A SPATIAL-LINKAGE MODEL OF COGNITIVE DYNAMICS[1]

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> ...after accumulating a vast quantity of data and an impressive number of theories -- perhaps more data and theory than in any other single topic in the social sciences...there was surprisingly little agreement concerning when, if, and how, the traditional source, message, recipient, and channel variables affected attitude change. Existing literature supported the view that nearly every independent variable studied increased persuasion in some situations, had no effect in others, and decreased persuasion in still other contexts.
>
> Petty and Cacioppo (1986, pp. 124-125)

> The physicist has to limit himself very severely he must content himself with describing the most simple events which can be brought within the domain of our experience; all events of a more complex order are beyond the power of human intellect to reconstruct with the subtle accuracy and logical perfection which the theoretical physicist demands.
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> Einstein (1954, pp. 225-226)

Why does the area of attitude change experience such a paucity of theoretical integration in the midst of such a wealth of data and theoretical attempts?

Einstein's quote gives us one clue. The effects of literally dozens of independent variables have been studied. This, however, has often been accomplished without the simplification provided by a theory which sees many of these variables as special cases of some more general variable. Even when there are attempts at creating theories dealing with a few general variables, the theories typically take layperson's terms (like credibility and commitment) and attempt to relate them to attitude change via some ad hoc formulation. There is no serious attempt to place these seemingly disparate variables into a common framework which provides a sense of process.

A second reason for the lack of theoretical integration is the crudeness of the theory and empirical research in this area (as well as many other areas of the behavioral sciences). What is typically predicted, and tested for, is the <u>presence</u> and <u>direction</u> of a relationship--not its <u>strength</u> or <u>functional form</u>. Precision is hindered by the unfortunate tendency to operationalize variables as if they were dichotomous or trichotomous (e.g., distinguishing low, medium, and high credibility source) rather than assuming that these variables can be measured on continuous scales, and attempting to do so.

Third, attitude theory and research has given inadequate attention to the role of time in additude change. Too often, time is not treated as a variable at all. In those studies which have dealt with time, typically the attitude has not been measured at a sufficient number of time points, and/or the measurement of time or attitude has been too crude, and/or there has been little attempt to provide a theory which makes sense of the observed time course. There is, however, evidence to suggest that an attitude which started moving in one direction can change its direction of motion (Kaplowitz, Fink & Bauer, 1983; Poole & Hunter, 1979; Walster, 1964). Further, we have the everyday experience of people reporting changing their minds and sometimes re-changing them.

The existance of such changes of direction suggests the idea of acceleration, which, in turn, suggests that there are forces involved in cognitive change. Furthermore, this suggests that we can construct a theory through which unobserved forces can be related to observed cognitive "motion". Hence, our goal is to develop a "physics of concepts" as advocated by Hofstadter (1982). Hence we develop a model of attitude change which uses a mechanistic or physicalistic methaphor. According to Leatherdale (1974), models are generally built on metaphors. Mechanics not only has a great deal of richness and precision but is, in some respects, analogous to attitude change.

Before presenting our model, we discuss variables which have been found to be of relevance to attitude and belief change resulting from persuasive messages. We will later show how they can be fit into our model.

Some Key Theoretical Variables

One obvious variable is the position advocated by a persuasive message. A second is the initial view of the receiver. The difference between the position advocated and the initial view is called the message discrepancy and various studies (e.g., Aronson, Turner, & Carlsmith, 1963; Bochner & Insko, 1966; Jaccard, 1981) show that attitude change is often maximized at moderate levels of discrepancy.

Another set of variables involves the source's characteristics, as perceived by the receiver. In one of the classic investigations in this area, Hovland and Weiss (1951) showed that sources who are presumed high in credibility are more effective than less credible sources. One aspect of credibility is expertise (see, e.g., Aronson, Turner & Carlsmith, 1963; Bochner & Insko, 1966). Another aspect of credibility is trustworthiness, which, in turn, is related to whether the source is perceived as unbiased (see, for example, Eagly, Wood, & Chalken, 1978). As Eagly et al. (1978) show, a source is especially likely to be perceived as unbiased when he/she takes a position which is substantially different from the position he/she was expected to take (i.e., when the message disconfirms expectations).

A third set of variables involves the relationship between the attitude being changed and other attitudes. Sherif, Sherif and

Nebergall (1965) write of ego involvement (the extent to which the individual is committed to an attitude) as creating resistance to change. Others have shown that such resistance can be increased by linking a belief to other beliefs (e.g., Holt, 1970; McGuire, 1964; Nelson, 1968; Watts & Holt, 1970) or to positively valenced groups or individuals (Kelley, 1955; Tannenbaum, 1967).

Links to other beliefs can cause, as well as inhibit, attitude change. A number of authors have shown that one can change beliefs about one concept, or a set of concepts, by providing messages or inducing thoughts about other concepts (e.g., Leippe, Greenwald, & Baumgardner, 1982; McGuire, 1981; Rokeach, 1975). These findings are consistent with the various theories of cognitive consistency, such as balance (Heider, 1946), source-object congruity (Osgood & Tannenbaum, 1955) and dissonance (Festinger, 1957). Such linkages are consistent with the idea that people's attitudes and beliefs are organized into belief systems (see McGuire, 1981) or into schemata (Bartlett, 1932).

Finally, there are relevant processes which may take place a good deal after the receipt of an external message. First, the message may be forgotten. As certain aspects of a message are forgotten, the attitude change which it induces may decay (see Cook & Flay, 1978, p. 31), or there may be a sleeper effect (see, Hovland & Weiss, 1951). Second, receivers generate subvocal responses to messages. Those working in the cognitive response tradition (see, e.g., Petty, Ostrom, & Brock, 1981; Petty & Cacioppo, 1986) argue that whether these cognitive responses are favorable or unfavorable to the view expressed in the external message has an important effect on attitude change. The number of these cognitive responses appears to be reduced by distraction (Petty, Wells & Brock, 1976), increased by involvement in the issue (see, e.g., Petty & Cacioppo, 1979), increased by exogenous factors which increase arousal (see, e.g., Cacioppo, 1979) and decreased by exogenous factors which decrease arousal. In short, memory and though processes induced by a message may affect an attitude some time after receipt of the message.

The Basic Structure of Our Model

Some models of attitude and belief systems emphasize connections between concepts (e.g., Heider, 1946; Phillips & Thompson, 1977), which may be of various strengths (J.R. Anderson, 1983). Other models represent systems of attitudes and beliefs as a configuration of concepts in a multidimensional space (see Woelfel, Cody, Gillham & Holmes, 1980; Woelfel & Fink, 1980; Woelfel & Saltiel, 1978 [chapter 3]). For such spatial models, it is assumed that the distance between concepts corresponds to their dissimilarity, and that concepts may be represented in a space whose dimensionality may be empirically determined. The model we have developed involves both a spatial structure and a set of linkages.

Spatial Models

One reason for using a spatial structure is that, as Tversky and Gati (1978, p. 79) state, "the notion of similarity -- that appears under such different names as proximity, resemblance, communality, representativeness and psychological distance -- is fundamental to theories of perception, learning, and judgment." Since the degree to which concepts are regarded as similar may involve considering many attributes, a spatial model is able to represent the complexity of thinking about relationships. Since the relations which Heider (1946) calls unit relations (i.e., similarity, causality, ownership) are closely related, they can all be represented in such a model. Affect (sentiment), the other relationship of Heider's concern, can also be represented within a spatial model -- as the proximity of a concept to an evaluative concept such as "My Preference," or "Things I Like" (see Fink, Monahan, & Kaplowitz, 1986; Neuendorf, Kaplowitz, Find, & Armstrong, 1987).

The spatial model has an important resemblance to balance theory, in that perceptual, cognitive, and affective judgments may all be represented within the same framework. It has, however, an important advantage in that degrees of similarity or affect are conceived of as distances, which may be measured on an unbounded, continuous magnitude scale rather than treated categorically or ordinally.

While Tversky and his associates (Tversky, 1977; Tversky & Gati, 1982) believe in the importance of similarity, they regard spatial models of attitudes and beliefs as inappropriate because the distances which subjects report may violate the axioms for a space with a Euclidean metric (axioms satisfied by ordinary physical space). In particular, they report violations of the axioms of symmetry (the axiom requiring that the direct distance between two points is the same, regardless of which is the starting point and which is the end point) and the triangular inequality (which requires that the sum of any two sides of a triangle be greater than or equal to the third side). For example, Tversky (1977, p. 325) suggests that Jamaica and Cuba will be regarded as quite similar (i.e., close) on the basis of geography, that Cuba and the USSR will be regarded as quite similar, based on political affinity, but that Jamaica and the USSR will be perceived as quite distant. Violations of the triangular inequality are also reported by those working within the Galileo paradigm (see e.g., Marron, 1985; Woelfel & Barnett, 1982; Woelfel & Fink, 1980, p. 73).

We see the violations of the distance metric more as problems of measurement than of theory. The observed violations of the Euclidean axioms are based on assuming that each concept is a point in the space. We believe that a concept is better regarded as a region, whose size is roughly proportional to the number of distinct attributes or meanings the concept contains.[2] The observed violations of the Euclidean axioms, come, we believe, from respondents reporting distances which are not center to center distances. Returning to the example above, we propose

that Cuba, Jamaica, and the USSR might be regions in an ordinary Euclidean space, in which the triangular inequality is satisfied. The apparent violation of that axiom, predicted by Tversky (1977), would occur if respondents are reporting the shortest possible edge to edge distances between pairs of concepts. (See Figure 1.) To avoid such violations, our model assumes that we are able, in principle, to obtain center to center distances between concepts.[3]

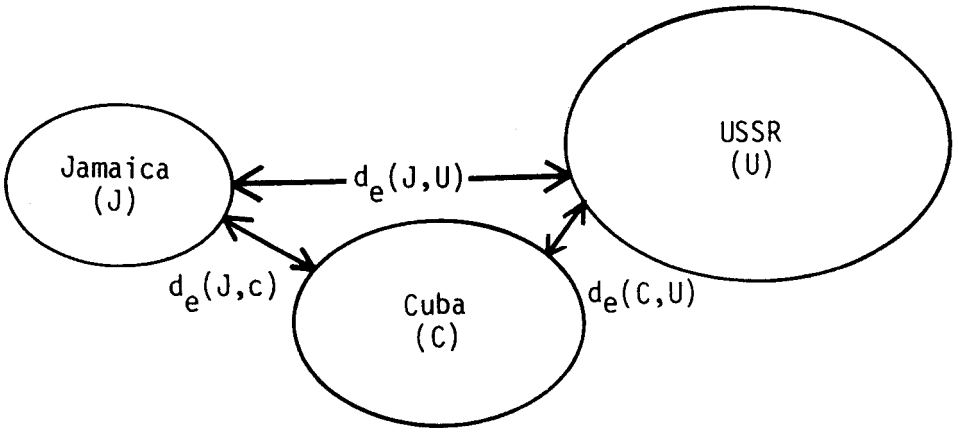

FIGURE 1

Hypothetical configuration of concepts Cuba (C), Jamaica (J), and USSR (U), and interconcept distance reported by subjects. The concepts are assumed to be regions in a Euclidean space, but the reported distances are assumed to be the smallest edge to edge distances ($d_{e(J,C)}$ is the edge to edge distance between Jamaica and Cuba) rather than center to center distances. Hence, the reported distances violate the triangular inequality.

Linkages and Dynamics

Not only are distances convenient for representing both similarity and affect, they are also very convenient for a dynamic model. Within a spatial model, attitude or belief change becomes analogous to motion. In keeping with our metaphor, if there is motion (other than at a constant velocity), there must be forces operating. We can borrow, from physics, equations relating force and motion and construct, by analogy, a relationship between cognitive forces and cognitive motion.

For both parsimony and explanatory effectiveness, our model should posit a cognitive force which (1) is created by a message and therefore capable of causing motion, and (2) whose effects continue after the message, so that any opposing force, generated by a later message, may be restricted. Such a force should also be able to account for the cognitive oscillations, or changes of mind, we have all experienced and which have been experimentally

demonstrated by Walster (1964) and Kaplowitz, Fink and Bauer (1983).

We assume that a message linking two concepts, A and B, established a linkage between them, which creates a force satisfying the following equation:

$$F_{A,B} = K_{A,B} \; (d_M(A,B) - d(A,B)) \qquad (1)$$

where $F_{A,B}$ is the force between concepts, $d_M(A,B)$ is the distance (dissimilarity) specified in the message, $d(A,B)$ is the distance between those concepts in the receiver's cognitive space and $K_{A,B}$ is the restoring coefficient of the linkage.

Several things should be noted about this equation: (1) The force generated by this linkage is zero whenever $d_M(A,B) = d(A,B)$ (i.e., whenever the message agrees with the recipient's current view.) Hence, if this were the only linkage, the system would be in equilibrium whenever this condition held. (2) If the message states a value which is greater than the subject's view (i.e., $d(A,B) > d(A,B)$ the force, $F_{A,B}$, is positive, which causes the distance between A and B to increase. If, on the other hand, the message value is less than the receiver's view, the force is negative, causing a decrease in the value of $d(A,B)$. In other words, the force is a restoring force in that it is always pushing $d(A,B)$ towards the equilibrium value (the message value). (3) Since this is a dynamic system, $d(A,B)$ is not constant. (4) As discussed below, the restoring coefficient is related to various source and message characteristics. In our initial discussion, we assume that $K_{A,B}$ is constant over time. Later, we shall relax this assumption. (5) This equation, which is analogous to the dynamics of a spring (see, for example, Ingard & Kraushaar, 1960) and to an inductance-capacitance circuit (see, e.g., Halliday & Resnik, 1960, p. 799), isbased on the assumption that the force inducing change is proportional to the departure of the system from equilibrium. Using the spring analogy, a large value of $K_{A,B}$ is analogous to a stronger or stiffer spring.

Thus far, we have discussed the creation of message linkages. We further assume that as long as the creating message is remembered, the linkage will continue to exist and to exert a force towards making the A-B distance the value specified in the creating message. Hence, a person's attitudes and beliefs are assumed to be a result, not only of the most recent message he/she has received, but of the entire system of linkages resulting from the various messages which have been received over time. These prior linkages can cause resistance to change advocated by and subsequent message.

Having laid out the structure of our dynamic model, we now compare it with an earlier dynamic model within the Galileo tradition. The earlier model, proposed by Woelfel and his associates (Saltiel & Woelfel, 1975; Woelfel et al. 1980; Woelfel & Saltiel, 1978) is based on the following assumptions: (1) The message "A is like B" or "A is B" is an impulse pushing those two concepts towards each other in P's cognitive space. (2) Information acts like inertia or mass. The more messages P has

received about a concept, the more resistant to acceleration that concept will be.

In one respect, the two models are indistinguishable. Both predict that concepts about which one has received many messages will be more resistant to acceleration than will concepts about which one has received little information. In one model, this would be attributed to increased mass; in the other, to an increase in the total strength of the linkages to that concept. Woelfel and Fink (1980; pp. 146-149) show that the relative masses of two concepts should be proportional to their relative motion. As shown in Eq. (8) below, the strength of the anchoring linkages of two concepts are also proportional to their relative motion.

There are, however, reasons why we prefer the linkage model to what we label the variable mass impulse (VMI) model. For one thing, the linkage model is more parsimonious. It posits one process, the linkage between concepts, to account for both the motion of a concept in response to a message, and the later resistance of the concept in response to a message, and the later resistance of the concept to motion caused by further messages. The VMI model on the other hand, requires one process to explain motion and a different one to explain inertia. Second, only the linkage model is able to predict cognitive oscillations in the absence of new messages.[4]

Equilibrium Predictions of Atttitude Change

Let us now apply the principles discussed above to deriving the equilibrium value of attitude change resulting from a single persuasive message stating that the distance between $\underline{A}$ and $\underline{B}$ is $\underline{d}_M(\underline{A},\underline{B})$. Assume that prior to receiving the message, the receiver, $\underline{P}$, places concepts $\underline{A}$ and $\underline{B}$ at locations $\underline{A}_0$ and $\underline{B}_0$ respectively. Following Eq. (1), the message should create a force, $\underline{F}_{A,B}$. Hence, if $\underline{M}(\underline{A},\underline{B})$ is less than $\underline{d}(\underline{A}_0,\underline{B}_0)$ ($\underline{P}$'s initial view of the $\underline{A}$-$\underline{B}$ distance), concepts $\underline{A}$ and $\underline{B}$ will be pulled towards each other.

Assume that $\underline{A}$ and $\underline{B}$ are anchored to their initial locations by linkages from prior messages. Each set of anchoring linkages may be the result of a number of distinct linkages, (e.g., linkages to conceptions of various significant others, to conceptions of a religious or ethnic community, or to an ideology). To simplify the algebra, we treat the combined effect of each set of anchoring linkages as a single anchoring linkage, linking $\underline{A}$ to its anchor $\underline{R}(\underline{A})$ and $\underline{B}$ to its anchor $\underline{R}(\underline{B})$. The anchoring linkages have their own restoring coefficients, $\underline{K}_{A,R(A)}$ and $\underline{K}_{B,R(B)}$, respectively.

As an example, let $\underline{A}$ be <u>President Reagan</u>, and $\underline{B}$ be <u>Trading Arms for Hostages</u>. Assume that $\underline{A}$ is anchored to, and located at, $\underline{R}(\underline{A})$, which is <u>Strong Foreign Policy</u>. $\underline{B}$, on the other hand, is anchored to $\underline{R}(\underline{B})$, which is <u>Weak Foreign Policy</u>. We further assume that the receiver views $\underline{R}(\underline{A})$ and $\underline{R}(\underline{B})$ as rather far apart (say 100 units). Since $\underline{A}$ is initially located at $\underline{R}(\underline{A})$ and $\underline{B}$ at $\underline{R}(\underline{B})$, this means the receiver initially views <u>Reagan</u> as 100 units from <u>Trading Arms for Hostages</u> . In other words, $\underline{d}(\underline{A}_0,\underline{B}_0) = 100$.

Suppose P, the receiver, now receives a message indicating that Reagan has traded arms for hostages. This message, therefore, claims that the distance between A and B is less than P had originally thought (say 20 units). In other words, $d_M(A,B) = 20$. The linkage created by the A-B message pulls A and B together. This motion, however, is resisted by the linkages of A and B to their respective anchors. In other words, P's view of the A-B distance is influenced not only by the A-B message, but also by his/her prior beliefs, which were established by earlier messages.

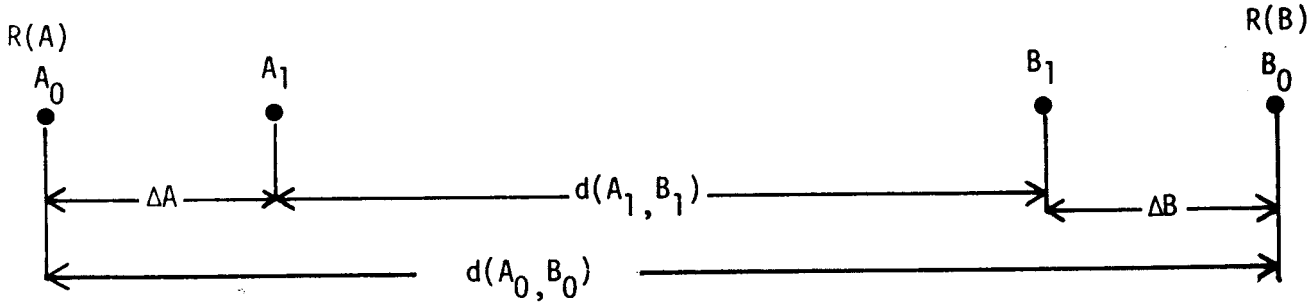

FIGURE 2

Geometric configuration of concepts A and B, and the concepts R(A) and R(B) to which they are respectively anchored. A_0 and B_0 are the locations of A and B before they were linked by the message and A_1 and B_1 are the post-message equilibria. Note that prior to the message, each concept is considered to be at the same location as its anchoring concept.

The combined effect of these linkages is to establish new equilibrium locations, A_1 and B_1, of A and B (see Figure 2.) While we have drawn Figure 2 for the case in which the message value, $d_M(A,B)$, is less than the original distance perceived by P, the derivation below does not depend on this assumption. We have also simplified things somewhat by assuming that the anchoring concepts at R(A) and R(B) are so well anchored that their movement can be ignored.

To determine these new equilibrium locations, we must consider three linkages and hence, three forces. They are the force between A and B, the force between R(A) and A, and the force between R(B) and B. Following Equation (1), in order to calculate $F_{A,B(A)}$ (the force between R(A) and (A), we must not only know the distance between those concepts and the restoring coefficient in that linkage, but also the implied distance between these concepts in the message which created that linkage. While this linkage may be a result of many distinct messages, its new effect is such that prior to the new message, A was at equilibrium when its distance from R(A) was zero. Consequently, we can say that $d_M(A,R(A)) = 0$. Analogously, $d_M(B,R(B)) = 0$.

After receipt of the message, concept A is pulled in opposite directions by the linkages $K_{A,R(A)}$ and $K_{A,B}$. At the new equilibrium, A_1, the magnitudes of the opposing forces pulling on

A must be equal. (The restoring forces in each individual linkage need not be zero, however.) Hence, we have

$$F_{A,R(A)} = F_{A,B} \qquad (2)$$

while from equation (1), above we have

$$F_{(A,R(A))} = K_{A,R(A)} \ (d_M(A,R(A) - d(A_1,A_0) \qquad (3)$$

and

$$F_{A,B} = K_{A,B}(d(A_1,B_1)) - d_M(A,B)). \qquad (4)$$

We can simplify the above expressions as follows. First, recall that $d_M(A,R(A)$ is zero. Second, we define $d(A_0,A_1)$ to be ΔA. (ΔB is defined analogously.) By simple geometry, the new distance between A and B, $d(A_1,B_1)$, must equal the original distance between them, minus the combined change in their locations (see Figure 2).

Further, by definition, the message discrepancy D, is

$$D = d(A_0,B_0) - d_M(A,B). \qquad (5)$$

Hence, in our example, D = 100 - 20 = 80.

Making use of all of this information and substituting into equation (2) gives us

$$K_{A,R(A)} \ (\Delta A) = K_{A,B} \ (D - (\Delta A + \Delta B)). \qquad (6)$$

Since concept B is also presumed to be at its equilibrium location, the two linkages at that point must also generate equal and opposite forces. Hence,

$$K_{B,R(B)} \ (\Delta B) = K_{A,B} \ (D - (\Delta A + \Delta B)). \qquad (7)$$

Since the left sides of equations (6) and (7) are equal to identical expressions, they must equal each other, which gives us the relationship between ΔA and ΔB:

$$\Delta B = \Delta A(K_{A,R(A)} \ / \ K_{B,R(B)}). \qquad (8)$$

Substituting fromequation(8) into (7), and solving for ΔA, gives us

$$\Delta A = (K_{A,B}D) \ / \ K_{A,R(A)} + K_{A,B} + ((K_{A,R(A)} K_{A,B}) / K_{B,R(B)}) \qquad (9)$$

Let us examine the implications of equations (8) and (9). First, since $K_{A,R(A)}$ appears only in the denominator, it is clear that the greater it is, the smaller is ΔA. In other words, the greater the anchoring of A, the less A will move. It is also

clear that the stronger the linkage between A and B generated by the new message ($K_{A,B}$), the greater is ΔA. From equation (8), however, we see that the relative motion of concepts A and B is inversely proportional to the strength of their anchoring linkages. (As indicated above, this equation is analogous to the prediction of the model which assumes that extra messages about a concept lead to extra mass for that concept; see Woelfel & Fink, 1980, p. 149.) To return to our example, whether P's view of President Reagan or his/her view of Trading Arms for Hostages will change more will depend on which of these concepts is more strongly anchored.

It is also clear that, other things being equal, the greater is D the greater is the attitude change. However, according to this model, the total attitude change will never exceed D and will only be equal to D if the restoring coefficients of the anchoring linkages are zero. (In other words, the recipient's view generally does not move all the way to the view advocated by the A-B message.)

To see this, we use equation (8) to create an equation for ΔB which is analogous to Eq. (9). We then add these together to get

$$\Delta A + \Delta B = \frac{(K_{A,R(A)} + K_{B,R(B)})K_{A,B}D}{(K_{A,R(A)}K_{B,R(B)})^2 + K_{A,B}(K_{A,R(A)} + K_{B,R(B)})} \qquad (10)$$

From Equation (10) above, we see that the total attitude change is D multiplied by a quantity whose denominator is larger than its numerator as long as neither $K_{A,R(A)}$ nor $K_{B,R(B)}$ equals zero. Hence, if neither of those anchoring linkages is zero, the attitude change will be less than D. If, however, at least one of the anchoring linkages approaches zero, the aforementioned numerator and denominator approach equality, and the total attitude change approaches D.

Relation of Source, Message and Receiver Variables to Restoring Coefficients

The degree to which a concept is anchored depends, we assume, on the degree to which it is strongly linked to other well-anchored concepts. This, in turn, reflects commitment or ego-involvement. Let us now relate the message linkage, $K_{A,B}$, to the variables which are known to influence attitude change. Since attitude change increases with increased source credibility, $K_{A,B}$ must be an increasing function of credibility. In order to account however, for the finding that attitude change is generally maximized at moderate levels of discrepancy, $K_{A,B}$ must be a decreasing function of the absolute value of D. In other words, highly discrepant messages are discounted. One function which would give us the desired result is an exponential decay function:

$$K_{A,B} = Ce^{-\gamma/D/} \qquad (11)$$

where C is proportional to source credibility and where γ is an increasing function of the receiver's commitment to his/her prior view and a decreasing function of source credibility. Both C and _ are assumed to be non-negative. Laroche (1977) shows that having _ depend on both credibility and prior commitment is consistent with the findings that the value of D which produces maximum attitude change depends on both of those variables.

Such an equation has also been found satisfactory by Fink, Kaplowitz, and Bauer (1983). Further, it is consistent with the idea that the "energy" in the message undergoes an exponential loss as the linkage is stretched or compressed the distance D, so that it can be "attached" to concepts A and B in the receiver's cognitive space.

Equation (11) is inconsistent with earlier work in the Galileo tradition (e.g., Saltiel & Woelfel, 1975, and Woelfel's "Theory of Linear Force Aggregation" which appears in this volume, Chapter 2). Those formulations imply that attitude change is proportional to discrepancy and do not predict that at large discrepancies, attitude change begins to decrease. In our view, such formulations are satisfactory approximations for relatively small discrepancies.

Source Bias and Congruity Theory

A number of studies (e.g., Eagly, Wood, & Chaiken, 1978; Walster, Aronson, & Abrahams, 1966) have found that the expected bias of the source has an effect on attitude change. Birnbaum and Stegner (1979) concluded that when a message is received from a source who is considered bliased, the receiver is likely to take bias into account by, in effect, correcting for systematic "error". This "correction" will cause that message to be viewed as the equivalent of a message from an unbiased source, which specifies a different position. Furthermore, Eagly and Chaiken (1976) found that if a message departed too greatly from the position expected from the source (i.e., it had too great a disconfirmation), the message was not believed

Source bias may be incorporated into our model by assuming that for each concept, A, and for each source, S, there may also be, within P's cognitive space, the concept A(S) (S's view of A). If P regards S as having a different view of A and P's own view, then A and A(S) will occupy different locations in P 's cognitive space. We further assume that when P receives a message linking A and B, the message also serves to link A(S) and B(S) in P's cognitive space. If the source's bias is well known and very salient, the A(S)-B(S) linkage may be stronger than the A-B linkage. Just as the strength of the A-B linkage is assumed to be a decreasing function of discrepancy, the strength of the A(S)-B(S) linkage is assumed to be a decreasing function of disconfirmation.

In order for these linkages to cause motion of A and/or B, A(S) and B(S) must be linked to A and B respectively. The strength of each such linkage should depend both on P's view of S's expertise about the concept and on the degree of confidence P

has in his/her prior judgment of S's bias or position. The latter factor should, in turn, depend both on S's location in P's cognitive space and on the degree to which S's location affects P's view of A(S). If the location of A is considered a highly factual of consensual matter, S's location may have essentially no effect on A(S), the position S is expected to take. For concepts which are considered highly value-laden, S's location may have a great effect on A(S). We are currently working (Fink & Kaplowitz, in process) on equations which will make these ideas more precise.

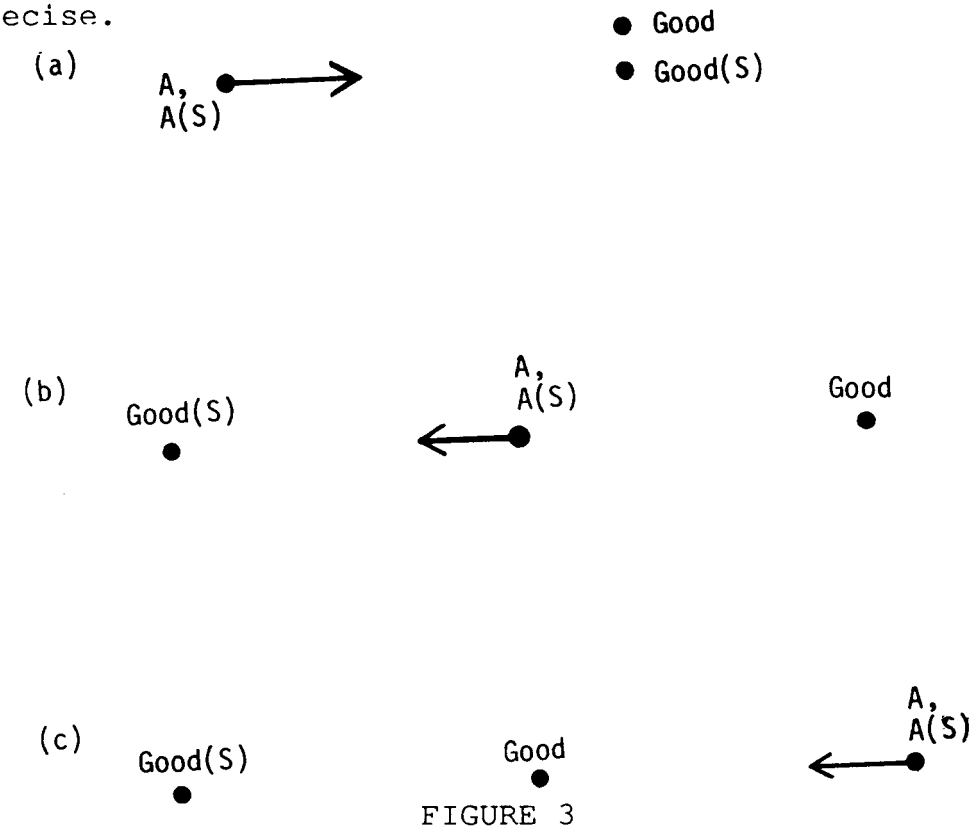

FIGURE 3

Configurations of object concept, A, Source's view of Good (Good(S)), and recipient's own view of Good, resulting in (a) successful endorsement of A by Source S; (2) kiss of death endorsement of A by S; (c) successful endorsement of A by negatively evaluated source. Arrows indicate the predicted motion of A.

An important consequence of assuming that P's cognitive space contains concepts such as A(S) is that it permits the model to explain both the successes and failures of Osgood and Tannenbaum's (1955) source-object congruity theory. A message endorsing concept A is a message linking concept A with some positively evaluative concept, such as Good. If the source's viewpoint is salient, this should have the effect of moving A(S) and Good(S) (P's view of S's view of Good) towards each other.

Let us now examine how the spatial configuration of concepts should determine congruity effects. If A is a consensually understood concept, then A and A(S) are very close together and

tightly linked. But the concepts Good (P's own view) and Good(S) need not have the same location in the space. If Good and Good(S) are located on the same side of A (i.e., P views S's view of Good as similar to P's own view), then, as A(S) and A move towards Good(S), they will also move towards Good. Hence, S's endorsement will be effective. (See Figure 3a.) If, however, Good and Good(S) are in the opposite direction from A and A(S), then as the latter two concepts move towards Good(S), they will move away from Good. In this case, the endorsement from S is a "kiss of death" (see Figure 3b).

Thus far, we have shown how our general model can also explain the predictions of source-object congruity theory. We now demonstrate that our model can also deal with findings which are within the scope of congruity theory but which it cannot handle. Suppose a negatively evaluated source (e.g., a convicted mobster) gives a message which greatly disconfirms expectations (e.g., he advocates tougher law enforcement). According to congruity theory, such an endorsement should cause the subjects to be less favorable towards the object endorsed. As Walster, Aronson, and Abrahams (1966) found, however, such a message was quite effective in changing opinions in the direction advocated. this can be explained by assuming that Good(S) (where S is the mobster) and Powerful Law Enforcement (PL) are in opposite directions from Good. As PL and Good(S) move towards each other, they move towards Good (see Figure 3c). Thus, the movement of Good(S) towards Good makes P more favorable to PL.

To summarize, we propose that the determinant of whether an endorsement of concept A causes A to be more or less like by P is not P's evaluation of S. Rather, it is the spatial configuration among three concepts in P's cognitive space: A, Good, and Good(S). (Good(S) should, however, often be located close to S in P's cognitive space.) If the three concepts are in a straight line, it is only when A is between the other two concepts that the endorsement should backfire.

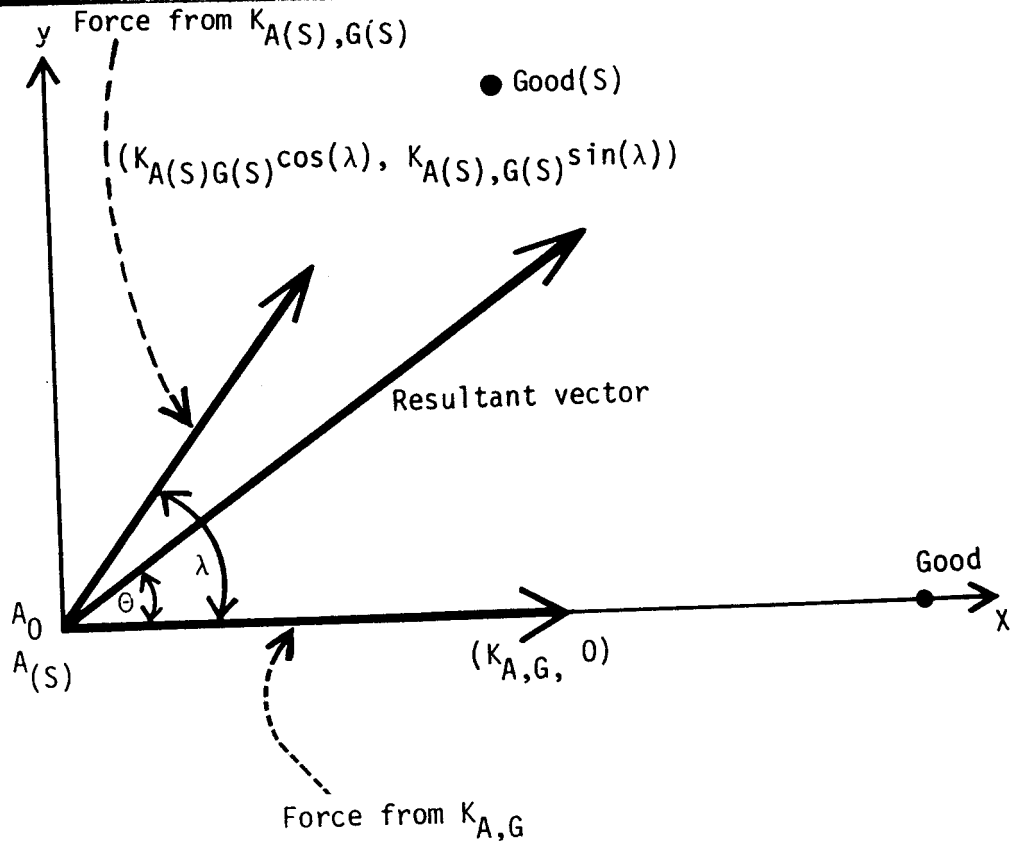

FIGURE 4

Deriving the angle, Θ, between the A-Good line and the motion of A, as a function of two the restoring coefficients of linkages, $K_{A,G}$ and $K_{A(S),G(S)}$ and the angle, λ, between those two linkages. A_0 is at the origin of the co-ordinate system and the expressions in parentheses are the coordinates ofthe ends of the force vectors created by each linkage.

In general, three concepts will not form a line but a triangle. Hence, assuming that the space satifies the Euclidean axioms (e.g. has no imaginary dimensions) we will now extend statements made above to the more general case. First, recall our assumption that there is not only a linkage between A and Good (with restoring coefficient $K_{A,G}$), but one between A(S) and Good(S) (with restoring coefficient $K_{A,G+a}$). Recall also that since A is viewed as consensual, A and A(S) are assumed to be at the same location and very tightly linked. In view of the two linkages, we must first find the direction of A's motion as a function of the strength of those two linkages and the angle between them. (See Figure 4).

Let λ be the angle between the two linkages and let Θ be the angle between the resultant vector and line A-Good. Let us next assume that the forces from these two linkages are proportional to their restoring coefficients.[5] To add the two vectors, let us set up a co-ordinate system so that the origin is at A_0 (where A_0 is the initial location of A) and the x axis is along the A -Good line. In this case, the end point of the A-Good vector has co-ordinates $(K_{A,G},\ 0)$. The vector from A_0 toward Good(S) has co-ordinates $(K_{A(S),G(S)}\cos(\lambda),\ K_{A(S),G(S)}\sin(\lambda))$. The resultant

vector is simply the sum of the co-ordinates, and the result angle, Θ, can be defined by them:

$$\Theta = \tan^{-1} \frac{(K_{A(S),G(S)} \sin(\lambda))}{(K_{A,G} + K_{A(S),G(S)} \cos(\lambda))} \qquad (12)$$

Note that in the special case in which $K_{A(S),G(S)} = 0$, $\Theta = 0^{o}$, and in the special case in which $K_{A,G} = 0$, $\Theta = \lambda$.

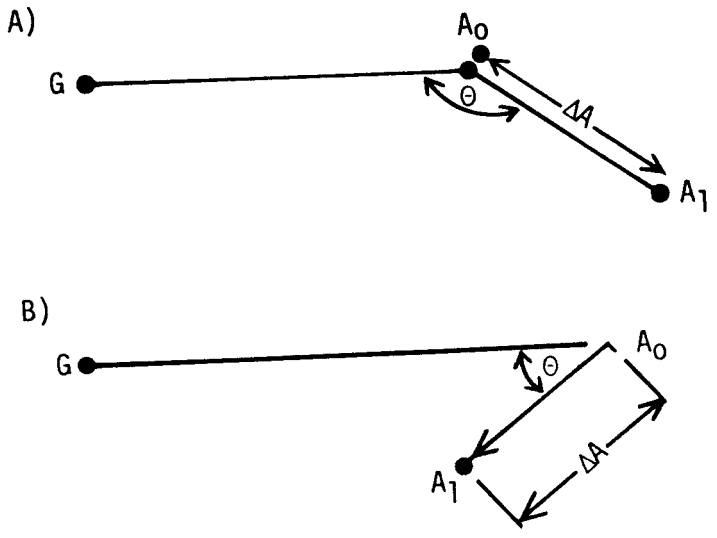

FIGURE 5

Changes in the evaluation of A as a result of a message, as a function of the spatial configuration of A_0, A_1 (the initial and final positions of A) and Good (abbreviated G). a) $\Theta > 90^{o}$. A moves away from Good as it moves from A_0 to A_1. b) $\Theta < 90^{o}$ and $\cos(\Theta) > \Delta A/2d(A_0,G)$. A moves closer to Good.

Let us now consider the conditions under which the motion of A will cause it to be viewed more positively by P than originally. We do so by examining the triangle formed by A_0, A_1, (A's post-message location) and Good (G). As before, we let $\Delta A = d(A_0,A_1)$. By the law of cosines, we have

$$d(A_1,G)^2 = d(A_0,G)^2 + (\Delta A)^2 - 2(\Delta A)^2(d(\Delta A_0,G)\cos(\Theta). \qquad (13)$$

In order for A to be more positively evaluated (closer to Good) after the message than before, it must be the case that

$$d(A_1,G) < d(A_0,G). \qquad (14)$$

Combining Eq (13) with Inequality (14) we find, that A will become more positively evaluated if and only if

$$\cos(\Theta) > (\Delta A/2d(A_0,G). \qquad (15)$$

If Θ is greater than 90°, this will never occur and A will always become less positively evaluated after the message. (See Figure 5a). The smaller Θ is, the larger is $\cos(\Theta)$ and the more likely this condition is to be met (see Figure 5b).

We have shown how a geometric model is able to improve on predictions which congruity theory attempts to make. Let us now show how our view of linkages enables our theory to be an advance over congruity theory in other ways as well. Osgood and Tannenbaum's original formulation of congruity theory predicted that P's attitude towards the source and object should converge to the same point and that the more extreme of these attitude would change least. Assuming that S is linked to Good(S) (and provided $K_{A,G}$ is not strong and is in a very different direction from $K_{A(S),G(S)}$) we also predict that A (the object concept) and S will move towards each other. Even if those assumptions are met, we do not predict that they will arrive at the same point. While there is a linkage, $K_{A(S),G(S)}$, pulling them towards each other, this motion is also being resisted by links to other concepts. Further, the relative motion of each should depend on how tightly it is anchored to other concepts (see equation (8) above), rather than on the attitude's extremity.

The Internal Structure of a Compound Messages

> As Petty and Cacioppo (1986, p. 132) have noted, . . . literally thousands of studies and scores of theories have addressed the questions of how some extra-message factor (e.g., source credibility, repetition) affects acceptance of a particular argument, but little is known about what makes a particular argument (or message) persuasive in isolation.

We believe our theory makes a contribution to this areas as well.

An argument is a compound message. According to Woelfel and Fink (1980, pp. 150-159), such a compound message may be regarded as composed of simple messages, each of which links two concepts. Each simple message will be most successful if not overly discrepant. The entire compound message will be most effective if each simple message creates sufficient attitude or belief change to make any simple message which comes later less discrepant, and hence capable of producing a tighter message linkage.

Let us consider an example. Suppose a simple message merely asserted the desirability of a substantial tuition increase. Such a message would be found highly discrepant by most students and would be quite ineffective. But suppose, instead, that the following compound message was sent:

A good education requires good faculty and good libraries. These things costs money--to pay higher salaries to attract good faculty, and to buy books for the library. The only way to get the necessary revenue is to substantially increase tuition.

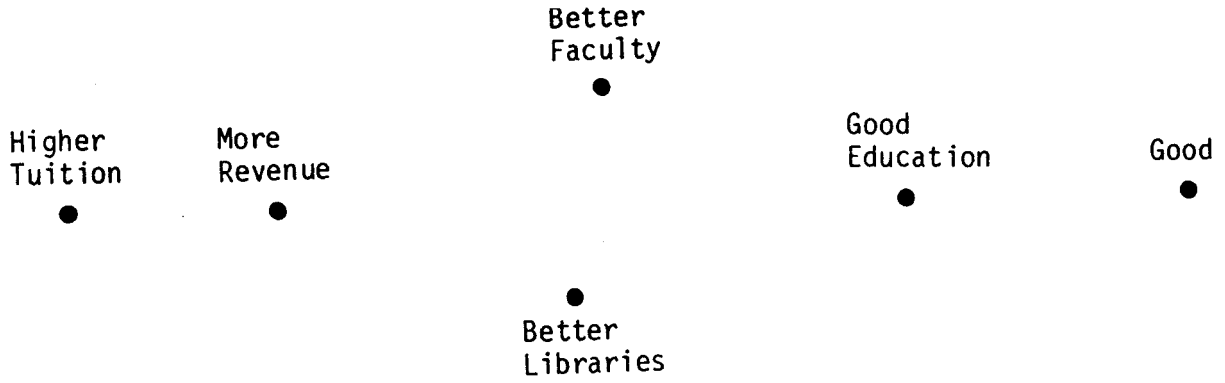

FIGURE 6

Hypothetical configuration of concepts invoked in an effective compound message advocating increased tuition.

Figure 6 shows a hypothetical space containing the relevant concepts. Higher Tuition is quite far from the concept Good in the recipient's cognitive space. Hence, a message simply asserting its desirability would be quite ineffective. Higher Tuition, however, should be quit cloe to More Revenue for the University, since such a causal relationship is quite plausible. More Revenue...should, in turn, be close to Better Faculty and Better Libraries. Both of the latter concepts should be close to Good Education, which is presumably close to (P's view of) Good. In each case, a strong linkage should be established between a concept and one close to it. The effect of this set of linkages should be to pull Higher Tuition towards Good Education and Good.

Forgetting and Delayed Messages

Thus far, we have said that the strength of the linkage created by a message linking A and B is a function of message discrepancy and source credibility. We have also stated that this linkage persists after the delivery of the message. But does its strength remain the same? To answer that, we note that (1) over time, messages are often forgotten, and (2) at least some aspects of memory of a message are related to the persistence of the attitude change induced by a message (see Cook & Flay, 1978, p. 31). Taking this into account, forgetting may be regarded as the weakening of one or more of the links established by a message. In view of Ebbinghaus' (1964) finding

that forgetting follows a decelerating curve, we predict that the strength of a message-induced linkage is a negative exponential function of the time elapsed since the receipt of the message.

While many messages are forgotten over time, some are not. In particular, messages which have been frequently repeated by external sources tend to be remembered, as do messages which are frequently thought about (i.e., subject to elaborate rehearsal; see Craik & Lockhart, 1972). Hence, forgetting (weakening of a linkage) can be counteracted through receipt of new messages on a topic. These messages may be either externally generated or self-generated. This suggests that cognitive responses may be treated as functionally equivalent to externally generated messages.[6]

The issue of forgetting has also been dealt with in previous Galileo work. Consistent with our current formulation, Woelfel and Fink (1980, pp. 156-158) suggested that forgetting involves the leakage of energy from the cognitive system. This led them to conclude that forgetting involves a loss of distinction among concepts--a shrinking of that part of the space including those concepts.

If, however, forgetting is viewed as a weakening of linkages, then shrinking of the space is only one possible outcome. Shrinking will occur if the messages which distinguished the concepts (i.e., linkages which pushed them apart) are forgotten while messages which presented common features (i.e., linkages which pulled them together are remembered. If, however, messages which distinguished the concepts are remembered, while messages which showed commonalities are forgotten, then forgetting will cause the concepts to more further apart.

The Time Course of Attitude Change and Its Consequences

Thus far, we have discussed the equilibrium or final value of the attitude change caused by a persuasive message. However, systems may have dynamic equilibria and it is useful to describe the trajectory (time course) that such systems follow. We shall briefly do so.

Recall that we derived, from Eq. (1), that the restoring force in a linkage is proportional to the displacement of that linkage from it equilibrium.. We combine this with Newton's law, that the magnitude of a force is equal to the mass being moved multiplied by its acceleration. This leads to the following equation of motion:

$$m(d^2x^*/dt^2) = Kx, \qquad (16)$$

where $\underline{x}^*$ is the distance of a concept from its equilibrium location (which may have changed as a result of a message) and $\underline{m}$ is the mass of a concept, and $\underline{K}$ is the effective restoring coefficient of all linkages on the concept. If the restoring coefficient is constant over time, this leads to a trajectory of <u>undamped</u> <u>oscillations</u> with constant period.

Both everyday experience and the behavior of many other systems suggests, however, that such cognitive oscillations

should die out. This suggests that there may be a damping process, which dissipates the cognitive "energy" on any one topic. Distraction, drugs which reduce arousal, and fatigue would all contribute to such a process. Arousal, whether from being involved in an issue, or from exogenous sources (such as from drugs increasing central nervous system activity) should decrease such damping. Hence we assume that there is a damping force which is proportional to, and in the opposite direction from, the velocity of a concept in motion.

Depending on the relative magnitudes of the restoring coefficient, mass, and damping coefficient, the behavior of this system may show oscillations (the underdamped case) or may not (the overdamped and critically damped cases). For the precise solutions to these equations, see Kaplowitz and Fink (1982, pp. 375-377.) For the phase planes of the solutions, see Kaplowitz and Fink (1988).

The Timing of Messages

The notion that attitude and cognitive change is a continuous function of time has some important implications for the timing of messages. It is well known that an important part of being successful as a comedian (e.g., Wilson, 1979) or a persuader (see McGuire, 1985, pp. 270-271) involves proper timing of message delivery.

Our dynamic model is relevant here. In the case of persuasion, since we have assumed that the strength of the message linkage is greatest with small discrepancies, the best time to deliver a new persuasive message is at the moment at which the recipient's viewpoint is closest to the viewpoint advocated; the worst time is when the recipient's view is momentarily furthest from the position advocated. In the case of humor, we have proposed a number of alternative models, based on our multidimensional linkage model, for the relationship between humor and timing (see Maase, Fink, & Kaplowitz, 1984). Unlike static views of the attitude change process, our model makes clear that the timing of messages should have an effect. To explain this effect, we need not invoke any new theoretical concepts.

Cognitive Responses

Let us now consider the relationship between attitude change and cognitive responses (i.e., self-generated messages, or thoughts). There are three possibilities for this relationship. One possibility is that there is no causal connection between these phenomena (i.e., attitude change neither influences nor is influenced by cognitive responses.) While those employing the cognitive response perspective (e.g., Petty & Cacioppo, 1986) assume that such responses are a cause of attitude change, others (Eagly & Chaiken, 1984) regard this idea as unproven and believe that cognitive responses may be spuriously correlated with attitude change. The possibility that attitude "motion" may

proceed in ways which are not accessible to conscious awareness is consistent with studies of creativity (see Perkins, 1981) and social cognition (see Nisbett & Wilson, 1977; Lewicki, 1986).

A second possibility is that cognitive responses affect attitude change. This follows from our earlier assumption that cognitive responses are messages, which create linkages like any other messages. Indeed, some of the cognitive response literature (e.g., Greenwald & Albert, 1968) has found that cognitive responses are even more effective than externally generated messages.

A third possibility is that cognitive responses not only affect attitude change but are also caused by it. In particular, cognitive motion should affect the amount that the anchoring linkages are "stretched" or "compressed." This, in turn, should change the restoring force (tension) in those linkages (even if K, the restoring coefficient, is constant.) This change of tension may constitute a disturbance which attracts attention and generates cognitive response.

If the second or third possibilities above hold, then cognitive responses (especially counter-arguments) may help explain the loss of effectiveness of an extremely discrepant message. It is also possible that only when the discrepancy gets big enough to cause the cognitive tension to exceed a certain threshold that counter-argments occur. If so, it may be the case that the functional relationship between attitude change and discrepancy is not the continuous one suggested by the smooth discounting function in Equation (11). It may, instead, be the case that the continuous function fits the aggregate data but not the individual level process. It may be that individuals experience abrupt downturns in attitude change, but do so at different levels of discrepancy.

In sum, the role of cognitive responses is an important question with which any complete theory of attitude change must deal. We are suggesting several alternatives which incorporate cognitive responses into the more general model in different ways. (For a discussion of the implications of alternatives for the effect cognitive responses have on the time course of attitude change, see Kaplowitz & Fink, 1988.) We hope this will guide further research in this area.

Our Research Program

We see our model as having several virtues. First, it proposes precise functional relationships among variables. Second, it integrates large numbers of seemingly unrelated factors by relating them to two key variables, distance relations among concepts, and linkages (of various strengths) among them. Third, the theory is testable. The theory is, however, sufficiently ambitious that in the seven years since we started developing it, we have not been able to test most if its implications. But we have been working on several aspects of it, building a foundation for some of the more radical predictions of the model.

Geometric Foundations of the Spatial Model: Testing the Metric Assumptions

The three metric axioms for a Euclidean space are:

minimality: $d(i,j) > 0$ if $i \neq j$
$= 0$ if $i = j$

symmetry: $d(i,j) = d(j,i)$

and triangle inequality: $d(i,j) + d(j,k) \geq d(i,k)$, where $d(i,j)$ represents the distance from i to j. The first assumption defines each object (here, concept) in a space as a point. The second assumption indicates that we are conceiving the distance between points as geodesics, or "shortest" distances which are equal, regardless of which point is the starting point and which is the terminus.

As we discussed, to the extent that the objects are regions rather than points, we should expect these assumptions to be violated. Since the violation of these assumptions may also come about from measurement error or from the fundamental failure of the spatial conception for attitudes and beliefs, we need to show that these violations are lawful.

Two studies, with which we have been associated, examined these assumptions. The first (Marron, 1985) sought to test whether the violations of the triangle inequality for words exhibiting ambiuity was lawful. To test this, words with two primary meanings (the focal concepts) were shown to subjects within sets of three words (triads) or four words (quadrads). For example, pupil was a focal concept used with eye and student. In the triad presentation, subjects would be asked to judge the dissimilarity of these three words. In the quadrad presentation, subjects would be asked to judge the dissimilarity of pupil (retina), pupil (person), eye, and student. The data on perceived dissimilarities was used to determine the extent of violations of the triangle inequality in each condition. Contrary to what was hypothesized, it was found that violations of the triangle inequality were more severe in the quadrad condition. More importantly for our purposes, the violations of the triangle inequality varied systematically across conditions, and this finding was confirmed across several sets of ambiguous words. In other words, such violations do not indicate unreliability; rather, they provide information as to how conceptual information is processed, and the spatial model can be used to reflect this.

Further, the notion that concepts are viewed as regions rather than points can also be evaluated with data from Marron (1985). Indeed, we have subjected that data to secondary analysis, and the radii of "conceptual regions" have been estimated and shown to be reliable.

A second study (Sandhaus, Fink, & Kaplowitz, 1987) examined the assumption of symmetry. Tversky and Gati (1978) criticize the spatial model on the grounds that there are often violations of the symmetry assumption. In particular, they claim that if A is more prominent (better known) than B, then the degree to which A is considered different from B is greater than the degree

to which A is considered from B.[7] Tversky and Gati also claim that A is considered more similar to B than B is to A.

Replicating the asymmetry study in Tversky and Gati (1978), Sandhaus et al. varied the type of scales used (Likert vs. magnitude estimation scales), the type of judgment to be rendered (similarity vs. difference), and also varied order of presentation of the concept (with the more prominent concept first or second in the comparison). There were six violations of the symmetry assumption is seriously violated with these data.

We conclude, from Sandhaus et al., that the asymmetries found by Tversky and Gati can be avoided by proper wording of questions. If instead of asking "how different is A from B?" we ask (as is the case in a typical Galileo study) "how different are A and B?", there is little asymmetry.

Cognition and Affect

In our model, we assume that cognitive and affective processes may be represented, and that, since attitude change often involves both processes, these processes can be represented simultaneously. Two of our studies are relevant to these ideas. The first (Neuendorf, et al., 1987) was designed to find how self-referential distances could be used to measure favorability (affect) and similarity (a cognitive judgment) in a spatial model. It was predicted, and found, that the distance a concept is from the term my preference is most associated with favorability, while the distance a concept is from the actual me is most associated with judgments of similarity. Most importantly, both the affective response and the cognitive judgment may be represented in one spatial configuration.

Fink, et al. (1986) provide another test of this idea. In this study, Zajonc's notion of the independence of cognitive and affective processing was tested, using the mere exposure paradigm (see Harrison, 1977; Zajonc, 1980). Subjects were shown one of two critical pictorial stimuli, which differed in complexity, within a film clip. The rapidity of exposure was such that recognition of the stimuli was at chance level (i.e., subjects could only guess at random as to whether they had in fact seen a particular stimulus). The results for the simple stimulus are consistent with the mere exposure hypothesis: exposure led to the increased liking for this stimulus, without any accompanying cognitive change. From the standpoint of the overall model, the most significant feature of this study is that the independence of the cognitive and affective processes was found using the multidimensional framework described earlier. A careful examination of the spatial configuration reveals a remarkably lawful trajectory which clearly shows affective change without cognitive change. While Neuendorf, et al. show how cognition and affect may be represented in the same space, Fink, et al. (1986) show how the independence of these processes may also be discovered with the same basic model.

Studies of Unidimensional Attitude Change: One or Two Points in Time

There is a mathematical model, related to information integration theory (N.H. Anderson 1974, 1981), which predicts attitude change as a function of message discrepancy, source, credibility and receiver's prior commitment. This model has been developed by Saltiel and Woelfel (1975), and Himmelfarb (1974), and elaborated and modified by us (Fink, Kaplowitz & Bauer, 1983; Kaplowitz, Fink, Armstrong, & Bauer, 1986). It is also closely related to the work of Birnbaum and Stegner (1979). In this model, the equation for attitude change after one persuasive message is

$$\Delta A = w_1 D / w_0 + w_1), \qquad (17)$$

where $\underline{w}_0$ represents the weight of the receiver's original attitude and where $\underline{w}_1$ is the weight of the new message. If we return to equation (9) and assume that $\underline{B}$ is so tightly anchored that it does not move at all (i.e., that $\underline{K}_{B,R(B)} = \infty$) then we see that the ratio $\underline{K}_{A,R(A)}\underline{K}_{A,B}/\underline{K}_{B,R(B)}$ goes to zero as $\underline{K}_{B,R(B)}$ approaches ∞. We then find that equation (9) is identical to equation (17) if we simply replace $\underline{w}_0$ by $\underline{K}_{A,R(A)}$ and $\underline{w}_1$ by $\underline{K}_{A,B}$. Therefore, the information integration model (called the "lever model" by Birnbaum & Stegner, 1979) can be regarded as a simplification of our multidimensional linkage model. In the information integration model, we assume that only one concept moves and all motion is in one dimension.

Since the information integration model is so clearly related to the multidimensional linkage model, theoretical and empirical research done on the former is relevant to the latter. In Fink, Kaplowitz and Bauer (1983), we accomplished several things of importance to the larger enterprise. First, as mentioned earlier, we showed that a model in which the weight (restoring coefficient) is a negative exponential function of discrepancy fits the data better than did a model in which the weight was independent of discrepancy. (The latter model would be consistent with the linear force aggregation model.) We also showed that the weight of a message was a negative exponential function of <u>psychological discrepancy</u> and that psychological discrepancy (someone's feeling about how big a discrepancy is) depends not only on the <u>positional discrepancy</u> (the discrepancy expressed in consensual units) but also on the other discrepancies with which a particular discrepancy is being compared.

In another study, (Kaplowitz, Fink, Armstrong, & Bauer, 1986) we extended the information integration model to include the effects of forgetting, cognitive responses, and delayed external messages. We proposed that the discrepancy of the original message might affect the degree to which each of these processes take place after the message. We showed that if this were true, the model predicted that the level of discrepancy which produced a greater <u>initial</u> attitude change might produce a smaller final

change. Using attitudes measured at two different points in time, we confirmed this prediction.

Our most recent studies of unidimensional attitude change in response to a persuasive message have focussed on message disconfirmation as well as discrepancy. In the literature, some studies have shown that discrepancy affects attitude change, while other studies have shown that disconfirmation (the difference between the position in the message and the position expected from the source of the message) affects attitude change.

The literature has a major problem, however. Studies vary discrepancy by varying the message position. This, however, varies discrepancy and disconfirmation at the same time. Hence, prior studies do not tell us whether the apparent effect of discrepancy is genuine or is a spurious effect caused the the association between discrepancy and disconfirmation. In an MA thesis done by one of our students (Nemecek, 1985) and in a more recent study, (Kaplowitz, Fink, Atkin, Mulcrone, & Nemecek, in progress) we have established that the effect of discrepancy on attitude change is not merely due to itscorrelation with disconfirmation.

Studies of the Time Course of Unidimensional Attitude Change

In Equation (16) above, we proposed a differential equation for the time course of attitude change. We have tested the trajectories predicted by this equation (Kaplowitz et al., 1983). In that study, student experimenters approached other students in the library, who became subjects. Each subject was given a message advocating an increase in the student health service fee and was asked to think about the issue prior to giving his/her own view. After a time interval, which differed for different subjects, the experimenter returned and asked the subject's view. Each subject's view was measured just once, but many subjects were measured at each different time interval. We assumed that our sample was sufficiently homogeneous so that the trajectory obtained from combining subjects who have been measured at different times, approximated the trajectory followed by a single subject in a particular experimental condition. While our resources did not permit either the control over independent variables or the precise measurement we would have liked, we made up for this with a large sample (of over 1200 subjects). We found significant, though modest, support for a trajectory with undamped oscillations and a period of about 13 seconds.

Coda: Researchers Wanted

In this chapter we have presented an elaborate model which has many empirical implications. We believe that this model is rich with ideas, and ripe for further investigation. Scientific investigation based on a nonstandard model typically takes three forms. First, we may compare the predictions of the nonstandard model to known empirical regularities. Second, we may derive implications from the new model and design experiments to test

them directly. Third, we may look for any internal inconsistencies in a new model.

We believe that we have provided the basis for further scientific investigation. We have shown how our model fits known regularities, and have described some studies that help evaluate its plausibility. We have shown where alternative versions of our basic model can lead.

Now, what is the plan for the future? This chapter, and this volume, will be read mostly by researchers who share some of the goals and much of the methodology that we do. Research is fundamentally a social endeavor: we do it collaboratively, are evaluated by peers, and communicating our work to others so as to influence their work is our fondest hope. Thus, this chapter on cognitive change is designed to influence your cognitions, not merely to display ours. And how do we wish to influence you? We want you, with all the proper scientific skepticism, to help us clarify, elaborate, modify, test, and, perhaps, falsify, this model.

We need other investigators who are not true believers, but who see a few ideas here that might be worth a carefully designed study or a carefully, crafted equation or a carefully thought out critique. Given such assistance, this model might not survive; then again, it might!

NOTES

1. Substantial portions of the chapter also appear in Kaplowitz, S.A., & Fink, E.L. "Dynamics of Attitude Change." In R.L. Levine & H.E. Fitzgerald (Eds.) Analysis of Dynamic Systems. New York: Plenum Publishing Corp.

2. The assumption that the size of a concept is proportional to the number of meanings or attributes it "contains" makes intuitive sense. When the meaning of a concept contains other attributes or meanings, its geometric representation should contain the representations of those other concepts. Violations of Euclidean axioms are most likely to occur when dealing with concepts which have such multiple meanings (e.g., "orange"; see Marron, 1985; Woelfel & Fink, 1980) or multiple attributes (see Tversky, 1977). The larger the size of an object, the greater is the potential for a reported distance, to or from it, to deviate substantially from the distance to or from its center, thereby causing violations of the Euclidean axioms.

3. The actual method used to obtain distance judgments and to derive the spatial configuration of the concepts is discussed elsewhere (see Woelfel & Fink, 1980) and will not be presented here. Suffice it to say that subjects are asked magnitude estimation questions regarding the psychological distance between concepts, and this information can be used to generate the spatial co-ordinates of a multidimensional space (see Torgerson, 1958, pp. 247-297).

4. Note that Woelfel and Fink (1980, p. 159) suggest a variable mass impulse model with linkages, so the idea of linkages within the spatial modelis not new. However, as

indicated above, it is difficult to empirically disentangle the effect of variation in mass from the effect of variation in linkages.

5. There is a simplifying assumption. In general, the force from a linkage is the product of its restoring coefficient and its displacement from equilibrium. Our simplifying assumption is in effect assuming that Good and Good(S) are both the same distance from A and that the two linkages have the same equilibrium length (i.e., advocate the same message).

6. It is also possible to treat such generated messages a mere epiphenomena, with no independent effects. This possibility is considered below and explored in more detail in Fink and Kaplowitz (in progress).

7. Additional findings from this study test Tversky's feature model of similarity. This is not directly revelvant here.

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