Communication & Science
JOURNAL
Classic Series 2011

Serota, K., Cody, M., Barnett, G. A., Taylor, J. (1977).
Precise procedures for optimizing campaign communication.
Originally published in Communication Yearbook I, 475-491.

A RAH Press Publication
http://www.comSciJ.com

PRECISE PROCEDURES FOR OPTIMIZING CAMPAIGN COMMUNICATION

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Multidimensional scaling has been used in political campaigns because it offers several advantages over the use of unidimensional scaling procedures. Specifically, multidimensional scaling allows the researcher to simultaneously observe change and rates of change with the public's attitudes toward the candidates and issues in the election campaign. Further, multidimensional scaling reveals the dimensions voters use to differentiate the candidates and their stands on issues. The goal of this paper is to describe two innovations which will enhance the utility of multidimensional scaling in campaign research: (1) a new least-squares procedure for rotating multidimensional configurations over time, and (2) a precise mathematical procedure for optimizing message strategies and for assessing the effectiveness of implemented message strategies. Reanalysis of campaign research data, over three points in time from a local Congressional election, indicates that the mathematical procedures provide a significant contribution to devising message strategies and in assessing the effectiveness of such strategies.

Recent years have seen an accelerating trend toward sophisticated mathematical theories and models, along with precise quantitative research techniques among human communication scientists. Among these, a simple "inertial" theory (Saltiel & Woelfel, 1975; Danes, Hunter, & Woelfel, 1976), and a combination of ratio-scaled dissimilarities estimates (Danes & Woelfel, 1975), and metric multidimensional scaling (Torgerson, 1958), have found particularly promising applications to questions of cultural belief, public opinion, and other macro-communication topics.

Following the procedures defined by Woelfel (1973, 1974), Barnett, Serota, and Taylor (1974) and Taylor, Barnett, and Serota (1975) asked randomly selected voters in a Michigan congressional district to estimate the dissimilarities among all nonredundant pairs of a set of 10 empirically derived issues in a congressional election campaign in ratio-level scales. Based on metric multidimensional scaling analyses of these data, Barnett et al. (1974), advised one of the candidates about the most effective campaign strategies. substantial evidence of the effectiveness of the strategy, and the candidate was elected by a large margin.

The present paper addresses two central developments in applied multidimensional scaling (MDS), and provides a significant reanalysis of the Barnett, Serota, and Taylor (1976) congressional campaign study. The first of these developments is the establishment of a theoretical reference frame against which to observe, systematically, the consequent effects of campaign communication strategies (Woelfel et al., 1975). The second development is a technique for the identification of optimized message strategy, and subsequent comparison of optimal strategies, actual campaign communications, and resultant attitude change (Woelfel et al., 1976). In the original analysis of the 1974 Congressional data, neither procedure was available to the researchers. Reanalysis yields new and surprising results which significantly support the trend toward mathematical optimizing in political communication and formation of persuasive communication strategy.

THE MULTIDIMENSIONAL SCALING TECHNIQUE

The significance of a multidimensional technique is its power for representing various influences in the projection of structure, simultaneously. Unlike unidimensional scaling, in which error is often better attributed to multiple influences upon judgment (Thurstone, 1927), multidimensional scaling accounts for all of the influences inherent and necessary in a *specific* set of judgments. According to Torgerson:

> . . . the notion of a single unidimensional, underlying continuum is replaced by the notion of an underlying multidimensional space. Instead of considering the stimuli to be represented by points along a single dimension, the stimuli are represented by points in a space of several dimensions. Instead of assigning a single number (scale value) to represent the position of the point along the dimension, as many numbers are assigned to each stimulus as there are independent dimensions in the relevant multidimensional space. Each number corresponds to the projections (scale value) of the points on one of the axes (dimensions) of the space. (1958, p. 248)

By repeating the spatial representation through several points in time, it becomes possible to observe simultaneous changes, and to use the trajectories of motion (across time changes in position) to make mathematically descriptive statements about those changes. It also becomes possible to examine change in light of the causal influences of communicative behavior.

The procedures for generating a metric MDS analysis, which are described in detail by Woelfel and Barnett (1974) and Barnett, Serota, and Taylor (1976), are presented here, briefly.

Subjects are given a complete (n[n–1]/2) list of pair comparisons for a set of concepts being scaled. They are asked to make ratio judgments of the dissimilarity between concepts using the form:

> If *x* and *y* are *u* units apart, how far apart are concept *a* and concept *b*?

Such a procedure requests a distance judgment from a respondent (". . . how far apart are *a* and *b*?") for all [n(n–1)/2] pairs of concepts. Specifically, it requests that this judgment be made as a proportion of a standard distance provided by the researcher ("if *x* and *y* are *u* units apart . . ."). This format allows the respondent to report any positive value; the scale is thus unbounded at the high end, continuous, and grounded with a true zero (meaning identity—two concepts are perceived to be the same).

Since the goal of public opinion research is to measure shared *social* or *cultural* conceptions or the attitudes toward a series of issues held by a defined population, one may use aggregation techniques to improve the measurements. By invoking the *Central Limits Theorem* and *Law of Large Numbers* one finds that the arithmetic average of all responses, for any cell in the matrix, will converge on the true mean for the population as the sample grows large. Thus, the first step in the analysis of the distance estimates is to determine the mean estimate for all possible pairs of n concepts (each cell in the n x n matrix). To the extent that the sample size is large, that cell estimate will be reliable.

The *mean-distance matrix* is then converted into a *scalar-products matrix*, which has been transformed (Torgerson, 1958) to establish an origin at the centroid of the distribution. This matrix is subsequently factored (using an unstandardized direct iterative or diagonalization procedure), to achieve a *coordinate matrix* whose columns are orthogonal axes, and whose rows are the projections of the concept location on each of the axes. This space has the property of representing the average distance judgments for all possible pairs simultaneously. Since the multidimensional space is constructed from the *unstandardized* distance vectors between all possible pairs, variance in the sample population is thus completely accounted for by the multidimensional space.

Finally, this procedure is repeated at each point in time, and the spaces are rotated about the centroid to congruence, to obtain approximations of the concept motions over time. From these resultant cross-time coordinate matrices, one can fit curves (trajectories) of motion which describe the relational changes from the set. Further, the cross-time loadings allow one to make predictions of consequent attitude change.

This scaling procedure has been extensively tested, and aggregate test-retest reliability coefficients of .90 and above have been reported by

Barnett (1972) with as few as 50 cases, and by Gillham and Woelfel (1976) with 29 cases. Simultaneous but separate random samples of approximately 100 have produced intergroup correlations ranging from .93 to .97 in repeated tests (Gordon, 1976). These coefficients, of course, are dependent upon the scaled concepts and the homogeneity of the population.

In the earlier analysis by Barnett, Serota, and Taylor (1976) the general utility of this procedure in the examination of political attitude formation was demonstrated. These data, which provided clear evidence for the validity of longitudinal application of metric multidimensional scaling, are reconsidered here in light of the new methodological developments. A brief review of the previous analysis provides a context for this reanalysis.

REVIEW OF THE EXISTING ANALYSIS AND CONGRESSIONAL STUDY

Data collection procedures are described in Barnett, Serota, and Taylor (1976). Separate random samples were employed in place of a single panel to insure against sensitization and subject mortality. Personal interviews were conducted by trained, professional interviewers using the following question format to generate ratio distance judgments for all possible pairs of concepts at three points in time:

> If John F. Kennedy and Dwight D. Eisenhower are 10 political inches apart, how far apart are:
> —Crime Prevention and the Republican Party
> —Crime Prevention and Inflation

This analysis utilized concepts selected either for reasons related to partisan political theory (party labels, candidate names, and self) or because they were identified in a pretest as being issues which the population under study was going to use to decide whom to vote for. The concepts scaled were:

1. Crime prevention
2. Integrity and honesty in government
3. The Republican party
4. Inflation
5. The Democratic party
6. Democratic candidate (actual name)
7. Campaign reform
8. Busing
9. Me (representing the "self" concept)
10. Republican candidate (actual name)

The district selected for this project is located in north-suburban Detroit. The racial composition is 99% white, with a median age of 39.9 years and a median education for registered voters of 12.4 years (Barone, Ujifusa, & Matthews, 1974).

This district has been traditionally Democratic. In 1968, Nixon received 35% of the vote, Wallace 10%, and Humphrey 54%. However, in 1972, Nixon captured 63%. The incumbent Republican Congressman received 53% of the vote in 1972 (Barone et al., 1974).

The incumbent was clearly recognized as conservative, and strongly identified with limited government spending and opposition to bussing to achieve racial integration. He had close ties with corporate business interests, and was a publicly ardent supporter of former President Nixon. The Democratic challenger (now Congressman) was a former assistant state attorney general. The 1974 campaign was his first attempt at elected office. Virtually unknown six months before the election, he won a hotly contested primary against three other candidates, with 34% of the vote.

The results of the three data collections are summarized in Barnett, Serota, and Taylor (1976). Figure 1 represents the changes in concept positions over time. Based upon the data structure at time one, which showed certain concepts clustering together, or located in the same general region of the spatial representation, the Democratic candidate was advised that campaign messages should stress identification with the Democratic party, and simultaneously emphasize his association with crime prevention. The vector representing the combination of these two messages appeared, upon inspection of the spatial representation, to most closely resemble the vector from the candidate to the self concept, *Me*. Previous political campaign research using multidimensional scaling (Barnett, Serota, & Taylor, 1974), suggested that this association, rather than the traditional association with an ideal candidate, would produce the desired effect for the campaign.

As a consulting strategy, it would appear to be conventional wisdom to have a candidate stress his or her party affiliation as well as personal associations with popular stances on the issues (Butler & Stokes, 1969). However, the salience and issue interrelationships present among a set of issues during a given political campaign may be misleading. For example, while the busing issue had high salience during the 1972 campaign in this district, it was neither an important issue nor an issue which was favorably located relative to the other issues and concepts. While the candidate had intended to take a strong stand on busing, it was advised that the issue be treated as unimportant to this race.

It was emphasized to the challenger that he should work to associate himself with desired concepts rather than attacking his opponent. Since the challenger was relatively unknown, his information history was much less than the incumbent and therefore much less resistant to change (Saltiel & Woelfel, 1975; Danes, Hunter, & Woelfel, 1976). The ramifications of this strategy include the possibility that the public may actually have agenda-setting powers commonly thought to have been usurped by the media and politicians, and that political advantage may belong to those candidates who orient themselves to entering the political process consonant with dominant public opinion.

Between the first and second data collection, the Democratic challenger distributed 145,000 leaflets, 100,000 of which went to areas of lowest awareness. This message dealt with his experience as an assistant attorney general and his position in law enforcement. It also clearly identified him as a candidate of the Democratic party. During this period the candidate also received major media coverage stressing the same basic concept associations.

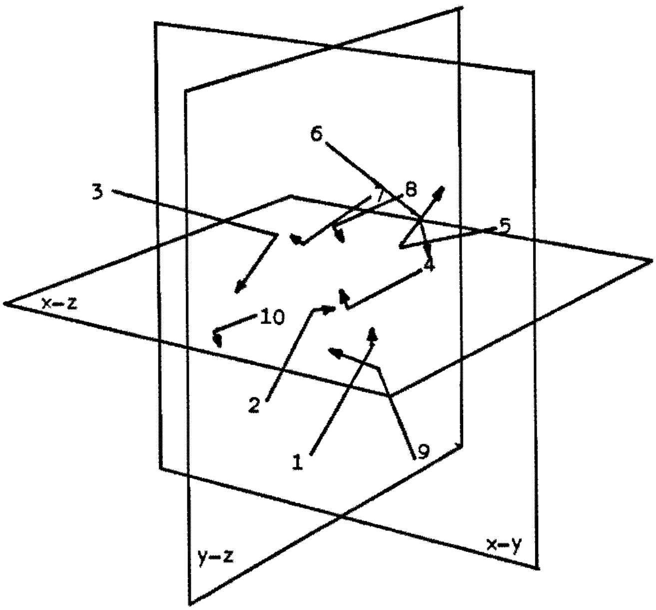
Using a simple least-squares orthogonal rotation, the following analysis of motion between time 1 and time 2 was made. Concepts which appeared to move more than average were *crime prevention* (11.71), the *Republican party* (15.15), the *Democratic candidate* (12.90) and *Me* (10.81). These motions could be explained in terms of significant news events and the campaign of the Democratic challenger. The *Republican party* may have moved because the reaction to the pardoning of Richard Nixon had subsided and the people were moving back toward their traditional party affiliations. The *Democratic candidate's* motion appeared to be a function of his campaigning, which had somewhat stabilized his position in the space. His net movement was toward *Me*, the *Democratic party*, and *crime prevention*, which reflected his campaign and messages stressing the fact that he was a crime fighter and a Democrat. The Republican incumbent was the most stable concept in the space, moving only 3.81 units. At this point, a prediction was made that if rates of change remained constant with those of late September, the Democratic challenger would be the new Congressman.

Based on the above discussion, the following strategies were recommended to the Democratic candidate. First, reference should be made to the opponent as a Republican, reinforcing his deviation from the Democratic plurality. Second, messages which would move the Republican away from *integrity and honesty in government* and *campaign reform* would also facilitate his movement away from the self concept, *Me*.

In general, these second-stage recommendations were not implemented and the earlier campaign strategy was sustained, however in less intensive form. During this later phase of the campaign, the incumbent employed most of his campaign messages, with little effect. The combined result of ineffective campaigning by the Republican candidate and low activity by the Democratic candidate, and the increased inertial mass of the concepts or issues, was less *relative* change during the month prior to the election. The Democratic candidate, however, continued to move toward the concept of *Me* in the space. The exact nature of this motion will be discussed in the section of this paper entitled *Computation of Message Effectiveness*.

Using the simple least-squares rotation the average motion in the space between t_2 and t_3 was 3.95 units; this was considerably less than between the first and second points in time. This indicates that by the second measurement the concepts had stablized in the space. Those concepts with movement greater than the mean were the *Republican party*, the *Democratic party*, the *Democratic candidate*, and *Me*. Again, the Republican

FIGURE 1
Trajectories of Motion for the Political Concepts Prior to the 1974 Congressional Election. Note That Changes Between Times Two and Three are Considerably Less Than Changes Between Times One and Two (Concepts Identifed in the Text)



incumbent was the most stable concept in space. If one examines Figure 1, it becomes apparent that *Me* had changed direction and was approaching the position of the *Republican candidate;* further, the little movement of the incumbent is in the direction of *Me*. Three hypotheses were confirmed, which further demonstrate the validity of the technique.

First, the candidates converged with those issues with which they were publicly associated. The Democrat came out in favor of crime prevention between the first and second points in time. At time one, the mean distance between the candidate and *crime prevention* was 32.42 units. At time two the distance, or discrepancy, had dropped to 8.85 units, a change of 23.57 units. The average motion of all concepts in the space was 9.23 units, and both concepts showed great movement toward each other in excess of the mean.

Between the second and third points in time, the campaign stagnated. This is reflected in the stable relationship between the candidate and *crime prevention.* On *busing* and *inflation* the challenger had made no public statements. His distance relative to these concepts, accordingly, remained stable throughout the campaign.

Second, the candidate clustering most closely to the issue positions that the respondents identified as central to themselves (*Me*) did converge with the average self position. At time one *crime prevention* was the issue located closest to the collective self concept, *Me; busing* was the furthest concept from *Me*. The *Democrat* would have to move in the direction of *crime prevention* and away from *busing*. If one examines the plot (see Figure 1) this can be seen in the trajectories of the three concepts; the Democratic candidate moved past *busing,* in the direction of *crime prevention.*

Third, the candidate whose distance from the position of the respondents (represented by *Me*), was minimized at the time of the election was the candidate chosen by the population. At time three, the distance between *Me* and *Democrat* was 8.6 units while *Me* was 10.8 from the Republican. If one sums the magnitudes of these vectors, then divides each individual distance by this total, and finally, subtracts this proportion from one, the result is the predicted vote. In the above case, the predicted percentage of the vote was 55.7% for the Democratic candidate and 44.3% for the Republican. The actual vote total for the area of study was 57.7% for the Democrat, 41.3% for the Republican and 1.09% for the independent candidates.

REVISED ROTATION AND OPTIMIZATION PROCEDURES

While the 1974 Congressional Study (Barnett et al., 1976) represents a significant innovation in polling methods, it is not without faults. Most important among the problems raised by this approach are the rotation of subsequent measurements into a congruence for "correct" interpretation of concept movements, and the precise optimization of campaign strategies.

In the earlier analysis, the static representations were rotated to congruence with an ordinary least-squares rotation (Cliff, 1966) of the configurations. That is, the squared discrepancies between the corresponding concepts at successive points in time were minimized. First, a translation with a common origin for all three spaces was applied. The operation superimposes the centroid of one distribution (time two) upon the centroid of the other (time one), and successive distributions upon the previous one. Then, the axes were rotated pairwise so that the distance between all concepts, on all possible pairs of axes, were minimized to a Gaussian least-squares best fit. This is given by the formula:

$$\text{Min} \sum_{i=1}^{n} \sum_{j=1}^{m} \sum_{k=1}^{m-1} [\Theta_{ijk(t)} - \Theta_{ijk(t-1)}]^2 \ (j<k), \quad (1)$$

where i is the subscript for concepts in the set of n concepts, j and k are the dimensions being paired for comparison, m is the rank or dimensionality of the space, and t and $t-1$ designate the two sets of data to be rotated (Serota, 1974).

In a recent article, Woelfel and associates (1975) critized the use of the rotation of spaces to a least-squares best fit (cf. Cliff, 1966; Schoñemann, 1966). The reason they suggest is that

> . . . such a solution uniformly attributes resistance to motion to all the data points regardless of position in the space. This method is disadvantageous because it renders highly complex the apparent change in situations where relatively simple laws could describe the "actual" change, given a more insightful rotation. (p. 4)

The least-square rotation has the effect of overestimating some changes, while underestimating others. This may lead to erroneous conclusions, such as the interpretation that the public's attitude toward a series of issues has changed when in fact only their attitude toward the candidates has been altered.

As an alternative to the least-squares procedure, Woelfel et al. (1975), propose a method which makes use of theoretical or "extra" information to provide a rotation yielding far simpler apparent motion. This information concerns the interrelationships of the concepts in the space, and is independent of their coordinate values. The information variable may be such things as the amount of coverage an issue has received in the mass media, a political candidate's use or lack of a campaign issue, some sociological invariants such as the perception of certain aspects of the occupational prestige structure, or an attitude theoretic construct such as Woelfel's inertial mass (Saltiel & Woelfel, 1975). Since this information is independent of the coordinate values, its value may be treated as invariant under rotation and the translation of the coordinates.

Two procedures for rotation to theoretical criteria have been developed by Woelfel, et al (1975). The first of these assumes a simple dichotomy between stable and motion concept sets; the concepts may be either components of a spatial reference system or elements of the set being quantified against the reference frame. The second assumes a more complex system of weights proportional to the stability of each of the elements in the concept set. This analysis will employ the first of these procedures.

Given m stable concepts out of n concepts represented as points in an r dimensional space $(m>r)$, the rotation procedure suggested here consists of two primary operations: (1) the establishment of a common origin for the t_n and the t_{n+1} spaces, and (2) the rotation of the t_{n+1} space to the t_n space so that the separation of any one of the *m stable* concepts from itself is a minimum.

Establishing a common origin consists of a straightforward translation of coordinate axes such that the centroid (of each axis) for both spaces is at the midpoint of the distribution for the hypothesized stable concepts. It is important to emphasize that these concepts are hypothesized to be stable *relative to each other;* against this stable reference constellation, location changes by the more volatile concepts will be calibrated.

Given the following coordinate matrices:

X = the matrix of coordinates at t_n, and
Y = the matrix of coordinates at t_{n+1}

the first task is to find:

A = the matrix X on the common reference system, and
B = the matrix Y on the common reference system.

Finding the centroid of a space which is to be used as the origin for a common reference system is accomplished by first determining the average of the coordinate loadings of the m stable concepts for each of the r dimensions; that is:

$$c_{kk} = \sum_{j=1}^{m} x_{jk}/m \qquad (k = 1,2,\ldots,r) \tag{2}$$

$$h_{kk} = \sum_{j=1}^{m} y_{jk}/m \qquad (k = 1,2,\ldots,r) \tag{3}$$

where, m = the number of stable concepts, and x_{jk} and y_{jk} are the projections of the j*th* stable concept on k*th* dimensions in X and Y respectively. The translation of the coordinate matrices from the old origin to the new "stable centroid" origin is given by:

$$a_{ik} = x_{ik} - c_{kk} \tag{4}$$

$$b_{ik} = y_{ik} - h_{kk} \tag{5}$$

where i refers to each of the concepts in the matrix, and c_{kk} and h_{kk} are the elements of the diagonal matrices C and H.

With both A and B coordinate matrices now located at a common origin, the next task is to rotate the B coordinates so that the distance for any stable concept j from itself is minimized; this amounts to the following minimizing function:

$$\text{Min} \sum_{j=1}^{m} s_{jj}^2 = \sum_{j=1}^{m} \sum_{k=1}^{r} (a_{jk} - b^{\circ}_{jk})^2 \tag{6}$$

where b°_{jk} are the stable projections in the rotated B matrix (denoted B°), and s_{jj} is the distance of concept j in matrix A to concept j in matrix B°. The value Σs_{jj}^2 is a minimum because, while the equation is computed by the method of least squares, it is unlikely that either the distribution of points in A or B will be a straight line. Hence, the sum of squares is not likely to equal the absolute value of zero. The purpose of this minimization is to find, among several alternatives, that set of elements, b°_{jk}, which most closely fit the elements of matrix A.

In order to find the elements of B°, b°_{jk}, it is necessary to perform a series of transformations on the set of all possible axis pairs. The transformation series, designated T_{pq} $(p<q)$, is defined as the two-space orthogonal transformation series commonly used in classical mechanics:

$$T_{pq} = \begin{bmatrix} \cos\Theta_{pq} & -\sin\Theta_{pq} \\ \sin\Theta_{pq} & \cos\Theta_{pq} \end{bmatrix} \tag{7}$$

where,

Θ_{pq} = the angles needed to minimize the distance of the m stable concepts in matrix A from those in matrix B.

The angles of rotation Θ_{pq} are determined by first noting that the projections of the stable concepts j on the p and q coordinates in the matrix B° are given by:

$$b^{\circ}_{jp} = b_{jp} \cos \Theta_{pq} + b_{jq} \sin \Theta_{pq} \tag{8}$$

$$b^{\circ}_{jq} = -b_{jp} \sin \Theta_{pq} + b_{jq} \cos \Theta_{pq} \tag{9}$$

The angle Θ_{pq} which minimizes the j concepts at two points in time in a pq plane is determined by:

$$S_{\Theta_{pq}} = \sum_{j=1}^{m} (a_{jp} - b^{\circ}_{jp})^2 + \sum_{j=1}^{m} (a_{jq} - b^{\circ}_{jq})^2 = \text{MIN} \tag{10}$$

By substituting 8 and 9, in 10 and expanding, yields:

$$S_{\Theta_{pq}} = \Sigma a^2_{jp} + \Sigma a^2_{jq} + \Sigma b^2_{jp} + \Sigma b^2_{jq} - 2 \cos \Theta \quad (\Sigma a_{jp}b_{jp} + \Sigma a_{jp}b_{jp}) - 2 \sin \Theta \quad (\Sigma a_{jp}b_{jq} - \Sigma a_{jq}b_{jp}) \qquad (11)$$

Taking the first derivative of $S_{\Theta_{pq}}$ with respect to the angle Θ_{pq} and setting it to zero gives:

$$\frac{dS_{\Theta_{pq}}}{d_{\Theta_{pq}}} = \sin \Theta_{pq} \, (\Sigma a_{jp}b_{jp} - \Sigma a_{jq}b_{jq}) - \cos \Theta_{pq} \, (\Sigma a_{jp}b_{jq} + \Sigma a_{jq}b_{jp}) = 0 \qquad (12)$$

which leads to the following solutions for the angle Θ_{pq}:

$$\mathrm{Tan}_{\Theta_{pq}} = \frac{\Sigma a_{jp}b_{jq} + \Sigma a_{jq}b_{jp}}{\Sigma a_{jp}b_{jp} - \Sigma a_{jq}b_{jq}} \qquad (13)$$

The arc-tangent of the expression in the right side of equation 13 will yield Θ_{pq}. The second derivative of equation 12 will indicate whether Θ_{pq} is a minimum or maximum for the transformation. If the second derivative is negative, then it is necessary to add 180° to angle Θ_{pq}.

Following each transformation, *Tpq*, the new values of $b°$ for vectors p and q are substituted into matrix $B°$. The subsequent transformation may then be performed.

Utilizing the above rotation procedure, stable and free-moving concepts can be differentiated and accommodated in the observation of concept motions. Accordingly, a more theoretically precise reference frame is generated, and the systematic nature of concept motions as a result of information influence is more readily evident.

A BRIEF SUMMARY OF MESSAGE OPTIMIZING PROCEDURES

After respondents have made distance estimates between all non-redundant pairs of concepts used in the pair comparison questionnaire, responses are averaged across respondents, yielding an aggregate matrix $\bar{S}$ (a matrix of arithmetic means). This matrix is then orthogonally decomposed to yield a multidimensional spatial coordinate system R in which candidates, issues, and a target concept are arrayed. The purpose of the optimizing procedure is to provide information about which subset of concepts in this array can be combined and included in a message that would move a candidate toward the target concept. The exact mathematical algorithm by which this subset of concepts can be selected utilizes the following procedure.

First, we center the coordinate system R on the concept representing the candidate for whom the strategy is to be devised, by the translation of coordinates

$$R^i_j = R^{i'}_u - R^{c'}_j \qquad (14)$$
$$j = 1, 2, \ldots, k$$

where, R^i = the position vector of the ith concept after recentering,
$R^{i'}$ = the original position vector of the ith concept, and
$R^{c'}$ = the original position vector of the candidate.

(R can be any coordinate system, in a series of data collections, at the point in time the researcher wishes to devise the message strategy.) Due to this recentering, the candidate's position vector R^c is now the null vector $|R^c| = 0$, and the position vector R^m, representing the location of the target concept, also represents the vector path along which the conception of the candidate is intended to move.

Further, R^i is the vector originating at the candidate's location and extending to each of the i concepts. It is assumed that any assertion which associates the candidate with concept i will move that candidate along the vector R^i. Similarly, R^i is further generalized to any combination of concepts by a vector addition procedure. R^i will be called the predicted vector.

Based on the above assumption, determination of a single optimal issue may be simply accomplished: first, the angle α_{im} between any predicted vector (R^i) and the target vector can be conveniently calculated from the scalar product

$$\alpha_{im} = \cos^{-1} \frac{(\cdot \ R^iR^m \ )}{|R^i| \quad |R^m|} \qquad (15)$$
$$i = i, 2, \ldots, k\text{-}1.$$

That concept whose position vector forms the smallest angle with the target vector will represent the concept that will draw the candidate most nearly in the *direction* of the target concept. The *amount of change* advocated by this message strategy is given straightforwardly by the length of the predicted vector $|R^1|$, which is given by

$$|R^1| = (\sum_{j=1}^{r} (R^1_j)^2)^{1/2} \quad (16)$$

where r is the dimensionality of R. The above equations are more fully elaborated in Woelfel, Fink, Holmes, Cody, and Taylor (1976). The computer subroutine computes the distance of R^m, distance of R^1, angles between R^m and R^1, the ratio of R^1 and R^m, and the correlation between R^1 and R^m.

R^1 in these equations is used in a general sense. The optimal message strategy (R^1) may be any single concept vector solution (Candidate A is Y), two-pair message solution (Candidate A is X and Y), three-pair message solution, or four-pair message solution. What is important to show, is that the manipulated candidate moves along the *predicted vector*. Procedures for such an analysis are given by Woelfel, et al. (1976) as follows.

Evaluation of the success or failure of such predictions is given straightforwardly by the cosines (correlations) of the angles between the predicted vector R^1 and the vector observed, $R^c(t_2)$, across the time interval of the message Δt. Given measures at two points in time t and $t + \Delta t$, we define the predicted vector across t as

$$R^1(t_2) - R^1(t_1) = R^1(\Delta t) \quad (17)$$

where $R^1(t_2)$ = the coordinates of R^1 at $t + \Delta t$

$R^1(t_1)$ = the coordinates of R^1 at t

Similarly, the observed vector across Δt is given by

$$R^c(t_2) - R^c(t_1) = R^c(\Delta t) \quad (18)$$

where $R^c(t_2)$ = the coordinates of R^c at $t + \Delta t$

$R^c(t_1)$ = the coordinates of R_c at t

But, due to the centering operation, $R^c(t_1) = 0$, so $R_c(\Delta t) = R^c(t_2)$. Since we make no prediction about the magnitude of either $R^1(\Delta t)$ or $R^c(\Delta t)$, then it is sufficient to confirm the prediction that $\cos \alpha \simeq 1.00$, $\alpha \simeq 0.00$.

In practice, however, it is difficult to hold the center of the coordinate system precisely on the spot where the candidate concept was at t for $t + \Delta t$, and so, frequently, a third origin may be chosen, generally at the centroid of the issues and concepts considered stable or least likely to move across the interval based on some criterion (see Woelfel et al., 1975). In this event the components of R_c at t_1 cannot be neglected, and we require

$$\frac{R^1(\Delta t) \cdot R^c(\Delta t)}{|R^1(\Delta t)| \quad |R^c(\Delta t)|} = \cos \alpha \quad (19)$$

Functionally, these procedures translate any sequential pair of configurations to a centroid which is the candidate's time-one null vector (the first two steps of the procedure to obtain the message, but performed on both sets of data after a least-squares rotation of theoretically stable concepts). The difference between the candidate's time-two location and time-one location represent the candidate's motion vector [$R^c(\Delta t)$]. This motion vector is correlated with the time-one predicted motion vector (R^1).

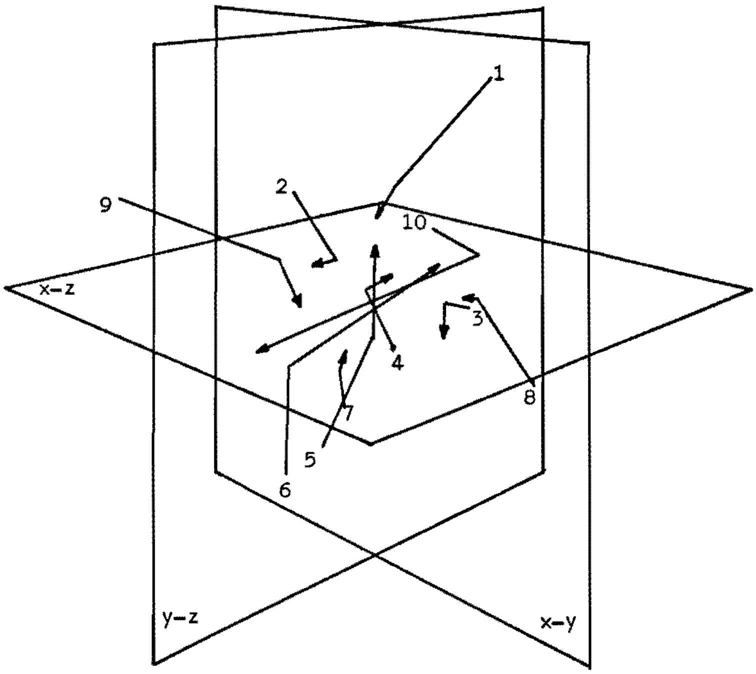
Woelfel et al, (1976), generalize these equations to account for the non-Euclidean characteristics of the multidimensional spaces.

CALCULATION OF MESSAGE STRATEGIES

The message optimizing procedure was used with the time-one data in order to construct message strategies that would move the candidate directly towards the target concept. This procedure produced five, single-concept solutions, and a large number of two-pair, three-pair, and four-pair message solutions. Recall that the solution (or a set of message solutions) in which the angle between R^1 and the target vector is (or are) minimal provide the best message strategy(ies). In this section of the paper we shall describe a number of "fair" and "good" message strategies.

Before discussing these solutions, let us first briefly describe the interrelations between concepts when employing the new rotation (Figure 2). The concepts, and concept identification labels, are referenced previously. The number represents the location of the concept at time one, and the dots along

FIGURE 2
Trajectories of Motion for the Political Concepts Prior to the 1974 Congressional Election; Rotation Utilizing the Woelfel et al. (1975) Procedure (Concepts Identified in the Text)

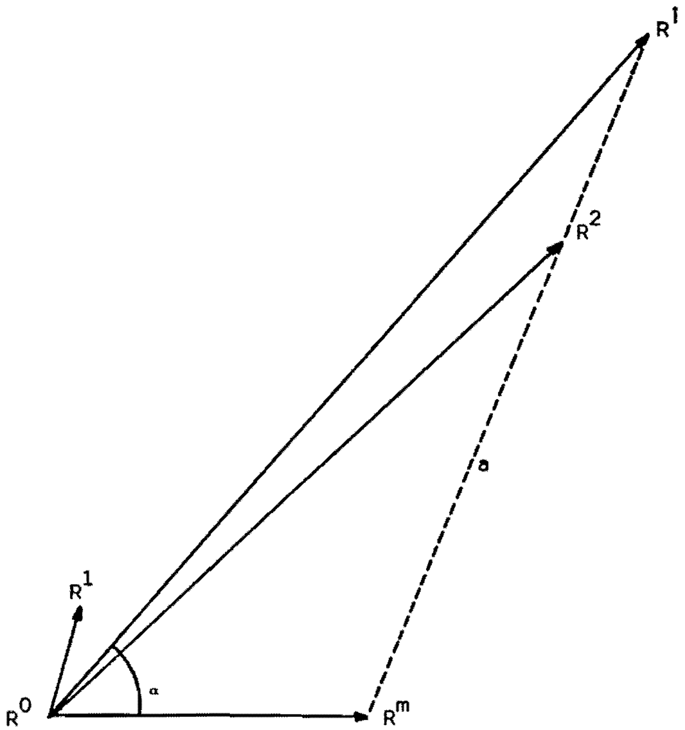


the lines report the concept's location at subsequent points in time. Note that Figure 2 is rotated at a different angle for representation—this rotation does not affect the location of the concepts in relation to each other, but does influence the ability to interpret the three dimensional representation. Some of the concepts appear to be in different quadrants of the space, and the reader should keep in mind that these quadrants are arbitrary. What is important is the relative motion between concepts.

The *Democratic candidate*, the *Democratic party*, the *Republican candidate*, and the target concept *Me* move more than the other concepts in the space. Even when employing the rotation with the least-squares rotation for the stable concepts, the *Democratic candidate* (concept 6), the *Democratic party* (5) and *crime prevention* (1) converge. Also, the aggregate *Me* (9) similarly converges toward these concepts—except less so between time two and time three. The *Republican candidate* (10) appears first to move towards the *Republican party* (3) and *Busing* (8) between time one and time two (although this movement appears to be small in magnitude), and then moves toward *campaign reform* (7) and *inflation* (4) between time two and time three.

By simply assessing the graphic illustration of the concepts in the first three dimensions, it would appear that the Democratic candidate's best time-one message strategy would be to use the issue of *integrity and honesty in government* (2) than any other single concept message strategy. Between time two and three, it would appear that the two-pair message strategy using *integrity and honesty in government* (2) and *crime prevention* (1) would move the candidate more closely toward the target

FIGURE 3
A Possible Message Strategy Based on Time One Data



R^0	=	Democratic Candidate			
R^1	=	Democrat	length	=	5.818
R^2	=	Crime Prevention	length	=	32.415
R^m	=	"Me"	length	=	14.239
R^i	=	resultant	length	=	40.789

length of a = 32.05

$r_{R^iR^m}$ = .722; " = 43.76 degrees

Me than the message strategy of *crime prevention* and *Democratic party* (5).

Note that the major differences between Figure 1 and Figure 2 is that the candidate's movements are attenuated when they are included as concepts in which the least-squares rotation procedure is implemented. In Figure 2, the candidates move more, and even among the theoretically stable concepts, the movement of the concepts which do exhibit true change (*Democratic party, Me,* and *crime prevention*) is not overly attenuated by the rotation.

Mathematical Message Optimizing Procedures

There is a serious qualification in using an eyeball approach to devising message strategies, as we briefly have done above for the Figure 2 configuration. Specifically, these configurations only represent three of the dimensions in the multidimensional configuration, and there exists considerable information in the remaining dimensions. Secondly, it is difficult to interpret depth in these three-dimensional configurations. Therefore, we shall now turn to the results of employing the mathematical message optimizing procedure.

Figure 3 presents the message strategy implemented during the campaign. This solution indicates that if the candidate were to move along the resultant vector for the concepts *Democrat* and *crime prevention,* he would move at an angle of 43.76 degrees from the target vector (a correlation of .722). It also reveals that if full effects of the message strategy were obtained, the candidate would move to a point 32.05 units away from the target—of course, we only expect the candidate to exhibit a certain percentage of distance moved along the R^1 vector. The following section will report the correlation between observed motion and predicted motion.

While a correlation of .722 may appear to be reasonably high, this solution should be considered a "fair" one. Since there will be potential variability in the motion of the candidate once a message strategy is implemented, one should attempt to reduce the angle between the message strategy (resultant vector) and the target vector. In the solution presented in Figure 3, this angle is 43.76 degrees. Once the message strategy is implemented, there will be some angle (small to moderate in magnitude) between the candidate's observed motion and the message strategy. Therefore, the angle between the candidate's observed motion and the target vector may be, in some cases, larger than 43.76 degrees. Thus, it is very important to select a message strategy in which the angle between the resultant and target vector is as small as possible.

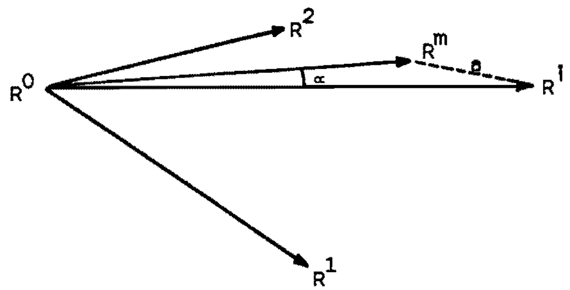
While the message strategy illustrated in Figure 3 is a "fair" solution, it is one of the best two-pair message solutions. There are only a few message strategies generated by our procedures which are better than this strategy for time-one data. A good single concept solution would be one that utilizes *integrity and honesty in government*—the vector of which correlates .867 with the target vector (an angle of 29.92 degrees). Another good single concept solution would be *crime prevention*—the vector of which correlates .823 with the target vector (an angle of 34.63 degrees). Besides the message strategy illustrated in Figure 3, the only other good two-pair message strategy is utilization of *inflation* and *Democratic party*—a resultant vector which correlates .921 with the target vector (an angle of 22.93 degrees).

Let us now turn to a post hoc analysis of time-two message strategies. Unfortunately, when the time-two data were used in the message optimizing procedure, the solution actually implemented in the campaign did not even appear as a solution. We hypothesize that the reason for this is that at time two, the candidate was located at some point which was approximately between the locations of *Democratic party* and *crime prevention* and that adding these vectors would provide a "bad" solution. (The message optimizing procedure is written such that any "solution" with an angle greater than 90 degrees is not printed. This is to keep the computer program from providing an excess of "solutions" which would be inappropriate. Any resultant vector whose angle with the target vector is more than 90 degrees would move the candidate either at a right angle to the target or away from the target. Obviously, such solutions are not worthy of consideration.)

Figure 4 presents one of the best time-two message strategies. The resultant vector includes the concepts *integrity and honesty in government* and *crime prevention* correlates .995 with the target vector (an angle of 5.74 degrees). If full effects of such a message strategy were obtained, the candidate would move to a location only 4.23 units from the target. The small angle between this resultant vector and the target vector indicates that if such a message strategy had been employed, the candidate would move directly toward the target.

In terms of single concept solutions, there are three worth mentioning. *Crime prevention* used by itself provides a vector which correlates .979 with the target vector (an angle of 11.90 degrees). *Inflation* used by itself also provides a good strategy—the vector of which correlates .889 with the target vector (an angle of 27.22 degrees). Further, *campaign reform* was also a good single concept solution. The vector representing *crime prevention* cor-

FIGURE 4
A Possible Message Strategy Based on Time Two Data



R^0 = Democratic Candidate

R^1 = Integrity and Honesty in Government	length =	10.546
R^2 = Crime Prevention	length =	8.846
R^m = "Me"	length =	12.281
R^I = resultant	length =	16.493
	length of a =	4.23

$r_{R^I R^m}$ = .995; '' = 5.74

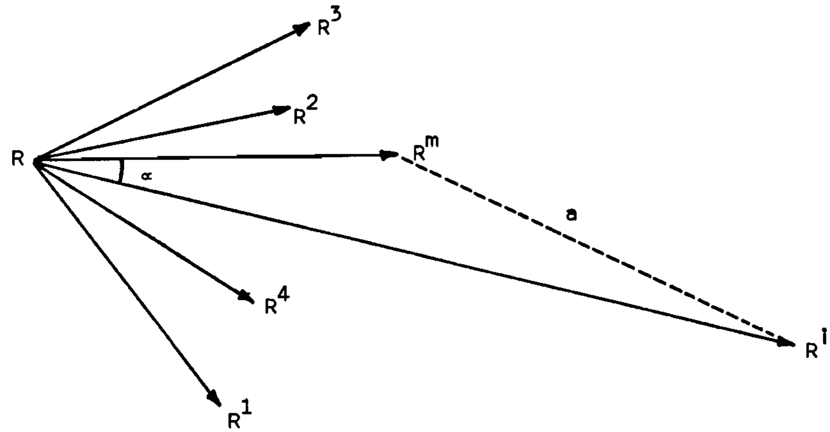
relates .932 with the target solution (an angle of 21.16 degrees).

Overall, there were more "fair" to "good" solutions obtained at time two than at time one. We shall discuss one other "good," usable solution. Utilizing *integrity and honesty in government* and *Democratic party,* provides a resultant vector which correlates .976 with the target vector (an angle of 12.65 degrees). The length of this resultant vector is 12.726 units and if full effects were obtained, the candidate would move to within 2.79 units of the target. What is important about his solution (as with the other "good" time two, two-pair message solution described above), is that it would move the candidate in a fairly direct path towards the target.

Figure 5 illustrates a solution that suggests the qualifications that should be placed on the use of the mathematical procedure—the use of sound reasoning in selecting a message strategy. The four-pair message strategy which utilizes *integrity and honesty in government, crime prevention, Republican party,* and *inflation* is a "good" solution—but only mathematically speaking. Obviously, no Democratic candidate would use such a strategy, despite the fact that the solution correlates .981 with the target vector (an angle of 11.13 degrees). The existence of such solutions does not necessarily indicate a fault with these mathematical procedures. Rather, they suggest that the use of sound reasoning be conjunctionally employed, since a potentially effective message may frequently be culturally taboo. While the "solution" in Figure 5 is a gross example of what may happen during the vector addition procedure, all solutions need to be carefully assessed for both pragmatic implications and ethical considerations.

The message strategy optimizing procedures generated a number of solutions. It is obvious, given the solutions presented briefly in this section of the paper, that a number of better strategies could have been designed for the Barnett, Serota, and Taylor (1976) study.

FIGURE 5
Potential Message Strategy Based on Time Two Data



R = Democratic Candidate		
R^1 = Integrity and Honesty in Government	length =	10.546
R^2 = Crime Prevention	length =	8.846
R^3 = Republican Party	length =	10.281
R^4 = Inflation	length =	8.812
R^m = "Me"	length =	12.281
R^i = resultant	length =	26.464
	length of a =	14.39

$r_{R^iR^m}$ = .981; '' = 11.13 degrees

In the next section, the extent to which the candidate moved as predicted will be discussed.

CALCULATION OF MESSAGE EFFECTIVENESS

To obtain a measure of message effectiveness, it is necessary to calculate a correlation between the observed candidate motion and predicted motion. To do this, the time-two configuration is rotated to the time-one configuration, utilizing a least-squares orthogonal rotation. Within this procedure those concepts which are theoretically stable (not predicted to move) are specified as stable and included in the minimizing procedures of the rotation. Those concepts which have been manipulated or are expected to vary then appear to move freely in the otherwise stable configuration (see Woelfel et al., 1975). The candidate's time-one coordinates are then subtracted from all time-two coordinates, to center the time-two space on the candidate's time-one position. Functionally, these two steps (rotation and subtraction) locate the two configurations at a common centroid for the purpose of the stable concepts rotation, and then disjoins the two concept structures to produce a candidate motion vector among the time-one concept position vectors. Vectors for the candidate's time-two location (the motion vector) and the predicted motion can then be compared and correlated.

Table 1 presents the results of the message effectiveness computations. Between time one and time

TABLE 1
Results of Message Effectiveness

	Time One-Time Two	Time Two-Time Three
Correlation between R^i and observed motion vector:	.865	.875
Angle between R^i and observed motion vector:	30.12°	28.90°
Length of Resultant Vector (R^i):	40.789	21.830

Distance between candidate and target:

Time One	Time Two	Time Three
14.239	12.512	8.577

two, the correlation between the predicted motion—that the candidate would move along the *Democrat* and *crime prevention* resultant vector at time one—and the observed motion of the candidate between time one and time two is .865. This is an angle of 30.12 degrees. The distance between the candidate's location, and the target concept's location, decreased by 1.727 units. The correlation between the predicted motion and observed motion, between time two and time three, is equally high, .875. This is an angle of 28.90 degrees. The distance between the candidate's location and the target concept's location decreased by 3.935 units. Note that the resultant vector's length also decreases over time. This provides support for the notion that the candidate is converging toward these concepts—adding the vectors *crime prevention* and *Democrat* at time one resulted in a length of 40.789 units; at time two, this length decreased to a distance of 23.66 units.

Utilization of the message effectiveness procedure, then, indicates that the campaign strategy was successful—the candidate moved along the predicted vector. The candidate continued to move along the resultant vector between time two and time three, when the campaign faltered, because of a time-lag in which campaign information permeated the congressional district. Therefore, the candidate moved closely along a resultant vector which was a fair solution at time one, but only a "poor" solution at time two.

There are two possible explanations for the candidate's continued motion along the resultant vector. The first concerns the diffusion of campaign information. It takes considerable time for the information about a congressional candidate's position on the issues to diffuse throughout his district. One reason for this is that campaign information is primarily spread through interpersonal channels rather than by the mass media. This is especially the case in large urban areas, where the media must simultaneously cover a number of congressional campaigns. Also, in these media markets, the cost of advertising is high and candidates would tend to use their scarce resources in a more effective manner. Added to these factors, was the fact that in 1974, there were no national offices at stake, thus limiting the coverage of campaign rhetoric. While, the candidate may have stopped campaigning on these issues, his stand on them may have continued to diffuse through the contituency's interpersonal networks to the people he did not reach directly.

The second possible explanation derives from the work of Saltiel and Woelfel (1975), who suggest that the *rate* of change of an attitude, rather than the *amount* of change, is proportional to the force to which it is exposed and inversely related to its inertial mass. Rather than assuming that attitude change is instantaneous, they argue that discrepant information initiates a process of change which takes place over time, and continues until an equilibrum point is reached. (These notions seem compatible with more informal notions of the "momentum" of a political campaign.) There is no set time limit by which the process is completed (Cody, Marlier, & Woelfel, 1976). In the example in this paper, there is no reason to expect that the process would not continue after the second measurement. This would clearly be the case if, as indicated above, an alternative campaign strategy were not implemented.

SUMMARY AND IMPLICATIONS

While the procedures discussed above have not yet been utilized throughout the life of a campaign, it is not difficult to see the extent to which these developments will aid researchers and campaign strategists in future political work. At time one, the candidate wished to campaign on the issue of *busing*. However, *busing* never appears to be an issue that would facilitate movement towards the target concept *Me*. Further, at time one, the candidate wished to campaign on *inflation*. This, however, was not a good single concept solution, but would have been a good message strategy if implemented in conjunction with the concept of *Democratic party*. The resultant vector of these two concepts correlated .921 with the target vector.

While the strategy that was implemented (*Democratic party* and *crime prevention*) was a "fair" strategy ($r=.722$), our reanalysis indicates that for the time one-time two period of the campaign, the use of *crime prevention* alone would have been a good campaign strategy (a correlation of .823 with the target vector). Unfortunately, between time two and time three, the candidate continued to move along the resultant vector that was no longer as good a solution as it was at time one, nor as good as a number of possible time two solutions. Specifically, the candidate could have campaigned on the issues of *integrity and honesty in government* and *crime prevention*.

The data reanalyzed in the present paper is based on an aggregation of all respondents. It is entirely possible, indeed preferable, for large sets of data to subdivide various respondents on the basis of the usual demographics, partisanship, or even behavioral ticket-splitters (DeVries & Tarrence, 1972), and to devise a set of message strategies for each subgroup or combination thereof. In deed, one may wish to use a message strategy that is a "good" strategy across particular target audiences.

Given time-one data, and an implementation of a campaign strategy on the part of an opponent, it is conceivable to estimate the potential effects of the opponent's campaign, and adjust one's campaign accordingly. Such adjustments are made all the time in a high activity campaign, and these procedures provide a precise means for estimating effects and adjustments.

Finally, we would like to stress several qualifications of these procedures. First, the vector addition procedure that serves as the basis for generating messages is oblivious to what concepts it adds together to form resultant vectors. Therefore, some solutions will be mathematically very good, but totally impractical to use. It is up to the researcher/campaign strategists to select a message that is both credible and ethically suitable to a candidate's philosophy.

In addition, it would also be extremely judicious to examine how *both* the target concept and the candidate move. The analyses presented in the present paper have sought to answer the question: *Does the candidate move along the resultant vector?* However, between any two points in time, the implementation of the message strategy (and other causes in the environment) may influence the location of the target concept *Me* in the space, particularly early in the campaign before the political domain crystalizes in the minds of the electorate. Thus it would be important to calculate motion vector correlations between the two moving objects. Such an analysis would address the following question: *Do the two concepts both move and con-*

verge towards each other over time? These analyses, while straightforward, were not yet available within the operational software existing at the time of this writing, and will be the subject of further analysis.

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