known that "established" beliefs are more difficult to change than are "de novo" beliefs (Hovland, 1959; Roberts, 1972). Anderson (1959, 1965) and Rosenberg (1968) suggested that this effect could be accounted for within the context of the discrepancy model if the parameter α were to decrease as a function of accumulated information. This model was specialized by Saltiel and Woelfel (1975) who asserted that the parameter α is:

$$\alpha_n = \frac{1}{n} \quad (8)$$

where n is the number of messages ever received on the topic. If α were to decline in this manner, then the belief after n messages would simply be the arithmetic mean of those message values. However, since the number of prior messages is unknown for other than "de novo" beliefs, the accumulated information model to be tested here will incorporate information as a continuous variable.

$$\Delta b_0 = \alpha(M - b_0) / (1 + i_0) \quad (9)$$

And with M=true=0, the model becomes:

$$\Delta b_0 = -\alpha b_0 / (1 + i_0) \quad (10)$$

where i_0 is the level of information at the time of the message.

The relationship of accumulated information to belief change messages may be interpreted in the following way: When a receiver decodes a message advocating belief change, the receiver, according to the proportional change model, makes a mental comparison between his or her initial belief and the

proposed belief, and then yields proportionately. However, other mental comparisons are likely; the accumulated information hypothesis implies that a receiver not only makes belief comparisons but also assesses the degree to which he or she is "informed" about the belief topic. If one is *not* informed; that is, if one cannot retrieve prior message content (pro or con) then this new information compared to the old (none) takes precedent and consequently alters the original belief. Further, if one has accumulated much information, then during the comparison process this information might be retrieved and used in defense of the initial belief, resulting in little to no belief change. The parametric curves which illustrate the theoretical relationships between belief change as a function of message-belief discrepancy and accumulated information are presented in Figure 3.

METHOD

Message-belief Topics

The following belief statements were used for the experiment: (1) the nuclear production of electricity is potentially more dangerous than the conventional methods of producing electricity, and (2) the U.S.S.R. military forces are becoming superior to the military forces of the U.S. Hereafter the first belief topic is referred to as the nuclear belief and the second as the military belief. The belief change messages dealt specifically with these two beliefs, both argued for "true," and both were abstracted from actual news stories presented in the March 8, 1976 issue of *Time*: "The struggle over nuclear power" and "That alarming Soviet buildup."

To insure that the "truth" argument came across clearly, each of the actual news stories were modified slightly; included in the nuclear experimental message was: "nuclear power is potentially more dangerous than conventional sources of power" and "to those in the antinuclear camp, the danger is clear, 'the nuclear production of electrical power poses a severe threat to the lives and health of millions of Americans.'" For the military message similar modifications were made; included in the military experimental message was: "Whether the Soviets actually plan to attack the Western world, one thing is clear according to NATO Commander in Chief... 'The massive Soviet buildup clearly indicates that the U.S.A. is becoming the weaker of the two military giants.'"

Procedure

The subjects were 134 students solicited from the communication department subject pool at Michigan State University. Each subject was given a questionnaire booklet which was made up of three parts. The first part contained the belief and information scales which the subject was to fill out for the pretest. The middle section was one of the two messages. The subject was asked to "carefully read and underline the main points of the article." The third section of the booklet consisted of the same belief and information scales which the subject was asked to fill out again as the posttest scores. For the purpose of double checking reliability, a third questionnaire was given one week later. In this design, those subjects who were randomly assigned the nuclear message acted as a control group to those subjects assigned the military message and vice versa.

Instruments

The belief index was composed of six items. Three were bipolar scales from *unlikely* to *likely*, from *improbable* to *probable*, and from *false* to *true*. The other three items used a different format. First, the subject was asked to make a forced choice between two endpoints such as *true* or *false*, and then to rate his/her confidence in that rating on a six-point Likert scale from *just guessing* to *certain*. This pair of responses was then combined to provide a scale by starting from 50 for *just guessing* and counting either up or down in steps of 10 to either 0 for *certain* and *true* or 100 for *certain* and *false*. The three items of the compound type used the same endpoints as did the three bipolar scales. All six items proved correlationally equivalent when subjected to a cluster analysis (Danes, 1976); all six measures were scored so that zero=*true* and 100=*false*.

For the measurement of information subjective information scales rather than the "objective"

TABLE 1
Pretest and Posttest Belief Change Means and Standard Deviations for the Experimental and Control Situations

Message Treatment	Belief Topic	Pretest	Posttest	Belief Change
Nuclear	Nuclear	33.7(21.7)*	21.1(26.4)	-12.6(18.7)
Control	Nuclear	35.4(27.0)	35.8(26.7)	0.4(15.3)
Military	Military	38.9(26.2)	34.3(26.4)	-4.6(16.3)
Control	Military	43.6(23.7)	46.0(26.4)	2.4(14.5)

*The value in parenthesis is the standard deviation.

knowledge scales were used to account for those receivers who may have been "misinformed" on the two experimental topics. Knowledge implies that the information accumulated is "correct"; whereas the subjective information construct makes no such implication. The information index consisted of eight items. Four of the items were global judgments on seven-point bipolar scales: *know a little—know a lot, not aware—aware, not informed—informed, not knowledgeable—knowledgeable*. Four of the items were counts (numerical judgments) of the number of times the belief topic had been heard on each of the four media categories: television and radio, newspapers and magazines, books, and interpersonal contacts. In a pilot study these counts did not relate linearly to the subjective information judgments. The maximal linear correlation was found for the logarithmic transformation. In the main study each numerical count was transformed by the formula $x' = \ln(x+1)$ where ln is the natural log function.

RESULTS

Scale Construction

Since each variable is measured by several indicators, the reliability of each instrument can be measured in two ways: by Cronbach's (1951) coefficient alpha or by an over time reliability coefficient such as is given by Wiley and Wiley (1970). Coefficient alpha for the nuclear belief was .97 and for the military belief was .96, while the Wiley and Wiley (1970) reliability coefficients were .90 and .93, respectively. Coefficient alpha for the nuclear information index was .94 and for the military information index was .91, while the Wiley and Wiley reliability coefficients were .98 and .94. For each instrument, index scales were created by averaging the multiple indicators.

Message Effect

The means and the standard deviations for the pretest, posttest, and belief change are shown in Table 1. For those who read the nuclear message, there was a mean change of −12.6 units on a 100-point scale; for whose who did not read this message, there was a mean change of .4 units. The point biserial correlation for this message effect is .36 which is significant ($F=19.62$; $df=1, 132$; $p<.001$). For those who read the military message there was a mean change of −4.6 units, while for those who did not read this message there was a change of 2.4 units. The point biserial correlation for this message effect is .21 which is significant ($F=6.42$; $df=1, 132$; $p<.01$) though only two-thirds as large as the effect for the nuclear message.

Screening the Models: A Quick Check

Each of the three models has the form

$$\Delta b = -\alpha d \quad (11)$$

TABLE 2
Correlations Between Δb, d, Accumulated Information and Belief Certainty for the Nuclear and Military Topics in Both the Experimental and Control Situations

Variable		Nuclear Message	Nuclear Control	Military Message	Military Control
Proportional Change	$d=b_0$	-.65	-.30 (-.07,-.50)*	-.30	-.27 (-.03,-.48)
Belief/Acc. Information	$d=(b_0/1+i_0)$	-.76	-.26 (-.02,-.40)	-.38	-.12 (.13,-.35)
Belief/Belief Certainty	$d=(b_0/1+c)$	-.16	-.13 (.11,-.36)	-.08	.07 (-.17,.31)
Accumulated Information	i_0	.51	.04 (-.20,.28)	.32	.16 (-.09,.39)
Belief Certainty	c_0	.39	.26 (.02,.47)	.14	.06 (-.18,.30)

*The values in parenthesis are the range of permissible values for 95% confidence levels.

where d is either the message-belief discrepancy or a modification of that discrepancy. In each case d can be calculated from the other variables. Thus, one quick check of the relative power of the three models is to compare the correlation $r_{d\Delta b}$ for each of the three models. These correlations are presented in Table 2.

The first column of Table 2 has the correlations for the nuclear message group. The correlation for the proportional change model in which $d=b_0$ is $-.65$ which is substantial. In part, this is the well-known regression artifact, but only in small part. The control group correlation for change on the nuclear belief is found in column two of Table 2 and is only $-.30$ with 95% confidence limits including the values: $-.07$ to $-.50$. The upper limit of this range represents the maximum value of this correlation that could be created by a regression artifact. The correlation for the accumulated information model in which $d=b_0/(1+i_0)$ is $-.76$ for the nuclear message group which is not only substantial in size, but is larger than the $-.65$ for the proportional change model. Thus, belief change is smaller for those whose belief is based upon more accumulated information. The correlation for the belief certainty model in which $d=b_0/(1+c_0)$ is .16 which is negligible in comparison to the fit for the other two models.

The correlations for the military message group are presented in column three of Table 2 and the corresponding control group correlations are found in column four. The correlation for the proportional change model is $-.30$, the correlation for the accumulated information model is $-.38$, and the correlation for the belief certainty model is $-.08$. These correlations are all lower than those obtained for the nuclear message group and reflect as indicated earlier a difference in the basic effectiveness of the two messages. However, the comparative size of the correlations is the same: the belief certainty model shows almost no fit at all, while the accumulated information model shows definitely better fit than the proportional change model.

Testing the Models

Thus far the "fit" of each of the models was discussed in correlational terms; the problems associated with the correlational approach to the "testing" of mathematical models are well known (cf.,

TABLE 3
Belief Change Means and Cell Size for the Three Levels of Accumulated Information and the Three Levels of Belief for the Nuclear Message

		Accumulated Information (i_0)			
		Low (1)	Moderate (2)	High (3)	
Belief (b_0)	False (3)	-53.9(2)*	-26.3(2)	-11.7(1)	-34.4(5)
	Uncertain (2)	-27.1(18)	-11.7(5)	-2.7(1)	-22.9(24)
	True (1)	-7.0(11)	-1.0(21)	-2.1(5)	-2.9(37)
		-21.7(31)	-4.7(28)	-3.6(7)	-12.6(66)

* The values in parenthesis refer to cell size, n = 66.

Birnbaum, 1974). Therefore, to determine the functional form of communication to belief change more precisely, a graphic method was used to analyze the communication and belief change models: A nonlinear bivariate regression which results in an *empirical* "plot" of the functional relationship of belief change to communication (Hunter & Cohen, 1974).

The above correlational analyses suggested that the accumulated information model was the superior of the three; thus for the analysis presented below, initial belief (b_0) was divided into the following three levels: 0-35=true, 35.001-65=uncertain, and 65.001-100=false. And initial accumulated information was divided into the following three levels: 0-1.75=low, 1.75001-3.25=moderate, and those values greater than 3.25001 were scored as high. Two criteria were used in producing the three-way splits for the belief (b_0) and the information (i_0) variables: (1) the split was made so that the proportions of scale values were equivalently distributed at the minimum and maximum regions, with the remainder assigned to the "uncertain" region for belief and the "moderately" informed region for information; and (2) so that an approximately equal number of receivers were present in each cell. However, it was discovered that belief and information were not linearly related; thus, the production of cells with roughly equal numbers of receivers was not possible. For the nuclear message, the belief change means and number of subjects are presented in Table 3. Since the reliabilities average .95, no correction such as that recommended in Hunter and Cohen (1974) was made on the data before cell membership was determined.

From Table 3 (and 4), a nonlinear relationship between belief and information is graphically revealed by the distribution of the receivers in the cells. For those who are "informed," practically none are "uncertain." For those who are "uninformed," the majority are "uncertain"; however, a substantial number of the "uninformed" are "certain" in their convictions. The existence of this nonlinear relationship between information and belief precluded an equal number of receivers in each cell.

If the proportional change model is more correct than the others, the resulting "plots" would reflect this if three *parallel* negatively sloped lines resulted from the analysis. If the accumulated information model is more correct than the others, the resulting

TABLE 4
Belief Change Means and Cell Size for the Three Levels of Accumulated Information and the Three Levels of Belief for the Military Message

		Accumulated Information (i_0)			
		Low (1)	Moderate (2)	High (3)	
Belief (b_0)	False (3)	-25.0(3)	-12.7(4)	0.3(6)	-9.5(13)
	Uncertain(2)	-10.8(17)	6.0(5)	--(0)	-6.9(22)
	True (1)	-6.9(6)	0.0(22)	0.2(5)	-1.3(33)
		-11.5(26)	-.07(31)	.007(11)	-4.6(68)

*The value in parenthesis refer to cell size, n = 68.

"plots" would reflect this if the three lines form a negatively sloped *bilinear fan* such that steeper slopes obtain with lesser amounts of accumulated information. If the belief certainty model is more correct than the others, the resulting "plot" should form three *collinear, V-shaped* curves, reflecting the theoretical expectation that those with extreme convictions are the most resistant to change.

The regression of belief change (Δb) onto the three levels of initial belief (b_0) and the three levels of initial accumulated information (i_0) produced the parametric curves for the nuclear message in Figure 4. The results of the regression analysis reported in Figure 4 clearly support the accumulated information model. The parametric curves almost exactly reproduce the accumulated information parametric curves reported in Figure 3: the empirical "plots" produced a *bilinear fan*.

Table 4 contains the mean change as a function of initial belief and information for the military message. These means are plotted in Figure 5. These parametric curves are also essentially of the same form as the information model in Figure 3, though the value of $\propto$ is not so large as for the nuclear message. The one point which appears to be deviant is that for $b_0=2$, $i_0=2$. However, this mean is based on only five subjects and does not differ significantly from the intermediate value that would make the parametric curve a straight line.

DISCUSSION

The ability of the proportional change model to more accurately account for belief changes was enhanced when this model included the accumulated information operator, a finding which supports the Saltiel-Woelfel (1975) hypothesis. In this model, the amount of change obtained is inhibited by the amount of information accumulated into the belief. Higher amounts of accumulated information yield lesser changes and lower amounts of accumulated information yield greater changes.

Other literature also supports this finding. Patterson and McClure (1973), in a political mass communication study, assessed the impact of a paid political message upon belief change. The message and belief evaluated was a "Democrats for Nixon" political message which argued that: (1) Richard Nixon does not favor spending less money on the military, and (2) George McGovern favors spending less money on the military. They found that potential exposure to the commercial message (as measured by prime-time television exposure) lead to belief changes in the direction of the message.

FIGURE 4
Regression curves of nuclear belief change on initial belief with accumulated information parameterized.

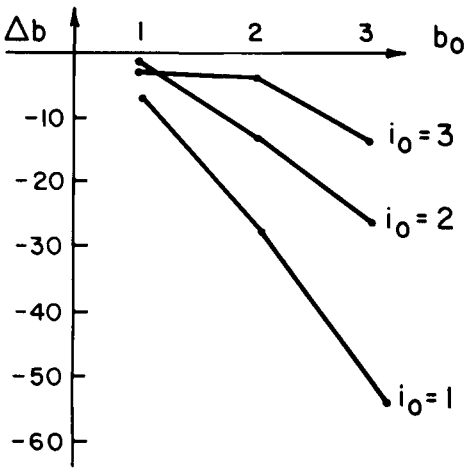
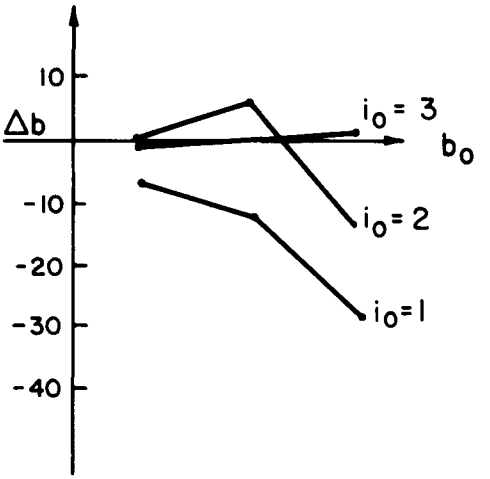


FIGURE 5
Regression curves of military belief change on initial belief with accumulated information parameterized.



Also, they found that the commercial message had less of an effect on beliefs about Nixon than on beliefs about McGovern. At the time of the study, Nixon had been president for more than three years, a vice-president for eight years, and was in the news frequently. McGovern, on the other hand, was well known only in his home state of South Dakota. It is, therefore, likely that many receivers had already accumulated much information about Nixon's relationship to the military, and very little about McGovern's relationship.

Could their findings be explained by the proportional change model? If more persons already believed that "Nixon does not favor spending less money on the military," then there would be less distance to move and hence less possible change. However, the way in which Patterson and McClure (1973) calculated belief change suggests that this is not so. These researchers obtained belief change values by subtracting the percent of persons who changed in the direction of the message from the percent of persons who changed in the direction away from the message. The amount of change was not considered, but only whether a person changed.

The belief certainty model clearly was the most inferior of the three models. It failed, and its failure indicates that the certainty which one ascribes to a belief is unrelated to belief change. An identical result was reported by Saltiel & Woelfel (1975), who found no net effect of belief certainty on belief change in a field setting across a six-month interval. Overall, the results of this study indicate that resistance to belief change is best viewed as being linked to an informational base, rather than belief certainty.

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