AN INVESTIGATION OF COMMUNICATION EFFECTS IN COGNITIVE SPACE

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[signature]
Major professor

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ABSTRACT

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By

Robert T. Craig

The working assumption of this study was that models of cognitive structure may fruitfully be elaborated into general models of information which describe the structure of messages and constrain theories of the cognitive effects of communication. Because of its intuitive appeal and mathematical convenience, and because of its prominence in several disciplines, the spacial model of cognitive structure was selected for study. The spacial model views the mind as a multidimensional space in which concepts are defined by their locations.

Several variations of the spacial model were discussed. The model tested in this study assumed that cognitive space is Euclidean and that cognitive change is representable as <u>motion</u> of concepts in cognitive space. A theory of linear motion was mathematically derived. The theory posits that the effect of information inputs about a pair of concepts is to induce change in the distance between those concepts along the line connecting them. Whenever the cognitive space comprises three or more concepts the theory makes non-trivial predictions of "indirect" change in distance between each "manipulated" concept (those which are the subjects of information inputs) and all other concepts.

Several lines of research bearing on the theory of linear motion were reviewed. Studies using the semantic differential (Osgood), nonmetric multidimensional scaling (Shepard and others), and metric

multidimensional scaling (Woelfel and associates) have all demonstrated that conceptual structures can be meaningfully represented by spacial models. There is less decisive but still suggestive evidence that motion of concepts in cognitive space is meaningful and that the effects of information may be linear. Thus the theory of linear motion has some plausibility based on previous research.

A study was performed to test the theory of linear motion.

A pretest-manipulation-posttest, within-subjects experimental design was used. Subjects were 64 graduate and undergraduate students in communication classes at a large university.

Fifteen concepts were scaled. The concepts were Nations. The Nations were selected by a procedure that combined random and judgmental features.

The procedure for measuring psychological distance was a direct, ratio judgment procedure suggested by Torgerson and developed by Woelfel. The scaling procedure used was also developed by Woelfel and his associates, and is based on the classical metric model of Torgerson: essentially an orthogonal decomposition of the variance-covariance matrix.

Three messages were constructed. Each message argued that a pair of nations was either "very similar" or "very different." The messages were of comparable length and structure.

In the pretest the fifteen nations were scaled. The subjects made direct, ratio judgments of the distances between all one hundred five pairs of concepts. The subjects then read the messages, which were intended to induce motion in six concepts, leaving nine concepts unmoved. The two sets of concepts (manipulated and not) provided experimental control. Theory predicts that specific changes should have occurred in 69 out of the 105 distances among the fifteen concepts, while the remaining 36 distances should not change. The subjects also made estimates of the distances between manipulated concepts "in the message," those estimates to be used as estimates of the content of the messages.

In the posttest (one week later) the subjects again read the three messages, then again estimated the 105 inter-concept distances, which distances were to be compared with those predicted by theory.

Pretest and posttest distances were aggregated across subjects and the mean distance matrices were subjected to metric multidimensional scaling, the second space rotated to comparability with the first by two procedures based on different assumptions.

Reliability and validity of measurement were assessed. It was concluded that the measurements and other procedures of the study were of acceptable quality.

The fundamental hypothesis test was a correlation coefficient between predicted and observed posttest distances among concepts. There are many bases upon which the correlation can be computed; all of them were computed.

Zero order correlations between predicted and observed distances were all in the .8 to .9 range. These high correlations reflect the overall stability of the cognitive space over time.

First order partial correlations controlling the pretest distances and computed for the sixty-six indirectly changed distances only, however, were generally small and non-significant.

These results were judged not to support the theory.

Seven alternative explanations of the results were discussed: (1) the experimental manipulations may have been too weak; (2) the experimental messages may have had unintended effects; (3) "noise"--uncontrolled information from the environment--may have caused unintended changes; (4) insufficient time may have been allowed for cognitive equilibrium to be established; (5) the concepts may have been in motion prior to the experiment; (6) the concepts scaled may not have composed a domain in the functional sense; (7) the spacial model may be radically false; the mind may be, instead, a network of concepts. In connection with (6), motion among a subset comprising the six manipulated concepts only was found to be substantially better predicted by the theory than was motion of all fifteen concepts. The six manipulated concepts might reasonably be thought to compose a domain. No support was found for the network interpretation.

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Introduction: A Working Assumption

It is perhaps unnecessary to remark that we would understand a great deal more about human communication if we understood the human mind. That in itself, however, is not sufficient justification for communication theory to embrace cognitive theory. The working assumption of this study is that there is potentially a more specific kinship between the two fields: that formal models of structure can be applied equally well to cognitions and messages, and that constraints on process inherent in those structural models can shape theories of the cognitive effects of communication. This implies that theoretical borrowing between the fields ought to be worthwhile.

The borrowing process is illustrated and the validity of the working assumption is put to the test in the present study. Beginning with a general "spacial" model of information, this study develops a model of message content and derives and tests a specific hypothesis about the cognitive effects of messages. Thus the purpose of this study is to test the general hypothesis that cognitive change brought about by messages is spacial in character, by testing a specific hypothesis derived from spacial assumptions. This chapter outlines the theoretical background of the general hypothesis, and derives the specific hypothesis of this study from general assumptions. Chapter II reviews the research literature bearing on the theory presented in Chapter I. Chapter III describes the design and procedures of an experiment intended to test the theory. Chapter IV presents the results of that study.

Chapter V, finally, discusses the findings in relation to the theory and to the adequacy of the study as a test of the theory, and draws implications for further research.

Spacial Models of Cognition

Several theorists have developed more or less elaborate models of the mind as a multidimensional space in which concepts are defined by their locations. In order to place in context the model used in the present study, some of the more important of these models will now be reviewed, and their assumptions compared and contrasted.

Scott (1969) conceives of cognitive structure as a multidimensional space spanned by attributes, in reference to which cognitive elements are located. The term "domain" refers to any set of "phenomenal objects which the person treats as functionally equivalent, and the attributes by which he comprehends those objects" (p. 262). That a "primitive" attribute such as evaluation (like-dislike) may be well-nigh universal among domains notwithstanding, the concept of domain is introduced precisely because it is assumed that the set of attributes differs from domain to domain. Not all cognitive objects are comparable. Moreover, not all objects even within a domain are necessarily directly comparable.

Objects are compared by reference to attributes:

> An attribute is represented in the model as a line in multidimensional space, divided into segments corresponding to characteristics (categories of the attribute) that the person recognizes (p. 262).

Scott does not appear to assign any particular significance to a set of reference axes of the cognitive space, except insofar as the number of "dimensions worth" of attributes in the space is a type of cognitive complexity. He apparently does not assume that attributes pass through the origin of the space, or that the origin is in any way meaningful. He does not assume that attributes are continuous. Quite to the contrary, he assumes that in the most common case, attributes are made up of gross segments within which the person makes no discriminations. Finally, Scott makes no mention of any concept of cognitive change.

The most interesting aspect of Scott's model is that not all objects within a domain are necessarily comparable. For the geometry of cognitive space, this implies that not all points in the space have projections on all attributes--a peculiar geometry! "Image comparability," the judgment of all objects in a domain on a common set of attributes, is a *variable* in this model, and is only one of several possible styles of cognitive integration. This view is well-suited to Scott's interest in cognitive complexity, a context in which to model the mind in the Appollonian idiom of Euclidian geometry might appear to beg the essential questions. Yet one wonders whether Scott, who sacrifices the continuous, homogeneous properties of Euclidian space without replacing them with a similarly coherent system, has not thereby denuded the spacial model of much of its suggestiveness. His model has no unambiguous entailments.

Several other cognitive theorists have worked with models which, like Scott's, might be characterized as "quasi-spacial." Zajonc (1960) and Runkel (1963) are further examples of theorists who view cognition as projection of a stimulus on a "set" of psychological dimensions, without making any further assumptions about the nature of this cognitive space. Kelly (1963, p. 146) also makes reference to a "psychological space" whose axes are dimensions (his term is "constructs"), but he develops the idea no further. Schroder, Driver and Streufert (1967) define the properties of information processing structures in dimensional terms: <u>differentiation</u> is the number of psychological dimensions in a structure, <u>discrimination</u> is the fineness of categorization along the dimensions, and <u>integration</u> is the manner in which the dimensions are interrelated in information processing. The issue of integration is crucial for a spacial model. Whether a "set of dimensions" constitutes a true space depends upon what one assumes about how the psychological dimensions are integrated. Schroder <u>et al</u>. define integration in terms of the non-spacial concept of "schemata" or "rules."

Certainly the most notorious spacial model of cognition is the "semantic space" of Osgood and his associates (Osgood, Suci and Tannenbaum, 1957).* More than do any of the models previously reviewed, this one employs the full resources of the spacial paradigm in both conceptualization and operationalization of cognitive structure. The essentials of the semantic space are succinctly stated in <u>The Measurement of Meaning</u>:

> 1. Semantic judgement can be completely represented in a [Euclidian] space defined by a set of elemental semantic factors . . .
>
> 2. Any axis or dimension placed through the origin of the semantic space represents a potential semantic scale or attribute of judgment . . .
>
> 3. The semantic nature of any such attribute is given by its relations [cosines of the angles between it and] the elemental factors . . .

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* I should stress that it is the semantic space concept only with which we are here concerned, and not the "representational mediation" theory of meaning (which Osgood nevertheless sees as the more fundamental explanatory principle). The representational mediation theory, in any case, seems not to have generated much interest among communication researchers, while the semantic space and its associated measurement and analysis techniques have become staples of the field.

4. Every concept in semantic space may be said to be "contained" by its characteristic attribute [the axis passing through the concept and the origin] . . .

    a. Another concept is different from this concept by virtue of having a characteristic attribute which is independent (not co-linear with) the concept;

    b. Another concept is different by virtue of having more or less of the same characteristic attribute.

5. Two concepts may interact [e.g. may be compared] to the extent that they are contained by the same attribute . . . (pp. 116-117).

The "elemental factors" are obtained by factorization of a matrix of correlations among a representative set of seven-point bipolar adjective scales (the "semantic differential") on which subjects judge the meanings of concepts. Research suggests that three such orthogonal factors are Evaluation, Potency and Activity. The meaning of a concept can be represented as the concept's projections on these factors (the origin being the point of neutral meaning), and the "semantic distance" or difference in meaning between concepts is given by

$$D_{il} = \sqrt{\sum_j d_{il}^2},$$

where D_{il} is the linear distance between concepts _i_ and _l_, and d_{il} is the difference between the projections of _i_ and _l_ on factor _j_. This equation also serves as a definition of cognitive change.

While not all kinds of belief or knowledge structures covered by the term "cognition" are representable in terms of the semantic space, the idea of "conceptual structure" is, nevertheless, defined within the model as a spacial configuration:

> Conceptual structure . . . The distance [D] between each concept and every other concept can be calculated and entered into an _m_ x _m_ matrix. This matrix represents the semantic structure of

> of the set of m concepts, giving the distance or similarity relations among all concepts. The set of distances representing the semantic structure are "plotable" in a space having the same (or fewer) dimensions as the number of dimensions represented in the measuring instrument (pp. 93-94).

The final model to be reviewed here is quite different from the others. This model has been developed by Woelfel and his associates (references under Woelfel, Saltiel, Gillham, Barnett, Serota, Taylor, Danes). If the majority of cognitive theorists cited have foregone the benefits of powerful mathematical assumptions for the sake of substantive assumptions about the cognitive attribute space, Woelfel represents an entirely contrary orientation. He argues for "the restructuring of existing theory or the creation of new theory itself designed to fit the most powerful measurement and research models currently available"* (Woelfel, 1974a). He argues, that is, that we should begin with the most mathematically powerful analysis techniques available, and construct measures and theories to fit their requirements. For cognitive theory, this implies a spacial model.

Woelfel (1974a) postulates that cognition is "a process of relating objects of thought to each other. Fundamentally, this involves taking note of similarities and differences between objects . . ." The phrase "similarities and differences" suggests the notion of attribute, and, indeed, this is what Woelfel has in mind. Attributes are important in his model, however, only insofar as the aggregation of respects in which two objects of thought differ is taken to underlie an overall

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*Woelfel makes this statement in the context of a discussion of sociological theories, but he applies its implications to cognitive theory as well.

dissimilarity or distance between the two objects. Thus dissimilarity, rather than attribute, is the generating concept of Woelfel's model.

> Dissimilarities among cognitive objects may be represented by a continuous numbering system such that two objects considered to be completely identical are assigned a paired dissimilarity score or distance score of zero (0), and objects of increasing dissimilarity are represented by numbers of increasing value . . . The definition of any set of [n] concepts or objects may therefore be represented in terms of the [n x n] matrix D . . . where any entry d_{ij} represents the dissimilarity or distance between i and j (Woelfel & Saltiel, 1974).

The distance matrix is analyzed by subjecting it to a metric multidimensional scaling routine (Torgerson, 1958; Serota, 1974) which yields a coordinate space of n-1 or fewer dimensions in which the concepts are "plotable." This definition of conceptual structure is obviously similar to Osgood's, but in both its derivation and its applications it is quite different. For Osgood, the conceptual structure is derived from distances between concepts on a set of fundamental semantic factors, which are obtained, in turn, from analysis of the semantic differential. For Woelfel, the conceptual structure is directly derived from an instrument which requires the subject to provide direct, metric, pairwise distance estimates. While attributional differences are assumed to underlie these distances, there is no assumption of an attribute space spanned by fundamental factors. The dimensions of the cognitive space, that is, are not assumed to have any psychological significance, although they may have such significance. Whatever overall interpretability the space may exhibit is a function of the extent to which the pairwise attributional differences between concepts fall into interpretable patterns. These patterns might be clusters, dimensions or other forms, depending upon the particular set of concepts scaled--or the patterns may not be at all interpretable. In any case, the configuration "is" just what it "is": it's validity is not considered to be dependent upon its interpretability.

What is of key importance for Woelfel is not the interpretability of cognitive space, but its dynamics. "Change in the definition of any object may be represented as movement of the object in the space relative to other objects" (Woelfel & Saltiel, 1974). Movement is measured by obtaining the matrix D and its spacial representation at several points in time, rotating the coordinate spaces to a criterion which is assumed to make them comparable to each other, and computing changes in location. Velocities can be calculated from locations at two points in time, accelerations from locations at three points in time, and so forth. The crucial test of Woelfel's model is whether "laws of motion" can be found to parsimoniously account for the changes observed in the cognitive space. If such laws cannot be found, or if more parsimonious laws can be found in another paradigm, then the model fails.

Assumptions of Spacial Models

The examples of the spacial model reviewed above encompass a considerable range of assumptions. Table 1 summarizes these assumptions roughly.

The table makes it obvious that most of the models are quite crude. In the majority of cases it is impossible to determine whether or not a given model implies a given assumption. Why I have applied the term "quasi-space" to all of the models except Osgood's and Woelfel's should also be clear: The models so designated have few unambiguously spacial properties.

Table 1. Assumptions of Selected Spacial Models.

	Scott	Zajonc	Runkel	Kelly	Schroder *et al*.	Osgood *et al*.	Woelfel
Dimensional Attributes	Yes	Yes	Yes	Yes	Yes	Yes	No
Continuous Attributes	No	?	?	?	No	Yes	No
All Objects Comparable	No	?	?	?	?	Yes	Yes
Interpretable Reference Axes	No	?	?	?	?	Yes	No
Interpretable Origin	No	?	?	?	?	Yes	No
Change = Motion In Space	?	?	?	?	?	Yes	Yes
Continuous Space	?	?	?	?	?	Yes	Yes
Unbounded Space	?	?	?	?	?	No	Yes
Homogeneous Space	?	?	?	?	?	No	Yes
Isotropic Space	?	?	?	?	?	No	Yes

The most interesting contrast in the table is that between the Osgood and Woelfel models, for these two are both unambiguous and very different from each other. The differences might be summed up by saying that, while Osgood makes strong assumptions about cognitive structure, Woelfel makes strong assumptions about cognitive change. It also appears that Woelfel's is the more general, and the more testable, of the two models.

I have already pointed out the differences between Osgood and Woelfel with respect to the nature of attributes and the "interpretability" of the structure of cognitive space. I might add that these differences are evidence for the greater generality of Woelfel's model. Were Osgood's assumptions true, Woelfel's model would be no less viable; but were Woelfel's assumptions true, Osgood's model would lose its soul.

The five assumptions at the bottom of the table are more relevant to change than to structure. The assumption that cognitive change is equivalent to motion in cognitive space is fairly trivial in the Osgood model, but is a very strong assumption in the Woelfel model. The assumption implies that cognitive objects can be observed to "move" in a geometrically reasonable fashion. In general, this means that the motion of a cognitive object does not disturb the overall structure of the space, or the locations of other objects. This is trivial in Osgood's model because a change in the meaning of a concept on the semantic differential would not generally be expected to change the factor structure of the scales or the meanings of other concepts. In Woelfel's model the motion of an object requires that definite changes occur in the directly measured distances between that concept and every other object in the space, an implication which allows for rigorous tests of "laws of motion" as in the present study.

Both models assume a continuous space, but Osgood's space is bounded whereas Woelfel's is not. The boundedness of Osgood's space is an artifact of (1) the semantic differential, which is made up of seven-point scales, and (2) factor analysis, which normalizes (to a range of ± 1.0) the projections of concepts on the reference axes of the space. Woelfel's is a metric model in which boundedness is a strictly empirical question. Both models pretty much beg the question of continuity.

A homogeneous space, in contrast to a heterogeneous space, is one whose density, or resistance to motion, is equal at all points. An isotropic space, in contrast to an anisotropic space, is one in which objects have no "natural resting place" or natural direction of movement (Gillham, 1972). Woelfel's model assumes a homogeneous, isotropic space (Woelfel, 1971, Chap. 1). These assumptions are a pragmatic, if not a strictly logical requirement of the assumption that the coordinate system of cognitive space is entirely arbitrary. If cognitive space is heterogeneous or anisotropic, then Woelfel's model may fail due to a failure to find "nice" laws of motion, because "dense regions" or "natural resting places," if they exist, cannot be located *a priori* with respect to an arbitrary coordinate system. In this case the model can be saved only by finding some other set of antecedents which can incorporate the peculiarities of cognitive space into the laws of motion.

Osgood's model appears to assume a heterogeneous, anisotropic space. I say "appears" because, although Osgood and his associates do not comment directly on the issue, there is considerable circumstantial evidence to justify my inference. The evidence comes mainly from the congruity model of cognitive consistency (Osgood & Tannenbaum, 1955). Three aspects of the congruity model have implications for the semantic space. First, the congruity model assumes a tendency toward "polarization" of meanings--

that is, a tendency for objects to be valued ± 3 on the semantic differential scales. Thus there appears to be a "natural resting place" at the boundary of semantic space. (Note that this would be expected as an artifact, were cognitive space "really" unbounded.) Second, the model assumes that the more polarized is a concept, the more difficult it is to change the concept (in any direction)--in effect, semantic space becomes "denser" as the boundary is approached. Third, there is evidence that the congruity model applies variously to the several dimensions of semantic space. Tannenbaum (1968) states:

> . . . It is worth noting that the congruity predictions in cognitive interaction studies are generally supported least (i.e., there is a greater discrepency between predicted and obtained scores) on the evaluative, as opposed to the activity and potency factors . . . One suggestion (and it is only a tentative suggestion) is that _the same rules do not apply to all dimensions_ (p. 62).

One ought to point out that any evidence for the uniqueness of evaluative judgments not only suggests that Osgood's semantic space is heterogeneous, but is evidence _for_ that assumption as opposed to the assumption of homogeneity in Woelfel's model. Whether Woelfel's model will encounter empirical difficulty along these lines remains to be seen.

Woelfel's model has some shortcomings, the most severe of which arise from the problems of measurement. The model handles measurement very well _in principle_, but in practice it is just measurement which most seriously limits the model's applicability. The model requires ratio level measurements of psychological distance which, quite simply, cannot be reliably provided by individual human subjects, at least under procedures so far devised. Thus the model, which _one would like_ to describe individual as well as aggregate phenomena, can be tested only on aggregate data--which, it has been pointed out, can be made as reliable as necessary by means of the sample size (Barnett, 1972; Woelfel, 1974b; Danes and Woelfel, 1975).

One could also attack Woelfel's model by citing cognitive structures which it seems unable to describe--my knowledge of how to tie my shoes, for example. But this sort of criticism ignores the large range of phenomena which the model does seem to describe, and avoids rather than attacks the central issues raised by the model, which are both empirical and interesting. No claim of universal synthesis can be made for the model. The literature of cognitive theory is a cornucopia of spaces, networks, schemata, groups, implicational structures, psychologics, algorithms and other paradigms (cf. Zajonc, 1968; Deese, 1969; Weick, 1968). To attempt to subsume all of those models under one model at the present stage would be folly. It would be better, as in the present study, to tackle the issues raised by a specific, well-formulated model, attempting thereby to determine the range of phenomena to which it applies.

Despite its possible shortcomings, Woelfel's model seems to be the best extant approximation to a general spacial model of cognition. This is because (1) the model is very general--general enough to subsume many of its rivals; (2) the model is fully spacial--it incorporates a full set of geometric assumptions and implications, and thus epitomizes the spacial paradigm; and (3) the model is more empirically testable (begs fewer questions) than the Osgood model, its closest competitor. Nevertheless, Osgood's model should be kept in mind as a viable alternative.

The model employed in this study is essentially Woelfel's. It assumes that cognitions are representable as locations in multidimensional space, that cognitive change is representable as motion in space, and that cognitive space is continuous, unbounded, homogeneous and isotropic. The model makes no assumption as to the psychological interpretability of the spacial coordinate system *per se*, but assumes that the coordinate system is a stable manifold for which concepts like location, distance and motion, and the full range of geometric implications of those concepts, are valid. This model has been selected because it is operationalizable and permits a full and fair test of spacial assumptions.

Spacial Models of Messages

A spacial model of messages assumes that the content of a message is a "scaling" or "plotting" of concepts in a message space having the same sorts of structural properties as the cognitive space which it reflects.

Woelfel has proposed a definition of the message in the spacial paradigm:

> Any message, whether verbal or otherwise, may be defined as a statement of the location of some object relative to some other object(s). To the extent that this definition differs from the location (definition) already assigned to that object by the individual, the message may be said to contain information. Any message, therefore, may be concisely and exactly defined as a vector from the point in the self at which the individual himself locates the object to the point in space at which the message locates the same object. When the message defines the location of the object to be the same as the individual's own definition, the information content, and consequently the force, of the incoming message is zero.
> . . .When the individual is in receipt of several messages at once (as is frequently the case) the vector sum of all the messages will constitute a resultant vector which describes the aggregate message at an instant in time (Woelfel, 1971, Chapter 6, pp. 11-12).

There are three directions in which I would like to extend Woelfel's definition. First, at least one aspect of the definition can be construed as ambiguous. The message is defined both as a statement of the location of an object, and as a vector from the receiver's location of an object to the location proposed in the message. But these are not the same--one can be thought of as a quality of the message itself, and the other is a relationship between the message and the receiver. While there is some justification in communication theory for a refusal to define the message except in relation to some receiver, that consideration must be weighed against the pragmatic need to study messages in their own right (as in content analysis). The two parts of the definition ought to be distinguished.

Second, the definition ought to more explicitly recognize that a message usually refers to several cognitive objects. This is logically required by the assumption that an object is defined by its location with respect to other objects (or with respect to attributes in Osgood's model). Since it is theoretically likely that the message will, to some extent, exert forces upon all of the objects to which it refers, the message should be expected to create more than one vector of change in the receiver.

Third, the definition fails to recognize that messages usually have some internal structure. A verbal message usually includes a set of sentences organized in some fashion. The theory of argumentation views the message as a proposition supported by arguments,which are, in turn, comprised of evidence, warrants, etc. We often want to manipulate or measure the internal structure of messages, and the definition of message should allow for this.

In view of these arguments I propose the following set of definitions.

Assertion: The coded representation of a psychological distance between two objects.

Message (coded form): A set of assertions.

Argument: A function defined on that subset of a message which includes all assertions referring to either or both members of a given pair of concepts.

Proposition : The output of an argument; the "distance in the message" between two concepts.

Message (cannonical form): An n x n matrix of propositions, where n is the number of objects referred to by assertions in the coded form of the message.

Message (reduced form): An n x m matrix of coordinate values, where n is the size, and m is the rank, of the cannonical form of the message; a "plotting" in m-dimensional space of the set of n objects referred to by a message.

Message (assimilated form): A transformation of the message as a function of the corresponding cognitive structure in the receiver.

Information in a message: The difference between the assimilated message and the corresponding cognitive structure of a receiver, assuming a "best fit" rotation of the two coordinate systems; a set of vectors from the location of an object in the cognitive structure of a receiver to the locations of corresponding objects in the assimilated message.

These definitions are designed to suggest a spacial model of the message, and to extend Woelfel's definition in the directions indicated above. The definitions are, nevertheless, admittedly crude. There is the problem of operationalization--I discuss this below, but obviously the problem is formidable. There are further problems at the conceptual level. Do the definitions of assertion, argument and proposition fully specify the internal structure of messages? The definition says that an argument is a function which operates upon the assertions in a message, but what sort of function? This is not so much a conceptualization as a category of conceptualizations which need to be developed. The definition is general because it cannot presently be further specified. What the definition does propose is that the assertions in a message are combined in some manner, and that the nature of that combination is a subject for investigation. What I have in mind is that the distance between concepts can be derived indirectly from assertions relating each of the concepts to "third" concepts, but this is only a hint. Similar comments could be made about the definition of the assimilated form of the message, which likewise is not so much a conceptualization as a subject for further thought and research.

In order to operationalize the concept of assertion, "the coded representation of a psychological distance," we must identify rules of transformation between linguistic and other codes, and spacial cognitive structures. This is, at best, a far off goal. Furthermore, one wonders whether such an enormous task is worth undertaking before we have good evidence as to the relative usefulness of the spacial model. But how are we to gather data for the model if we cannot operationalize it? The answer, of course, is that when we cannot directly measure variables, we look for indirect indices of them. There appear to be some promising routes toward this more modest objective.

Osgood (1959) discusses two methods, one of which is closely related to the semantic space model, but the other of which is more directly applicable to the general spacial model.

"Evaluative Assertion Analysis" is a method of measuring the evaluation of concepts in a message. It does not provide an index of psychological distance, but it is an approach which could be extended to provide such an index. The method proceeds in several steps from identification of the attitude objects in the message, to "translation" of the message into a series of evaluative assertions, to assignment of directions and weights to each assertion, and finally, to averaging of the evaluations. The result is a scaling of the concepts in the message on an (assumed) unidimensional attitude scale. This method could be extended by performing a similar series of steps for other semantic dimensions, such as Potency and Activity, and deriving a distance matrix from the multidimensional differences between objects. This procedure would, of course, be extremely laborious. Still worse, it would be practically impossible to computerize. Nevertheless, the method would yield an index of psychological distance which would have a good presumption of validity in terms of both the semantic space model and the set of definitions given above.

"Contingency Analysis" might yield a cruder but more direct index of psychological distance. Osgood sees this method as giving an index of the association structure of a source, but whether one interprets the data in terms of association or psychological distance is, at present, purely a function of the model one prefers. Contingency analysis proceeds by (1) dividing the message into units, (2) noting the presence or absence of reference to each concept or category in each unit, and (3) computing the contingencies or co-occurences among concepts. Osgood suggests that the contingencies be tested for statistical significance (in effect, treating the results dichotomously), but from the standpoint of the spacial model, it would be better to treat contingency directly as an index of proximity. The selection of units is a problem: the general criterion is to select units which are neither so small as to preclude co-occurence of concepts, nor so large as to insure universal co-occurence. Another potential source of problems is that a rather large "message" may be necessary in order to obtain a complete, reliable distance matrix. The advantages of this method (and they are strong advantages) are that (1) the whole process, from division of the message into units to multidimensional scaling of the distance matrix, can be made explicit enough for a computer program; and (2) the output from the procedure has face validity as an index of psychological distance (see Osgood, 1959, pp. 66-73, for examples). The face validity of contigency analysis might be questioned on the grounds that, for example, "communism" and "democracy" co-occur frequently in Western propaganda, despite their great psychological distance. How does the method account for the linguistic difference between comparison and contrast, both of which are co-occurences? The answer is that is doesn't directly, and this might indeed be a problem. One only hopes that experience will show that contrasts and explicit dissociations are not so frequent as to distort the inferred cognitive space. One might find, for example, that "communism" and "democracy" are quite close on a dimension of "politicalness," but quite far apart on a dimension of evaluation. Such an interpretation would be possible if the concepts co-occur only in the presence of other "political" terms.

Smith (1974) has developed a set of computer programs, based on principles similar to Contingency Analysis, which yield "computer generated analogues of mental structures from language data." The programs generate multidimensional spacial representations of message content and permit observation of changes over time. The existence of this software opens up new possibilities for exploration of spacial models of messages.

Unfortunately, none of the above techniques are applicable in situations (such as the present study) in which short messages are to be presented to subjects as part of an experimental procedure. Two approaches to operationalizing the spacial model of message content remain. One approach would be to infer message content from its effects on receivers. In a study like the present one, however, such a method would beg the essential question, since what is at issue is just what effect messages do have on cognitions spacially conceived. The final method is to have a sample of subjects directly estimate the distances between pairs of concepts "in the message." This, too, has its shortcomings, insofar as message "content" is likely to be as much a function of the judges as of the message, reflecting, in short, the "assimilated" message. However, the use of the receivers' judgments of message content is a defensible and practicable, if less than ideal, method of estimating message content in an experimental situation. (One might argue that the subjects who judge message content should be other than the experimental subjects. One might as easily retort, however, that the judgments of "outside" judges would be simply a less accurate estimate of the message as assimilated by the experimental subjects.)

Thus a spacial model of messages appears to be operationalizable in all types of situations in which it is likely to be applied, indicating that the project of coordinating formal models of cognitive and message structure is practical as well as theoretically interesting.

Spacial Theories of Communication Effects

Woelfel (1971; Woelfel and Saltiel, 1974; Saltiel and Woelfel, 1975) has proposed two hypotheses regarding communication effects in terms of the spacial model.

The first hypothesis, which we may call the cognitive Law of Motion, holds that cognitive objects have constant resistance to acceleration in a cognitive space which is continuous, unbounded, linear, homogeneous and isotropic. Formally, this reduces to the classical, mechanical equation, F=ma. In principle, this hypothesis can be tested by experiments analogous to experiments which confirm the mechanical law. For example, the assumption of constant inertial mass is confirmed if the ratios among accelerations induced in concepts by identical forces (e.g. identical messages) are constant across experiments. A further implication of the law is that motion (velocity), once induced, remains constant unless it is opposed by some force. In the case of human cognition, the influence of a message would result in constant change until the force of the message is countered by some opposing force--other messages either internally or externally generated. The law assumes that the cognitive space itself has no viscosity, or resistance to motion within it, but we could be forced by data to amend this assumption and complicate the law accordingly.

Woelfel's second hypothesis, known as the Theory of Linear Force Aggregation (FAT), proposes that a cognition is equal to the arithmetic mean of all information accumulated by a person. Communication effects are thus equivalent to a change in the mean given additional values. In this theory, the number of messages which have formed a concept may be identified with the constant inertial mass referred to in the cognitive law of motion. From the standpoint of FAT, the effect of communication is to establish equilibrium points toward which concepts will tend to move; while, from the standpoint of the Law of Motion, the effect of a message is to generate force as a function of the discrepancy between the message content and the cognitive space of the receiver.

The two theories are not entirely integrated with each other, although Woelfel and Saltiel (forthcoming) have taken a step in that direction. The assumption which naturally arises from FAT is that the force generated by a message is directly proportional to its discrepency from the belief of a receiver. Woelfel and Saltiel show, however, that this assumption can run into problems when one attempts to explain certain attitude change findings--boomerang effects, for example. Woelfel and Saltiel suggest the possibility that the broadest range of findings in the literature can be explained by supposing that the theory predicts an equilibrium point to which the belief will converge over time, but that the instantaneous force generated by a message is inverse to its discrepancy from the receiver's position.

The present study sidesteps most of these issues, which are left for later investigation. The study of "motion" in the strict sense can be pursued after it has been determined that cognitive change is describable generally in spacial terms.

Thus The Linear Force Aggregation Theory is the basis for the present study for two reasons. First, FAT is the more closely tied of the two theories to the spacial model of message content, in that it explicitly includes messages as the key explanatory variable. Second, FAT is testable without necessitating the measurement of the acceleration of concepts in cognitive space--a tricky procedure better not attempted at this early stage of experimental investigation. Roloff (1974) measured acceleration in an experimental setting; however, that

was acceleration of a unidimensional attitude rather than of concepts in a multidimensional space. Gillham (1972) computed accelerations in a multidimensional space; however, he used the accelerations only as an index of inertial mass, and could not test any hypotheses regarding acceleration, because he lacked the necessary experimental and statistical controls.

One point concerning spacial theories of communication effects should be made clear: the test of any particular theory is not equivalent to a test of the general spacial model. Many spacial theories are possible--some more complicated than others. The theory to be presented here, for example, assumes linear motion in a stable, Euclidian space. Complications such as nonlinear motion and warpage of space could be introduced later if the simpler theory fails to explain data. The general strategy should be to test simpler theories first, and to complicate theories only when forced to by data. It should be recognized, however, that there is a point at which the repeated failure of ever-more-complex theories to account for the observed phenomena would force us to conclude that the general spacial paradigm is unfruitful. So while no study can provide a "crucial" test of the general spacial model (or even, for that matter, of the specific theory under investigation), a study such as the present one can contribute to the ultimate evaluation of the general spacial model.

Theory: Communication Effects as Linear Motions in Cognitive Space

Scope Conditions

The theory predicts the time *t*' distances among a set of concepts (s'_{ij}) given the following:

(i) The following quantities are known: the set of distances between each pair of concepts _i_ and _j_ at time _t_ (s_{ij}), the projection of each concept on each dimension of cognitive space at _t_ (f_{ik}), the inertial mass of each concept (n_i), the number of messages received in the interval _t_ - _t_' (p), and the set of assertions contained in messages received during the interval _t_ - _t_' ($\tilde{s}_{ij}$).

(ii) The interval _t_ - _t_' is sufficient for equilibrium to be established in the cognitive space following receipt of messages.

(iii) No change occurs during the interval _t_ - _t_' except that induced by known messages.

Derivation of the General Structural Equation

Woelfel's Linear Force Aggregation Theory states that a belief is equal to the mean value of all messages received. Translated into terms of the spacial model,

(1)
$$s_{ij} = \frac{\sum_{k=1}^{n} s_{ijk}}{n} ,$$

Where: s_{ij} = the psychological distance between concepts i and j,

s_{ijk} = the distance proposed by message k,

n = the total number of messages which have located i and j--the 'inertial mass' of s_{ij}.

A direct implication is that the effect of "new" messages on an already established belief is equivalent to a change in a mean given additional values.

(2)
$$s'_{ij} = \frac{ns_{ij} + p\tilde{s}_{ij}}{n + p} = s_{ij} + \frac{p}{n + p} \cdot (\tilde{s}_{ij} - s_{ij})$$

Where: s'_{ij} = the new belief

p = the number of new messages

$\tilde{s}_{ij}$ = the mean distance proposed by the new messages

In view of the conclusions of Woelfel and Saltiel (forthcoming), we oug to regard s'_{ij} as an <u>equilibrium value</u> that will be approached over tir as the messages are processed. In short, we are dealing here with what strictly might be called "comparative statics" rather than dynamics.

Assume that n, the total number of messages which have located i and j, can be expressed as a sum of two quantities,

(3) $$n = n_i + n_j ,$$

where n_i and n_j are the number of messages which have located i and j, respectively. This assumption allows us to partition the expression or the right in equation (2) so as to reflect the relationship between in- ertial mass and message effects.

(4) $$s'_{ij} = s_{ij} + \left[\frac{n_i}{n} \cdot \frac{p}{n + p} \cdot (\tilde{s}_{ij}-s_{ij})\right] + \left[\frac{n_j}{n} \cdot \frac{p}{n + p} \cdot (\tilde{s}_{ij}-s_{ij})\right]$$

where the left bracketed expression is the change brought about in j ar the right bracketed expression is the change brought about in i. The change brought about, that is, is inversely proportional to the number of messages which has located a concept. In still other words, the cha brought about by new messages is "apportioned" between i and j in inver proportion to their inertial masses.

Now assume that i and j are located in a multidimensional space, and our problem is to determine the change in location of a "moved" cor cept i with respect to all other concepts in the space. The first ster in doing this is to note that s_{ij} can be expressed in terms of the projections of i and j on a set of orthogonal reference axes of the space.

(5)
$$s_{ij} = \sqrt{\Sigma_{k=1}^{r} \quad (f_{ik} - f_{jk})^2} ,$$

where f_{ik} and f_{jk} are the projections of i and j, respectively, on axis f, and r is the dimensionality of the space. $\tilde{s}_{ij}$ and s'_{ij} can, of course, be expressed similarly.

The general structural equation for post-message pairwise distances among concepts in the space can now be derived in three steps. First, we need an expression for $\tilde{f}_{ik}$, the projection of concept i on axis f as proposed by new messages. Second, we need an expression for f'_{ik}, the new equilibrium for the projection of i on f brought about by the new messages. Third, we can write the general structural equation.

The expression for $\tilde{f}_{ik}$ assumes that one-half of the change proposed by $\tilde{s}_{ij}$ is directed toward concept i, and that the change proposed is apportioned among the dimensions of the space proportionate to the distance between the projections of i and j on the dimensions.

(6)
$$\tilde{f}_{ik} = f_{ik} + \frac{(f_{ik} - f_{jk})^2}{(s_{ij})^2} \cdot \frac{1}{2} \cdot (\tilde{s}_{ij} - s_{ij}) \cdot \frac{f_{ik} - f_{jk}}{|f_{ik} - f_{jk}|}$$

The last factor in expression (5) is needed to determine the sign of the changes proposed in f_{ik}. The expression for f'_{ik}, the post-message equilibrium value of the projection of concept i on axis f, can now be adapted from the appropriate parts of equation (4).

(7)
$$f'_{ik} = f_{ik} + \frac{2n_i}{n} \cdot \frac{p}{n + p} \cdot (\tilde{f}_{ik} - f_{ik})$$

In equation (7), $\frac{n_i}{n}$ is multiplied by 2 to take account of the fact that the derivation of $\tilde{s}_{if}$ has already divided the proposed change, and allocated the change to concepts i and j separately. Note that if either p=0 or $\tilde{s}_{ij}=s_{ij}$, then equations (6) and (7) result in $f'_{ik}=f_{ik}$. These equations, that is, can be applied to any concept in the space, regardless of whether any messages have affected that concept.

Substitution into equation (5) now gives the general structural equation.

(8)

$$s'_{ij} = \sqrt{\sum_{k=1}^{r} (f'_{ik} - f'_{jk})^2} \quad ,$$

where i and j are <u>any</u> two concepts in the space. Equation (8) is a general structural equation in the sense that it gives the post-message distances between all pairs of concepts, including pairs in which neither, one or both concepts have been affected by messages.

<u>Summary of Empirical Assumptions Inherent in the Theory</u>

(i) The theory assumes that the variables such as n_i and $\tilde{s}_{ij}$ are stable phenomena, quantities that can be measured, and quantities which in fact <u>are</u> measured by the instruments employed.

(ii) The theory assumes that all relevant messages are known, implying both that messages received before time <u>t</u> have no effects during the interval t - t' and that all information received during the interval is included in the calculations. This assumption could be especially dangerous if Woelfel's hypothesis that cognitive objects have constant resistance to acceleration (but not velocity) is valid.

(iii) The theory assumes the spacial model of message content--that a message is composed of a set of assertions which propose distances between pairs of concepts, thus setting up forces along the lines connecting these concepts. The theory further assumes that the force of an assertion is divided equally between a pair of concepts, and that a concept's resistance to that force is a function of the number of messages which have located the concept.

(iv) The theory assumes that complex cognitive processes occur out of the awareness of subjects. It seems rather unlikely, that is, that subjects consciously make indirect changes in cognitive distances so as to conform to the spacial model. If these processes go on, they do so implicitly and unconsciously.

(v) Finally, the theory assumes that the pairwise distances among cognitive objects are constrained by the stable, Euclidian character of cognitive space, so that the pairwise distances are not independent of each other: the motion of a concept implies precisely calculable changes in its distance from every other concept in the space.

CHAPTER II

PREVIOUS RESEARCH BEARING ON THE THEORY

This chapter surveys research literature bearing upon the theory of linear motion at several points. The issues discussed include (1) the existence of cognitive structures conforming to the spacial model; (2) the meaningfulness of motion in cognitive space; (3) Woelfel's Theory of Linear Force Aggregation; and (4) the occurrence of complex cognitive processes out of the awareness of subjects. Following the review of these issues, we consider the overall status of the theory in light of previous research.

Spacial Cognitive Structures

Evidence that cognitive structures exist which can be represented in terms of a spacial model has come mainly from (1) studies of Osgood's "semantic space," and (2) studies employing nonmetric multidimensional scaling methods. Both of these lines of research tend to support the spacial model, although the MDS studies are perhaps the more credible.

Osgood and his associates have found that at least some dimensions of semantic space are remarkably stable and invariant across cognitive domains. Osgood, Suci and Tannenbaum (1957) state:

> The same three major factors of evaluation, potency and activity (which were empirically rather than theoretically derived) have reappeared in a wide variety of judgmental situations, particularly where the sampling of concepts has been broad. The relative weights of these factors have been fairly consistent: evaluation accounting for approximately double the amount of variance due to either potency or activity, these two in turn being approximately double the weight of any subsequent factors. (p. 325)

This central finding has held up quite well in subsequent studies in many cultures. Seventeen years after publication of The Measurement

of Meaning, Osgood (1974) is able to assert that the accumulated research "is rather convincing evidence for the universality of the affective meaning system" (pp. 33-34).

There are, however, several problems associated with the semantic space research. First, and most significantly, Osgood's research methods are such as to make it difficult to falsify his central assumptions. The relative success of those methods in a massive accumulation of studies is certainly evidence of the merit of the assumptions. On the other hand, the question of whether cognitive space is best thought of as an attribute space cannot very directly be answered by a method which involves measuring meaning on interval attribute scales and factoring those scales. The method begs the question. Second, there is evidence that the sort of bipolar scales used in the semantic differential do not actually represent psychological poles. Wishner (1960) found indications that "grammatical antonyms do not necessarily correspond to psychological opposites" (p. 110). Danes and Woelfel (1975) performed a multidimensional scaling study including adjectives frequently used in the semantic differential, and found that supposed polar opposites (1) were at substantially different distances from the origin and (2) were at angles to each other through the origin substantially different from 180 degrees. Third, as noted in Chapter I, the semantic space is bounded as a result of both the seven step scales and the factor analysis procedure used to generate the semantic space. Such a set of procedures must lead to ceiling effects in measurement. Thus not only the apparent boundedness of semantic space but its apparent anisotropism and heterogeneity are methodological artifacts.

These three difficulties are sufficiently serious to cast some doubt on Osgood's findings, although it must be admitted that the consistency of those findings and the consequent wide and successful application of the methods of the semantic space in social science research provide at least some support for the utility of a spacial view of cognition. Thus the semantic space research is one source of evidence for the existence of stable, spacial cognitive structures.

The basic logic of multidimensional scaling as applied in psychological research has been expressed by Helm, Messick and Tucker (1959):

> . . . The fundamental concept in multidimensional scaling is psychological distance, which is usually estimated in terms of judgments of similarity among stimuli; i.e., two stimuli judged to be very similar are considered to be psychologically closer together than two stimuli judged to be very different. Given judgments of similarity among all the stimuli in a set, mathematical models exist which provide an interpretation of this psychological distance in terms of Euclidian space, and analytical techniques are available to obtain the dimensionality of the space as well as stimulus scale values determined within a rotation and translation. (p. 111)

Serota (1974) has outlined the background and history of MDS in some detail. Within the category of MDS we can distinguish between metric and nonmetric techniques. Metric or classical MDS was developed as a psychological measurement technique largely by Torgerson (1958). Metric MDS requires the input of interval or ratio level paired comparisons data among a set of concepts, and operates upon the data to scale the concepts in an orthogonal vector space which retains all of the information in the original data (i.e., the distance matrix can be exactly reproduced from the coordinate matrix by application of the Pythagorean Theorem).

Serota (1974) describes the concerns about metric MDS that led to the development of nonmetric techniques by psychometricians:

> First, the notion that subjects could make reliable interval or ratio judgments was not readily accepted. It is axiomatic that the reliability of the judgment is inversely proportional to the difficulty of the judgment task. Since the model was attempting to describe individual differences in cognitive arrangement, or psychological distance, it was believed that the technique should be adapted to function with ordinal judgment data which simplify the subject's task and increase the reliability of the findings reported.
>
> Second, the use of the "additive constant" approach was considered suspect since its use with ratio scaling violates the assumption of absolute magnitude and its use with interval scaling required separation of systematic and random error to get the data to fit a Eculidian real space. Richardson (1938) made the assumption, which Torgerson defends, that the data was fallible and represented a foreshortening of the differences which when strictly interpreted would yield triangle inequalities and add unnecessary dimensions. The nonmetric approach (Shepard, 1962a, 1962b; Kruskal, 1964a, 1964b) avoided the problem rather than attempting to deal with it by (1) eliminating the distance component from the procedure, (2) artificially generating a configuration in a Euclidian real space of m dimensions (m is less than n and is determined from the data) which could be adjusted to fit the dissimilarities relationship and (3) reporting the degree of monotonicity between the scale distances and the reported dimensionality (stress).
>
> Third, the process of determining dimensionality was itself challenged as contradictory to the goal of simplicity. Shepard (1962a, 1972) states that the purpose of multidimensionality in scaling should be to produce an expression of interrelationship which is readily interpretable. Techniques built upon this viewpoint tended to emphasize rank reduction at the price of isomorphism of the solution to the raw data . . . (pp. 48-49).

Because of its emphasis upon producing an interpretable space of small dimensionality, nonmetric MDS can be and has been used to determine the utility of a spacial concept of cognitive structure. A representative, indeed almost comprehensive source for the current theory and applications of nonmetric MDS in the behavioral sciences is the two volume collection by Shepard, Romney and Nerlove (1972). A review of the papers in those volumes tends both to further evidence the utility of the

spacial model of cognition and to justify our suspicion of Osgood's methods of operationalizing that model. Many MDS studies, that is, have found interpretable spacial configurations, but many of those studies also suggest that not all interpretable multidimensional spacial representations of cognitive structures also have interpretable dimensional structures. Spacial structures may appear as interpretable clusters, circumplexes or other nondimensional forms. The set of possible forms has been somewhat systematized by Degerman (1972).

In a study that exemplifies the flexibility of MDS, Rapoport and Fillenbaum demonstrated that color terms in American English scale as a two dimensional circumplex corresponding quite closely to the theoretical color circle, and that "Have" words in American English (return, steal, take, etc.) scale as a set of clusters in space. Regarding the "Have" words, the authors conclude (p. 121): "The two dimensions are difficult to interpret, and as the tight clusters appearing on the plot suggest, any attempt at a dimensional representation imposes structure on the data that is not there . . ." Indeed, Rapoport and Fillenbaum argue that MDS analysis is inappropriate in such a case, but their argument rests entirely on the assumption that a spacial representation must yield interpretable dimensions--a doubtful assumption in view of the clearly interpretable clusters present in the plot of their data.

When MDS studies have found interpretable dimensions, the dimensions are sometimes similar to the Evaluation, Potency and Activity dimensions of the semantic space and sometimes not. The study of Nations reported by Wish, Deutsch and Biener (1972) found the evaluation-like dimension of Political Alignment and the potency-like dimension of Economic Development,

but also found dimensions of Geography-Population and Culture-Race which have no correspondence with semantic space findings. Rosenberg and Sedlak (1972) found, for personality terms, clear dimensions of good-bad and dominance-submission. Burton (1972) found that occupation names fall long dimensions of dependency, prestige and skill, D'Andrade, et. al. (1972) found that disease terms scale by seriousness and contagion.

These studies all give evidence both of the validity of the general spacial model of cognition and the utility of MDS as a way of operationalizing the spacial model. Perhaps more compelling evidence, however, comes from those studies which have related spacial representations to human behavior assumed to depend upon the cognitive similarity of objects. That such relations hold has been demonstrated for the substitutability of consumer products (Stefflre, 1972) and of political candidates (Mauser, 1972): products or candidates found by MDS to be closer together are more likely to be substituted for one another (switched among) in the market or the electoral arena. Jones and Young (1972) found that frequency of social communication could be predicted from distances among people in a spacial representation of a social structure.

In sum, both semantic space and nonmetric MDS research tends to confirm the utility of a spacial model of cognition, in that those studies have shown that the spacial representation is stable, valid on its face, and reliably related to other human behavior.

The Meaningfulness of Motion in Cognitive Space

If nonmetric MDS has a strength it is in the reduction of data to interpretable spacial representations. If we take seriously Woelfel's theoretical argument as presented in Chapter I, however, the existence

of such interpretable configurations is neither necessary nor sufficient to support the spacial model. Interpretability is unnecessary in that a cognitive structure might be spacial and yet display no "interpretable" dimensions or other structures. Nor is interpretability sufficient to support the spacial model, for the concept of space implies motion, in terms of which the space may be described as homogeneous or heterogeneous and so forth.

Because the relationships it displays can be assumed, even in principle, to be merely ordinal, nonmetric MDS may be considered unsuitable for the investigation of motion in cognitive space. Thus their interest in the study of change has motivated the renewed interest of Woelfel and his associates in metric techniques. This revived interest has led to the development of the Galileo system--a set of measurement and design techniques and a package of computer programs--which adapts classical MDS to Woelfel's interest in the study of "cultural processes." The Galileo system has been described in detail by Serota (1974), but a succinct overview of the technique is provided by Taylor, Barnett and Serota (1975):

> The subjects are given a complete (n(n-1)/2) list of pair comparisons for the 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 an item wording requests a distance judgment from a respondent (" . . . how far apart are a and b?"). However, 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 (identity - two concepts are perceived to be the same).

> Since the data for an individual case is highly unreliable (reliability being inversely proportional to the difficulty of the judgment task), and since our goal here is a measure of social or cultural conceptions (Serota et. al., 1975), we may use aggregation techniques to improve our measurements. By applying the Central Limits Theorem and Law of Large Numbers we find that the arithmatic average of all responses for any cell in the matrix will converge on the true mean for the population as the sample grows large. . . *
>
> The mean distance matrix is further transformed to a scalar-products matrix which has been double-centered (Torgerson, 1958) to establish the origin at the centroid of the distribution. This matrix is subsequently factored (using a direct iterative, unstandardized 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. Additionally, the multidimensional space is constructed from the unstandardized distance vectors between all possible pairs, and all variance in the sample population is thus accounted for by the n-dimensional space.
>
> Finally, this procedure is repeated at each point in time and the spaces are rotated about the centroid to a least-squares best fit to provide approximations of the concept motions over time. From these resultant cross-time coordinate matrices we can fit curves (trajectories) of motion which describe the relational change from the set. (pp. 4-5)

A more recent addition to the system is an alternative rotation procedure which takes account of theoretical assumptions about which concepts have and have not "moved" during the interval between observations (Woelfel, et al., 1975).

Woelfel's mathematical theories and the (in principle) precision of the Galileo system as an operationalization of cognitive space notwithstanding, the evidence thus far produced to support the inference

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*Studies by Barnett (1972) and by Danes and Woelfel (1975) have achieved adequate levels of reliability with samples of well under one hundred people.

of meaningful motion in cognitive space is both sparse and rather imprecise. An examination of four studies bearing on the question finds that the inference of meaningful motion rests largely on the post hoc "interpretability" of observed changes in location of concepts. Even so, the obtained results are sufficiently interesting to warrant further investigation.

Gillham (1972) found that motion over two intervals (encompassing several months) in the aggregate cognitive space of members of a sociology department was "lawful" according to several criteria, including interpretability in terms of post hoc explanations, general stability of the configuration over time and predictability of magnitudes of changes of concepts from gross differences and changes in volume of information flow about the concepts. Gillham made no specific prediction of forms of motion; nor did he measure or control the content of information. The study incorporated only rough indices of the amount of information communicated about each concept. Gillham's post hoc interpretations of motions were aided by interviews in which respondents to the study were asked to explain specific changes in their responses. The resulting flavor of Gillham's interpretations is given by a brief quotation:

> Once again the dimensions that are used vary considerably across respondents. The professor who has the largest changes from time two to time three is said to be ' . . . a nicer guy than I had thought' and 'more of an outcast' in relation to another professor who once had much power in the department. It is clear from personal observation that this professor whose position changed so much has recently spent much more time talking with graduate students than he once did. Two respondents who were later interviewed mentioned meeting him in the graduate lounge . . . (pp. 53-54)

In a five wave panel study of the 1972 U. S. Presidential Election, conducted in Champaign County, Illinois, Barnett, Serota and Taylor

(1974) tested several qualitative hypotheses about motion of candidates and issues in the aggregate space. These were: (1) that candidates would converge over time with issues with which they were publicly associated; (2) that the candidates would diverge from each other over time; (3) that the candidate whose aggregate distance from "Me" (one of the concepts scaled) was minimal at the time of the election would be elected; and (4) that the overall magnitude of the space would shrink as the election approached. The study suffered from methodological problems --in particular, a very high rate of subject attrition. And again, as in Gillham's study, the hypotheses could be tested only by *post hoc* interpretations of observed changes in light of what the authors informally knew about the events of the election campaign. By that weak criterion the data were claimed to provide some support to the hypotheses. The authors conclude:

> These findings clearly lack the rigor necessary to test the primary hypothesis that movement in the vector space is a function of the amount of information the subjects receive. We can only infer this from the results reported above. It is, however, possible to observe regular motion in the space reported here which maintains a high level of face validity with both current political polling practices and actual voting behavior for the population. To usefully apply these techniques and test our main hypothesis it will be necessary to control the information concerning the scaled concepts and/or perform a content analysis about those topics, while utilizing the metric multidimensional scaling instrument at a level of rigor consistent with the precision which it is able to achieve. (p. 30)

Taylor, Barnett and Serota (1975) have since completed a trend study of a congressional election near Detroit, Michigan. The trend study, by observation of independent samples at several points in time, avoids the problems of subject attrition and sensitization. Hypotheses one, three and four of this study were identical to those of the previous study, while hypothesis two was replaced. The new hypothesis two was that "identification of a candidate with the issues clustering closest to the average position for the respondents (Me) will cause that candidate to converge with the average position for 'Me'."

The method of analysis employed--post hoc, qualitative interpretation of motions in light of informal knowledge about the campaign--was similar to that of the previous study. This time, however, the authors appear to have had much more direct and intimate knowledge of the Democratic candidate's campaign strategies, and, indeed, seem to have influenced those strategies to a degree. This greater knowledge permitted the authors to make several qualitative predictions, which generally were confirmed.

The Democratic candidate attempted to identify himself with crime prevention and subsequently converged with that concept in the space. The candidate's distances from two concepts on which he did not comment, however, remained relatively stable. This was considered to support Hypothesis One. The new Hypothesis Two is still more interesting because it introduces a question of indirect change--whether identifying a candidate with an issue that is "close" to the aggregate Me will move the candidate closer to Me. Significantly, a qualitative analysis of the Democratic candidate's motion with respect to Bussing, Crime Prevention and Me was judged to support the hypothesis. Since the prediction of the election outcome by a formula based on the distance of the candidates from Me was accurate within two percent, and was more accurate than a prediction based on customary polling methods, Hypothesis Three was also considered supported. Hypothesis Four, however, was not supported.

Although the study discussed above is in many ways quite impressive, its limitations are also obvious (and readily admitted by the authors). The most general and serious problem is that lack of control (statistical or experimental) over information flow prevented before-the-fact prediction of motion based on explicit mathematical assumptions. A second problem is that the analysis tended to focus upon certain motions and ignore others. In particular there was no attempt to systematically explain all observed changes, to seek out evidence contrary to theory, or even to account for apparent anomalies (like the great motion of the Republican Party, presumably a relatively massive concept).

A fourth study which has attempted to assess the meaningfulness of motion in cognitive space is reported in Woelfel, et al. (1975). This study was conducted in a controlled setting. Data were collected at four points in time. Between measurements subjects received messages, attributed to two sources, advocating a behavior, the CTP, the meaning of which was left vague. As predicted, the two message sources and CTP were observed to converge in space. This motion was especially evident when a rotation procedure was employed which attempted to leave only those three concepts free to vary, a result which suggests the possibility that the results of previous studies would have been more clear-cut had they been able to use the new rotation procedure.

Just because this study was so much more controlled than the previous three its weakness as a test of theory, rather than as a piece of research per se, become prominent. Once again, despite the mathematical precision of Woelfel's theories and the presumed precision of the scaling technique employed, only a qualitative prediction was made. Furthermore, only some of the spacial information available was used in making and testing the predictions. Specifically the prediction that the two sources and CTP would converge says nothing about how those concepts would move with respect to other concepts in the space. If the notion of "Laws of Motion in Cognitive Space" is to have any nontrivial meaning then that additional information must be taken into account and the corresponding phenomena explained.

Linear Force Aggregation Theory

The hypothesis that a cognition is equal to the mean of all the information to which a person has been exposed has been somewhat successfully tested from several standpoints in studies carried out by Woelfel and his associates.

One line of research has considered whether a belief or attitude can be predicted from estimates of the information to which the person has been exposed. In the earliest of these studies, which predated the theory itself, Woelfel and Haller (1971) accounted for 64 percent of the variance in high school students' educational aspirations, and 57 percent of occupational aspirations, with linear regression models which included as predictors the means of the educational and occupational expectations for the student held by the student's designated "significant others." Mettlin (1970) successfully replicated those results with a different sample of students. Using linear regression models, Woelfel and Hernandez (1974) accounted for about 55 percent of the variance in college students' self-conceptions as marijuana users, and Woelfel, et al. (1974) accounted for about 62 percent of the variance in French-Canadian separatism.

The impressive coefficients of determination reported in these studies should be interpreted with a great deal of caution. First, as a practical matter we will seldom be able to measure all messages to which an individual has been exposed, and we certainly will not be able to do so in field settings and for substantially interesting cognitions. Thus FAT cannot be, and in fact has not been, strictly tested in field studies such as those cited above. Second, the linear models tested in studies incorporated many variables, which are only interpretable to varying degrees as indices of "information." In Woelfel and Haller (1971), for example, Educational Aspirations were about as strongly predicted by Occupational Aspirations and Academic Performance as by Significant Other Expectations, and all three of these variables contributed to the reported R^2 of .64. Academic Performance can be considered as self-reflexive behavior and therefore as information, but to similarly interpret Occupational Aspirations would be questionable. The results of Woelfel and Hernandez (1974) and Woelfel, et al. (1974) are even more dubious from this standpoint. Information exposure in these studies was measured by subjective reports, which over twenty years of cognitive consistency research (Abelson, et al., 1968) suggests may correlate with attitude quite independently of actual communication content. Furthermore each study included over thirty variables in the multiple regression models, and in each case demographic ("structural") and "related attitude" variables independently explained significant proportions of variance. Again, demographic variables may incorporate location in the societal communication network, but "related attitudes" seem entirely indefensible as information measures. Third, these studies actually contradict the simple mathematical formulation of the theory insofar as they have found indications that not all sources "count" equally in attitude formation. This is evident to some extent from the varying regression weights of the exposure variables. More directly, Woelfel and Hernandez (1974) estimated the "inertial masses" of various sources and found them to vary considerably.

Woelfel, however, has always regarded the theory as oversimplified in this respect (see, for example, Saltiel and Woelfel, 1975); and the necessity, under some circumstances, of differentially weighting messages from different sources does not seriously compromise the principle of a linear force aggregation theory. Nor is the above critique intended to assert that the available evidence denies the predictive utility of FAT. It asserts only that the available evidence, while suggestive, falls far short of "proof."

A second line of research into FAT comprises two studies which test the implication that the more information upon which a cognition is based the more resistant to change is that cognition. First, Gillham (1972) examined the hypothesis that motion of a concept in multidimensional cognitive space is inversely proportional to the amount of information composing it. The concepts in his study were members of a sociology faculty, and the amount of information was indexed by such variables as the number of graduate assistants working with the professor and the mean number of hours respondents reported talking with the professor. All correlations between these indices and the "inertial mass" (relative stability) of the concepts were in the predicted direction, although most of the correlations were quite low. Second, Saltiel and Woelfel

(1975) found that attitude change in a sample of high school students over a six month interval inversely correlated ($r=.19$, $p<.05$) with an index of "number of messages." The index was computed for each respondent by multiplying the number of people with whom the respondent reported (specifically named) having talked about the attitude issues by the average amount of communication the respondent reported having with these "significant others." Thus two very different studies have both found absolutely low but directionally consistent correlations supporting the FAT implication that information accumulates as the inertial mass of concepts.

Saltiel and Woelfel (1975) report additional results bearing on the theory. Most interesting among these are the negative findings that attitude change was <u>not</u> related to heterogeneity of significant other opinions (as measured by the variance of attitude responses directly obtained from respondents' nominated significant others), nor to an index of psychological stress, nor to self-reported strength or certainty of opinion. These negative findings tend to rule out possible competing explanations of attitude stability.

A third and final line of research into FAT includes studies which directly attempt to assess the theory's utility for predicting the cognitive effects of information inputs. The study reported in this dissertation is in this line, which may be said to have begun with Roloff (1974).

Roloff tested the basic implication of the theory for cognitive change: the proposition that attitude change is directly and linearly related to the number of incoming messages and the discrepancy of those messages from the old attitude, and that attitude change is inversely related to inertial mass (accumulated information). In a multiple-message experiment Roloff found significant correlations between discrepancy and attitude change at different times, for two of three topics. For the third topic discrepancy and attitude change were correlated at one time but not at the other time. The deviant issue was later identified as having the highest inertial mass of the three. Roloff also found that the maximum attitude change on each topic occurred with the delivery of the first message. Subsequent messages induced significantly smaller change increments. Again, this is consistent with the idea that information accumulates as inertial mass. Although these are not precise tests of the mathematical theory, they do lend the theory some support.

The political study by Taylor, Barnett and Serota (1975) also attempted to test the cognitive change implications of FAT. The authors grant at the outset that in

> . . . field studies such as the research described here, however, lack of experimental controls prevents adequate empirical examination of these [FAT] equations. Attitude change, then, is treated as a simple quantitative function of the number of messages an individual has received about a given attitude object. Thus, the greater the information history about an attitude object the more difficult it becomes to foster attitude change. (p. 2)

By this weaker test findings such as that the less known Democratic challenger moved more in cognitive space than did the more known Republican incombant, and that the Democratic candidate moved more with respect to issues on which he campaigned than issues which he didn't mention, may provide some support for the theory. On the other hand, how are we to explain the fact that among the concepts that underwent the greatest change were the Republican Party, the Democratic Party and

Me--presumably highly massive concepts? The support given FAT by this study is weak at best.

Finally, Woelfel et al., (1975) report a laboratory experiment in which three low mass concepts associated with each other by means of messages converged toward each other in cognitive space. These results conform generally to the theory; although again no direct test is made of the mathematical theory, and the relative motions are not entirely consistent with what one might reasonably suppose to be the relative masses of the concepts.

Considered together these three studies are rather weak evidence for the utility of FAT for predicting the cognitive effects of messages. In fact, the present study is the first to attempt a direct test of FAT as a mathematical theory of the cognitive effects of communication.

Two very substantial lines of research in addition to the three sets of studies discussed above might be interpreted as bearing on FAT. These are studies of the relation between advocated and obtained attitude change and studies of information integration.

FAT quite unambiguously predicts a positive linear relation between attitude change advocated and obtained. A summary of the research literature by Greenberg and Roloff (1975), however, makes clear that nonlinear and even negative relations frequently have been found. Ultimately either the conflicting studies will have to be reinterpreted to fit the theory or the theory itself will have to be changed or restricted in scope. The last choice is taken by Greenberg and Roloff, who suggest that the relation is linear and positive (thus FAT may apply) only for low mass concepts. Greenberg and Roloff report data showing a linear

relation between attitude change advocated and obtained on a set of topics relatively unknown to the experimental subjects. This is consistent with their interpretation, but does not, of course, demonstrate the proposition, fatal to FAT as a general theory, that the relation is nonlinear for high mass topics.

The main event in the information integration literature has been a bout between models which assume that information inputs are _added_ to form an overall impression and models which assume that information inputs are _averaged_. Considered as an information integration model, FAT is quite definitely an averaging model. Reviewing the literature on "summative" versus averaging models of information integration, Wyer (1974) concludes:

> It is undoubtedly clear by now that 'critical' tests of summative and averaging models, and the identification of the psychological processes to which they pertain, are very difficult to construct. The data usually interpreted as evidence for a summative process (e.g., the 'set size' effect) can be accounted for by an averaging model such as Anderson's. On the other hand, the 'averaging-like' effects when moderately polarized information is added to highly polarized information could in principle be predicted by a summative model, such as Fishbein's, which takes into account the influence of attributes other than those specified in the information presented. (p. 300)

Wyer goes on to present further data which he argues support a summative over an averaging model. However, he goes still further to suggest that both models may be false or may apply only in limited circumstances.

All considered, the research evidence bearing on FAT must be regarded as equivocal. Clearly there are many issues to be resolved. As is frequently the case in the behavioral sciences, resolution of these issues is made more difficult by the fact that competing theories are applied in different research paradigms which are not always easily comparable. How do we relate Gillham's results to the information integration literature, for example? Still unless a theory succeeds _on its_ own ground it is not at all worthy of consideration. In the present case the "home ground" of FAT is the set of studies by Woelfel and his associates which seem generally consistent with the theory, although the support is weak and the studies unrigorous. Research is called for to test the theory more rigorously.

Cognitive Consistency Without Awareness

At least one aspect of the theory of linear motion presented in Chapter I may be quite counter-intuitive. As we previously have noted, the theory assumes a total integration of cognitive structure in terms of a "consistency" principle which is representable as the stable, Euclidian character of cognitive space. Thus motion of a concept with respect to any other concept implies motion of that concept with respect to all other concepts in accordance with a straightforward application of the Pythagorean Theorem. Not only does such a consistency principle imply exceedingly complex cognitive processes, but those processes must operate entirely outside of the subject's awareness. Does psychological research lend any plausibility to such a hypothesis?

Brock (1968) has considered this issue from the standpoint of consistency theories in social psychology. Brock cites several examples of studies in which dissonance reduction (or a corresponding consistency process in terms of some other theory) has apparently taken place without the conscious awareness of subjects. Lack of awareness is assumed on diverse grounds, including young age of subjects (three-year-olds, Brock, 1963), assessment of awareness of response-reinforcement contingency in a verbal conditioning setting (Cohen, Greenbaum and Mansson, 1963), and use of hypnosis (Brock and Grant, 1963; Blum, 1961; Rosenberg, 1960).

Perhaps the most impressive evidence, however, comes from studies of consistency models which are both complex and unfamiliar to subjects but to which subjects' behavior nevertheless conforms, thus presumably unconsciously. Brock cites one such study in which McGuire (1960) found, among a sample of below average achievement high school students, indirect attitude change as required by the multiplicative probability rule on propositions syllogistically related to propositions which were the targets of persuasive messages. McGuire comments:

> In the present study several procedures were employed in an attempt to minimize the degree of conscious awareness. (For example, no mention was made to the Ss that their consistency was being assessed; the related propositions were widely separated from one another in the questionnaire; a quantitative expression of opinion was required and the assessment of inconsistency involved a mathematical model unfamiliar to the Ss.) (p. 352)

McGuire's main finding was replicated in two experiments reported by Dillehay, Insko and Smith (1966), who conclude that "it is unlikely that a conscious effort toward logical consistency is operating: the properties of the model are far too complex to be understood and applied by even the most astute subjects" (pp. 653-654).

A somewhat similar line of reserach has been pursued using the congruity model (Osgood and Tannenbaum, 1955) as the criterion of consistency. Tannenbaum and Gengel (1966) established three source-concept linkages, and, in a separate message, made the concept attitude positive or negative. Congruity predictions of subsequent attitude changes toward the sources (which were not mentioned in connection with the persuasive messages) were generally supported, although there were some contrary findings. The subjects were college students. Tannenbaum (1966) extended the logic of the first study to a situation in which linkages were established between a single source and two concepts, and attitude toward one of the concepts was then changed by a persuasive message. The congruity model prediction that change in the first concept would influence the source attitude, and that this source change would, in turn, produce appropriate changes in the second concept, was strongly supported in the results. The subjects were high school males. Although it is not mentioned in the original report, Tannenbaum (1968) adds:

> When subjects were queried for their reasons for showing fairly substantial attitude change toward one concept as a result of reading a 300 word message on another concept, a considerable number first indicated surprise and doubt that they had changed. When their pre- and post-test scores were made available and they were convinced that they had indeed changed their beliefs, they voiced considerable resentment and were clearly upset with themselves. (p. 434)

The accumulated evidence impressively supports the proposition that complex consistency processes can occur without the conscious awareness of subjects. None of this, of course, directly bears on the theory tested in the present study, except that it generally lends plausibility to theories of a certain type; i.e., theories which postulate complex, unconscious cognitive processes. Whether the maintenance of relationships as required by the theory of linear motion is a process that actually goes on is an unanswered empirical question. The point is that the evidence suggests the question is worthy of serious study: it is not on its face absurd.

Summary

This chapter has reviewed research literature bearing upon (1) the utility of a spacial representation of cognitive structure; (2) the meaningfulness of motion in cognitive space; (3) Woelfel's Theory of Linear Force Aggregation; and (4) the occurrence of complex and unconscious consistency processes in the human mind. What, in general, is the status of the theory of linear motion in light of the literature?

First the literature strongly supports the inference that spacial models can be meaningful and useful representations of cognitive structures. This is not to say that all cognitive structures can be represented spacially, but is to say that a broad range of structures can be so represented, and that such representations have won an important place in behavioral research.

Second, however, the evidence for the meaningfulness of motion in cognitive space, while suggestive, is far from conclusive. The research so far has not been very rigorous; and in fact the accumulated evidence largely consists of post hoc interpretations of selected features of the observed changes in spacial locations of concepts. The theoretical work in this area is rather highly developed. Needed is research of comparable quality, research that will test a priori hypotheses derived from explicit assumptions.

Third, the evidence bearing on FAT is quite equivocal. Despite its conceptual simplicity the theory is very difficult to operationalize. All evidence, both positive and negative, can be attacked, for example, on the ground that it fails to take account of all information to which the subject has been exposed. While studies by Woelfel and his associates have generally been interpreted as at least consistent with the theory, little effort has been made to explain the apparently contradictory findings of research on message-attitude discrepency and information integration. There is a presumption that the theory is oversimple and will ultimately have to be complicated. Here the need is for research of precision sufficient to suggest the necessary complications. Attention must be directed particularly to operationalizing the concepts in the theory and testing numerical predictions.

Fourth, plenty of evidence points to the occurrence of complex, unconscious consistency processes. Thus our theory of linear motion cannot be rejected out of hand merely because it assumes that such processes occur. Of course the theory may well be rejected because the specific processes it posits happen not to occur--but that is a matter to be settled by empirical investigation.

This dissertation was conceived in view of the above. Building upon the secure foundation of spacial models of cognitive structure, the theory of linear motion extends those models into less-explored territory: the explanation of cognitive change. The particular assumptions made permit numerical predictions, which, in turn, permit a more rigorous test of both the spacial model and FAT. The study reported in the following chapters is an attempt at such rigorous theory-testing.

CHAPTER III

METHODS

This chapter describes the methods--design, procedures and analysis --of an empirical study intended to test the theory of linear motion presented in Chapter I in view of the research background presented in Chapter II. The study is described under the two main headings of Design and Procedures, and Data Analysis.

Design and Procedures

Overview

A pretest-manipulation-posttest, within-subjects experimental design was employed. The study was conducted at Michigan State University on two successive Mondays, June 23 and 30, 1975.

In the pretest a cognitive domain of 15 concepts was scaled using the Woelfel technique of direct, ratio judgments of inter-concept distances (see below "Measurement of Variables"). Subjects then read three messages, each intended to change the distance between a pair of concepts. Thus motion should have been induced in six concepts, leaving nine concepts which were not manipulated. The two sets of concepts (manipulated nad not) provided experimental control. As a result of this procedure, theory predicts that specific changes should have occurred in 69 of the 105 pairwise distances among the 15 concepts, while the remaining 36 distances should not have changed.

In the posttest the actual post-message inter-concept distances were measured, these to be compared with those predicted by theory. Pretest and posttest were separated by one week. Messages were presented both immediately following the pretest and immediately before the posttest. The purpose of this procedure was to allow for a period of time sufficient for complex cognitive changes to occur, while also taking account of the tendency for the effects of messages to "wear off" over time.

In sum, the pretest consisted of a printed packet containing the following: (1) a cover letter explaining the purpose of the experiment, (2) an instrument for obtaining estimates of the inertial masses of the 15 concepts, (3) the 105 distance estimates, (4) the three messages, and (5) questions following each message for obtaining estimates of the distance proposed by the message. The posttest, administered one week later, consisted of a printed packet containing the following: (1) a cover letter, (2) the three messages, (3) questions following each message for obtaining estimates of the distance proposed by the message (in order to assess reliability of those items), (4) the measures of inertial mass (in order to assess reliability and validity of those items and provide a filler following the message), and (5) the 105 distance estimates.

Subjects

The participants in the study were students in communication classes at Michigan State University. The questionnaires were administered during classes, and the students were informed that participation was strictly voluntary.

A total of 93 students participated. Of those, 64 provided usable data. Fourteen subjects were present at the pretest but not at the posttest, while ten subjects were present at the posttest but not at the pretest. Four subjects, although they were present at both administrations, failed to complete one or both questionnaires. Thus 28 subjects had to be excluded from the data analysis because they provided insufficient data.

The data of one additional subject were excluded. The posttest data of this subject displayed a pattern which the experimenter interpreted as intentional non-cooperation with the experiment. 102 of the 105 distance estimates of this subject were identical (all were 100). The remaining three estimates were sharply changed from the pretest in the direction opposite to that suggested by the experimental messages. Whatever may explain the behavior of this subject it is not the hypothesis under investigation.

Thus 64 subjects were included in the data analysis. Of these, 36 were students in one graduate course and 28 were students in two undergraduate courses. 38 of the subjects were males and 26 were females. The mean age of the subjects was 26 and the median age was 24. In general, then, the subjects tended to be advanced college students, people who are capable of performing complex cognitive tasks.

Cognitive Domain

The cognitive domain of "nations" was selected for study. The domain seemed suitable for spacial modelling because it consists mainly of a set of discrete entities (nations) to which we attribute various characteristics. The domain also has previously been studied--for example, by Wish, Deutsch and Biener (1972). The spacial representation of the domain should, therefore, be somewhat predictable. Fifteen nations were studied. The number 15 was considered to be the approximate upper limit possible for the subjects and setting of the study.

The specific nations to be included in the study were selected by a three-stage procedure that combined random and judgmental features. First, a set of six nations judged to be diverse and relatively familiar to most people was selected from the list used by Wish, Deutsch and

Biener. The six are U.S.A., U.S.S.R., China, Brazil, West Germany and India. The purpose of this procedure was to provide a stable framework for the cognitive space and to make the structure of the space somewhat predictable (Wish, Deutsch and Bierner found clear dimensions of Political Alignment and Economic Development). Second, a pool of 18 countries was selected by means of a table of random numbers from the roster of the United Nations (Office of Public Information, 1972). Third, 9 of the 18 countries were discarded based on three criteria: (1) eliminate countries duplicated in the six chosen from the Wish, Deutsch and Bierner study, (2) retain pairs of countries which seem promising for message construction, and (3) retain countries so as to maintain a roughly even spacial distribution in terms of the expected dimensional structure. The nine countries chosen by this procedure were: Singapore, Mexico, Portugal, Poland, Fiji, Central African Republic, Congo, Greece and Guyana.

The 15 countries to be included in the study were assigned numbers from a table of random numbers. These numbers determined the order of appearance of the countries on the questionnaires and were used as identification numbers in the data analysis. Thus the final list of nations was: (1) China, (2) Singapore, (3) Mexico, (4) U.S.A., (5) Portugal, (6) Poland, (7) India, (8) Fiji, (9) West Germany, (10) Brazil, (11) Central African Republic (C.A.R.), (12) Greece, (13) U.S.S.R., (14) Congo and (15) Guyana.

Experimental Messages

The decision to use three messages was constrained by several considerations. A "message" is conceived of as a set of arguments bearing upon the distance between a single pair of concepts. With respect to a message the whole set of distances among concepts in a cognitive domain can be divided into three subsets: (1) the single distance "directly" changed by the message, (2) the set of distances "indirectly" changed by the message, and (3) the set of distances not at all changed by the message. "Direct" change in distance means simply that the manipulated concepts move either toward or away from each other. "Indirect" change in distance means that the manipulated concepts, as they move toward or away from each other, each also move with respect to all of the remaining concepts in cognitive space. Distances neither directly nor indirectly affected by a message are assumed not to change at all. In a domain of 15 concepts there are 105 distances. If one message is processed the spacial theory predicts one directly changed distance, 26 indirectly changed distances and 78 unchanged distances. Table 2 gives the whole set of possible distributions of types of changes in a 15-concept cognitive domain.

Table 2. Possible Distributions of Changes of Distance in a Domain of 15 Concepts.

No. of Messages	No. of Distances Directly Changed	No. of Distances Indirectly Changed	No. of Distances Unchanged
0	0	0	105
1	1	26	78
2	2	48	55
3	3	66	36
4	4	80	21
5	5	90	10
6	6	96	3
7	7	98	0

All three types are theoretically important in that the theory purports to exactly predict them. A failure with respect to any type would constitute a failure of the theory. The "indirect" changes, however, are particularly crucial because they alone are a unique consequence of the spacial model. The "direct" and "no change" types are predicted by many other possible theories and thus do not distinguish among theories. In light of this the number of messages should be selected so as to provide for some of each type of change, but should emphasize the theoretically crucial "indirect" changes.

Another general consideration is the practical limitations imposed by the subjects and the experimental setting. Both of these factors suggest that the smallest possible number of messages be used, as each message exacts a price in time and in the information processing capacities and the good will of subjects.

Three messages seemed to be an optimal number, all of the above considered.

Three pairs of concepts were selected for inclusion in messages. The selection was based on both theoretical and practical grounds. The theoretical grounds were that the nations be of no greater than moderate inertial mass and that the members of each pair be at a moderate distance from each other. The former criterion was established to facilitate manipulation of the concepts with a single message, while the latter criterion was established to maximize flexibility in message construction and minimize the possibility of regression artifacts in the results. Nations were measured against these criteria by the judgment of the experimenter. The practical ground for selecting pairs of nations was that the mere presentation of factual information by a moderately high credibility source could be expected to imply a substantial change in the distances between the concepts. This test also was applied by the judgment of the experimenter.

The pairs of countries selected were (1) Singapore and Fiji, (2) Congo and Guyana, and (3) Portugal and Brazil.

Information about the six countries was obtained from the Encyclopaedia Britannica (1974: "Brazil, History of"; Fu-kiau kia Bunseki-L.; "Guyana"; Ho; Honeybone; Perez de Amaral). Information was selected based on its judged interest and relevance to a consistent theme of similarity or difference between the pairs. The information was used in composing three messages. The first message developed the theme that "Fiji and Singapore are remarkably similar"; the second message argued that "Congo and Guyana are very different"; and the third message proposed that "Portugal and Brazil are closely related."

The messages are included with the questionnaire in Appendix A. The messages are of similar length. The Fiji-Singapore message is 204 words long, the Congo-Guyana message is 204 words and the Portugal-Brazil message is 178 words. The structure of the first and third messages differs somewhat from that of the second. In the former cases the countries are compared point by point; whereas in the latter case the countries are discussed in separate but parallel parts of the message. This structural difference was intended to reinforce the content emphases of the messages by associating the similar countries and dissociating the dissimilar countries.

Measurement of Variables

The measurement of variables in this study was throughout based on the principle of direct, ratio estimation advocated by Woelfel (see

Woelfel, 1974; Danes and Woelfel, 1975). In brief, the rationale for this method holds that the measurement of any cognitive variable can be thought of as the measurement of conceptual separations, or distances between entities. Given this assumption the problem of measurement becomes just a practical one of establishing a unit of measurement in terms of which all values of the variable may be expressed as ratios. Danes and Woelfel (1975) reason:

> Let's suppose for a moment that no standardized metric existed for the measurement of distance, a problem that our ancestors were faced with years ago. Then could the distance between A and B be measured? Yes. But a metric and a rule for doing so must initially be created before measurement could proceed. That is, some arbitrary distance, say the distance between x and y, must first be generated, and the distance between A and B could then be given in relation to that arbitrary distance . . . With respect to the measurement of conceptual separations, the identical logic could be used, and measurement of the conceptual domain could then be given by a two-staged procedure: the specification of a metric and a request to use ratios of that metric for the measurement of the separations among other conceptions. As an example, the following kind of question could be asked: If NIXON and AGNEW are one hundred (100) units apart, then in relation to NIXON and AGNEW how far apart are NIXON and McGOVERN? From the experience of the authors, most persons would report a number considerably larger than one hundred. (p. 3)

The technique proposed by Danes and Woelfel is not entirely new. The technique was recommended by Torgerson (1958), who suggested: "The subject might be told to assume that on some scale the distance (amount of difference) between stimuli A and B is ten units. His task would then be to report the distance (amount of difference) between stimuli A and C on the same scale" (p. 293). Torgerson also warned, however, " . . . the task may ordinarily be too difficult for the subject, since it involves judgments of a fairly high level of complexity" (p. 293). The difficulty of the task would be expected to produce unreliability of measurement. Anyone who proposes to use the technique, then, must confront and deal with the problem of unreliability.

Woelfel (1974, p. 12) accepts that unreliability seriously limits the technique's utility for measuring individual subjects (though he suggests, without much basis, that the diffusion of the technique through the scientific community and the general culture would improve precision in the task because of practice and familiarity).* Woelfel argues, however, that the reliability problem disappears when attention is focused upon measurement of aggregate variables rather than individual variables. In the aggregate case one can use large samples of people, taking advantage of the statistical principle that the sample mean converges toward the true population mean as sample size increases. Thus the problem of unreliability becomes essentially one of cost. Given unlimited resources and a large population from which to sample, the reliability of aggregate measurement (the sample mean) can be made as high as one might wish.

Two papers have systematically investigated the reliability of Woelfel's technique of aggregate measurement.

Barnett (1972) reports two studies which tested the reliability of a metric multidimensional scale for which direct ratio judgments were used to obtain the distance matrices. In the first study he tested reliability by correlating time 1 with time 2 projections of 17 concepts on the first three dimensions of the space. Before calculation of the correlations, the time 2 coordinate matrix was rotated to least squares best fit with the time 1 matrix. The analysis was performed separately upon random subsamples of sizes 25, 50, 75 and 100 subjects. Findings

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*Woelfel (personal communication) has proposed the additional argument that the apparent unreliability of the technique in many situations may result not from the faultiness of the technique but from the true instability of the phenomena supposedly measured. This argument, however, only redefines the problem as one of invalidity--trying to measure something that doesn't actually exist.

were that the larger the sample the greater the reliability, that the first dimension was more reliable than the second and the second more reliable than the third, and that reliability ranged from a low of .23 for the third dimension and 25 cases to a high of .80 for the first dimension and 100 cases. In a second study Barnett examined 15 concepts at three points in time (four weeks and then three weeks apart) for subsamples of 25, 50 and 61 subjects. Here again the reliability increased with both size of the sample and "size" of the dimension, but the correlations in this case were somewhat higher, ranging from .13 to .86 with 25 cases, from .44 to .97 with 50 cases and from .45 to .95 with 67 cases. Barnett attributes the greater reliability of the second scale to several factors, including greater homogeneity of the subject population, better data preparation, shorter time interval between administrations, fewer concepts and a more homogeneous conceptual domain. Barnett conducted a third analysis with random data and found correlations of .21, .01 and .38 for the first three dimensions. These numbers suggest the order of magnitude at or below which one should question whether the data reflect real phenomena.

Danes and Woelfel (1975) obtained judgments of separation among 17 concepts from 50 respondents at two administrations with an interval of five weeks between measurements. The researchers evaluated reliability by three methods. First the test-retest correlation computed over the 136 cells of the inter-concept distance matrix was .86, indicating good reliability of the aggregate separations. Second the technique of correlating test-retest coordinates in the multidimensional space generated by a metric MDS procedure with rotation of the second space to least squares best fit with the first space--the technique used previously by Barnett--yielded correlations of .97, .81 and .87 for the first three coordinates. Thus this study found slightly better reliability than did Barnett's. Third the absolute amount of reliable variance was computed by multiplying the total variance for all items on each coordinate by the reliability of that coordinate. This was compared by several procedures to the reliable variance of a set of seven-step Likert-type items that correlated highly with the first (evaluative) dimension of the multidimensional scale. The procedures involved transformation of the Likert items to make them comparable in range to the MDS coordinates. All comparisons were said to indicate that the multidimensional scale had greater reliable variance than the set of Likert-type items.

In sum, research on the reliability of aggregate, direct, ratio judgments of separation indicates that adequate reliability can be achieved with a relatively homogeneous sample of about 50 people and a relatively homogeneous set of 17 or less concepts. Although it must still be regarded as experimental, the technique is not without basis.

Three sorts of variables were measured in the present study: concept inertial masses, inter-concept distances and message contents. The questionnaire referred to in the following text is included as Appendix A.

The inertial mass of a concept is defined by Woelfel as the concept's resistance to acceleration, which is theoretically a function of the total information about the concept accumulated by a subject or aggregate. A set of items was devised based on this conceptualization and the technique of direct, ratio estimation. The subject was asked to estimate "how much information you have--how much you know--about each of fifteen countries. Consider all that you know about each country, from whatever source." The unit for the scale was established by anchoring zero as "the complete absence of knowledge" and 100 as "an average amount of information." Thus the mass of each nation was estimated as a ratio of an "average" amount of information.

Inter-concept distance is conceptualized in the spacial model as psychological distance or total attributional difference. Accordingly, the inter-concept distances were measured by direct, ratio estimation of "how different (or in other words 'far apart') you perceive the countries to be." The unit was established by stipulating that "Italy and England are 100 units apart." The value of zero was said to mean that the pair of countries was "exactly the same." Each subject estimated all 105 inter-concept distances in this fashion. The items were listed systematically in order of concept numbers (1-2, 1-3, . . . , 2-3, 2-4, . . .). The items were grouped in clusters of eight on the page in order to enhance readibility.

Message content is conceptualized in the spacial model as an assertion about the distance between a pair of concepts. Its theoretical function necessitates that message content be measured on the same scale as the inter-concept distances. Thus the subjects were asked to estimate, for each message and the corresponding pair of nations, "how different the two countries are according to the message." The unit of measurement was again established by stipulating that "Italy and England are 100 units apart." The instructions for the items were placed on a separate page preceding the messages. Each message was placed on a separate page, with the items measuring message content at the bottom of the page.

Loading of the Theory

The theory of linear motion requires that the following quantities be estimated: s_{ij}, s'_{ij}, f_{ik}, f'_{ik}, $\tilde{s}_{ij}$, n_i and p for all concepts _i_, pairs of concepts _i_, _j_ and spacial coordinates _k_.

s_{ij} and s'_{ij}, the pretest and posttest inter-concept distances, were taken from the means (across subjects) of the direct, ratio judgments of inter-concept separations. f_{ik} and f'_{ik}, the pretest and posttest spacial coordinates, were obtained by metric multidimensional scaling analysis of the mean distance matrices S and S', with rotation of the posttest coordinate space to congruence with the pretest space. This procedure is described below (see "Program Galileo"). The $\tilde{s}_{ij}$, the inter-concept distances as proposed by messages, were assumed equal to the corresponding s_{ij}, except for the three distances intended to be manipulated by the messages. These three $\tilde{s}_{ij}$ were taken from the three items for measuring message content. The grand means of the pretest and posttest sample means were used as the most stable estimates available. The n_i were estimated by the grand means of the pretest and posttest sample means of the inertial mass items discussed above. Finally, p was assumed equal to unity for each of the six concepts directly affected by the three messages and zero for all other concepts.

Hypothesis

The hypothesis tested in this study was that the observed, posttest, mean inter-concept distances and the observed, posttest spacial coordinates would correlate highly with those predicted by theory. The preceding sections describe the design and procedures upon which a test of the hypothesis was based. The following sections describe the data analysis procedures by which the hypothesis was tested.

Data Analysis

Preparation of Data

Data were keypunched by the author directly from the (pre-coded) questionnaires. The data deck was cleaned by visual inspection of a list and by tabulation and inspection of variables having restricted "legal" values. After those procedures ten cards were selected randomly, inspected and found to be error-free.

Program GALILEO

GALILEO is a package of computer programs, developed by Woelfel and his associates, which accepts as input sets of inter-concept distance estimates, computes descriptive statistics, performs a metric multidimensional scaling analysis on aggregate inter-concept distance matrices, performs rotations to make spaces from different samples or different time periods comparable, and outputs printed statistics, printed and punched distance and coordinate matrices, and two-and three-dimensional, static and dynamic plots. The inner workings of the GALILEO package have been described in detail by Serota (1974, pp. 52-81, 87-99).

GALILEO was used in the present study in two stages. In the first stage the raw inter-concept distance data were subjected to the "Distance Means Matrices" option, which computes descriptive statistics and outputs printed and punched aggregate inter-concept distance matrices. The program allows the user to specify a "maximum value" for the inter-concept distances. Values larger than the maximum are ignored in computing the aggregate matrices.

One disadvantage of unbounded scale items is that subjects who use relatively large numbers have disproportionate influence on the aggregate results. With vary large samples this problem is negligible, but with smaller samples it can lead to serious distortions when, for example, one subject uses extraordinarily large numbers. Gillham (1972, pp. 40-42) encountered this problem and solved it by discarding the data of the deviant subject. The "maximum value" feature has been incorporated into GALILEO to facilitate the solution of similar problems.

The raw distance data were run with the Distance Means Matrices option twice: once with no maximum value and once with a maximum of 1000. Punched mean distance matrices were obtained from both runs. Only the means matrices with a maximum value of 1000 were used in subsequent runs. This involved deletion of 10 data points from the calculation of the posttest means matrix. Eight of these were from one subject and two were from a second subject. The effects of these values on the corresponding mean distances are given in Table 3. It is evident that these values would have had a greatly disproportionate influence on the results of the study.

The second stage use of GALILEO involved processing of the mean distance matrices (maximum value of 1000) by means of the "Comparison of Spaces" option. This option performed multidimensional scaling analyses on both pretest and posttest mean distance matrices, rotated the posttest coordinate system to congruence with the pretest coordinate system, output printed and punched, rotated and unrotated coordinate matrices, and prepared dynamic plots of the pretest and posttest data in a common coordinate system of both two and three dimensions.

The Comparison of Spaces option of GALILEO allows the user to incorporate assumptions about which of a set of concepts have remained

Table 3. Effect of Deletion of Extreme Values on the Posttest Mean Inter-Concept Distances.

Concept Pair	Extreme Value	Subject ID	Mean Including Extreme Value	Mean Excluding Extreme Value
Mexico-USSR	2184	08	211.406	180.095
Poland-Guyana	1084	08	178.203	163.825
China-Guyana	7000	62	277.141	170.429
Singapore-Mexico	7000	62	231.078	123.635
Singapore-Brazil	9000	62	288.812	150.540
Mexico-Fiji	5000	62	227.000	151.238
Mexico-W. Germany	4000	62	209.125	148.952
Mexico-Brazil	2000	62	117.891	88.016
Mexico-C.A.R.	4000	62	207.078	146.873
Brazil-Greece	9000	62	270.687	132.127

stable over time. The default assumption is that all concepts are stable. Thus the posttest coordinates are rotated to least squares best fit with the pretest coordinates. The main advantage of this procedure is that it is based on the simplest possible assumptions. The main disadvantage of the procedure is that it tends to distort and obscure "real" motion of concepts by minimizing that motion and distributing it among all of the concepts scaled. Alternatively the user may specify a set of concepts which may be assumed to be stable. The rotation then proceeds in such a way as to minimize the change of _those_ concepts while allowing the others to change. This procedure is described in detail by Woelfel, _et al._ (1975). Briefly, the procedure involves translation of the coordinate systems to the centroid of the specified stable concepts and rotation to the criterion of least squares best fit of those concepts with themselves. The main advantage of the stable concepts option is that it can yield more accurate description of motion by taking advantage of information about stable concepts. The main disadvantage is that it can distort and obscure real motion if the assumptions about stable concepts happen to be false. It also leaves the researcher open to the charge of question-begging.

The Comparison of Spaces option was run twice: once specifying no stable concepts (the default option), and once specifying the nine unmanipulated nations (those not mentioned in messages) as stable. The later procedure took advantage of what was known about the experimental procedures and their intended effects; while the former procedure allowed for the possibility that the experimental procedures might have had unintended effects. All further analyses were conducted in parallel fashion on the output of both options. Thus the researcher hedged his bets.

Program TESTLAW

TESTLAW is a FORTRAN IV program written by the author to perform calculations necessary to the analysis of this experiment. The program is included as Appendix B. The general functions of the program are to accept as data the output from GALILEO, to compute theoretical predictions, and to output predicted and observed inter-concept distances and concept coordinates. The output may then be subjected to further statistical analysis. Although TESTLAW was written especially for the present study, it is sufficiently general to be applicable to a range of studies testing the same or a highly similar hypothesis. By some further effort the program could have been made still more general (certainly more elegant!), but those are matters for the future.

The punched output from GALILEO--mean distance matrices and rotated coordinate matrices--may be input into TESTLAW. Additional required inputs include a run name, a set of parameters (number of concepts, number of dimensions, number of real dimensions-time one, number of real dimensions-time two), message content values and concept masses.

The punched output from TESTLAW consists of three decks. The first is a deck of Coordinate Values. This deck comprises one "case" for each coordinate value--$n \times m$ cases, where n = the number of concepts and m = the number of dimensions. Each case includes, in addition to the concept and dimension identification numbers, four variables: the pretest coordinate (f_{ik}), the posttest coordinate (f'_{ik}), the coordinate predicted by theory including inertial mass in the computation ($\hat{fm}_{ik}$), and the coordinate predicted by theory excluding inertial mass from the computation ($\hat{f}_{ik}$). $\hat{fm}_{ik}$ is computed from the theoretical equations given in Chapter I (expressions 6 and 7); while $\hat{f}_{ik}$ is computed from the same equations only excluding n_i, the concept mass, from the computation. The predictions are computed both ways in order to permit a check of the usefulness of the variable mass.

The second output deck from TESTLAW is a deck of Pairwise Distances. This deck comprises one case for each inter-concept distance--$n \times n$ cases. Each case consists of $l + 1$ cards, where $l = (m/3) + 2$, m is the number of dimensions and m/3 is rounded down to the lower whole number. The dimensions included are the first three and every third thereafter (1, 2, 3, 6, 9, . . .). Each card begins with the two concept numbers, and each of the first l cards follows those by a dimension number. The l + 1th card indicated 99 for the dimension number. Each of the first l cards includes four variables. The four variables on the kth card ($k \leq l$) have been computed based upon the first k coordinates. The variables are pretest distance (s_{ijk}), posttest distance (s'_{ijk}), distance predicted by theory including inertial mass in the computation ($\hat{s}m_{ijk}$), and distance predicted by theory excluding inertial mass from the computation ($\hat{s}_{ijk}$). Again, $\hat{s}m_{ij}$ is computed from the theoretical equations given in Chapter I (expressions 6, 7 and 8); while $\hat{s}_{ij}$ is computed from the same equations only excluding n_i from the computation. The purpose of computing l versions of the four variables is to allow the user to check whether, for example, predictions based on the first few dimensions are superior to predictions based on more dimensions which presumably include more random error. The l + 1th card includes, in addition to the two concept numbers and the number 99, three variables. These are the two concept inertial masses (n_i, n_j) and the actually observed mean posttest distance (s'_{ij}). This last variable will differ from (s'_{ijm}), the posttest distance as computed from all m coordinates, because of distortions introduced when GALILEO rotates the imaginary dimensions of the posttest coordinate system. See Danes (1975, pp. 34-37) for a discussion of this problem.

The third output deck from TESTLAW is a deck of concept variables. This deck comprises one case for each concept--n cases. Each case includes the following: the concept number, m values for "the change in concept i" (Δi_k), each computed on the basis of the first k dimensions (k = 1, m), the pretest distance of i from each manipulated concept, the change in distance of i from each manipulated concept, the pretest distance of i from each unmanipulated concept, the change in distance of i

from each unmanipulated concept, the total of the pretest distances of _i_ from all manipulated concepts, the total of the changes in distance of _i_ from all manipulated concepts, the total of the pretest distances of _i_ from all unmanipulated concepts, the total of the changes in distance of _i_ from all unmanipulated concepts, and the mass of _i_. All of the changes in distance referred to above are absolute changes.

In the present study TESTLAW was run once with each of two sets of GALILEO outputs: the set deriving from the stable concepts rotation procedure and the set deriving from the no stable concepts rotation procedure.

Statistical Analyses

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) programs (Nie, _et al._, 1975). "Statistical significance" of a result is taken to mean a probability of .05 or less, as determined by the SPSS program.

Assessment of Measurement and Procedures

Several analyses were conducted to assess the measurement and procedures of the study. These include tests of reliability and validity, and procedural and manipulation checks.

Reliability of measurement was assessed in three, distinct ways. The first involved analysis of the raw data--the data of the 64 subjects. Test-retest Pearson correlations were computed across subjects for each variable--the 105 inter-concept distances, the 15 concept masses and the three message content estimates.

The second way of assessing reliability involved analysis of aggregate data. Here the reliability of the aggregate inter-concept distances was assessed by correlating pretest with posttest means across the 105 distances. This correlation was computed in 60 different ways. First, three different versions of s'_{ij} could be used: that derived from the no stable concepts rotation procedure, that derived from the stable concepts rotation procedure, and that derived from the raw data. Second, the correlation could be computed for four important subsets of the 105 inter-concept distances: the whole set of 105, the 36 unmanipulated distances, the 69 manipulated distances and the 66 indirectly manipulated distances. Finally, for each of the two rotation procedures, s'_{ij} could be based on 1, 2, 3, 6, 9, 12, or 15 coordinates (these are the $\underline{l} = 7$ values of s'_{ijk} computed by TESTLAW for these data). Thus there were $((2 \times 7) + 1) \times 4 = 60$ possible ways of computing the reliability of the aggregate inter-concept distances. All of these were computed.

The third way of assessing reliability was to use the methods of such studies as Gillham (1972), Barnett (1974) and Danes and Woelfel (1975). This involved correlating the pretest coordinates with the post-test coordinates for each dimension of the multidimensional scale to determine the stability of each dimension. This method assesses the reliability of the structure of the multidimensional space, rather than the reliability of the individual or aggregate inter-concept distances.

All three methods of assessing reliability, of course, confounded unreliability and real change, although these could be sorted out somewhat at the individual level by comparing the reliabilities of manipulated distances to those of unmanipulated distances.

Measurement validity was assessed by two kinds of procedures. The first involved inspection of the data and judgment of face validity based on such questions as whether very "close" and "distant" countries are those that one would expect, and whether more prominent countries have larger measured masses than less prominent countries. A second kind of procedure involved comparison of the reliabilities of manipulated versus unmanipulated variables. For the reliabilities of manipulated variables to be lower than those of unmanipulated variables would be consistent with the assumption of greater real change of the manipulated variables. Taken together, these procedures could yield some, albeit imperfect indications of the validity of measurement.

The procedural assessment of the study included three checks. The first check was to determine whether the pairs of nations selected for inclusion in messages met the stated criteria of low to moderate inertial mass and moderate distance. This was determined by comparing the masses and distances to the means of those variables. The second check was whether the messages, as measured by the message content estimates, actually advocated changes in distance as intended by the experimenter. The third check was whether the experimental manipulation worked. One would expect to find that t-tests for correlated means performed on the pretest-posttest changes would be significant for the three directly manipulated distances, and for many of the 66 indirectly manipulated distances as well; while the 36 unmanipulated distances should not have changed significantly.

Hypothesis Tests

The general hypothesis test was a comparison of predicted with observed posttest inter-concept distances and concept coordinates. Such a test, however, may be conducted in many different ways, each of which contributes information from a unique point of view. Three general types of tests were employed in this study.

The first type of test involved inspection of changes in the inter-concept mean distances, and of the plotted results of the multidimensional scaling analysis, to determine whether the pattern of changes from pre-test to posttest was consistent with the hypothesis. This type of analysis, admittedly, can produce no clear decision as to the merits of the hypothesis. It can, however, at once make an overall impression and yield up a wealth of details that might help in interpreting findings derived from more structured procedures.

The second type of test was a correlation of predicted with observed posttest inter-concept distances. This correlation can be and was computed on 384 distinct bases. First, two different rotation procedures were used to make the posttest space comparable to the pretest space (see above "Program GALILEO"). Each procedure (because it involved rotation of some imaginary coordinates) yielded a unique set of "observed" post-test distances as computed from spacial coordinates. The actually observed mean posttest distances were, of course, still a third set. Thus at least three correlations might be computed, one for each set of post-test distances. Second, there is some reason to believe that the theoretical predictions may be more accurate when restricted to the first few dimensions of the space, since the higher (smaller) dimensions may contain a larger proportion of error and the imaginary dimensions may represent some sort of cognitive inconsistency. Program TESTLAW gives, in the present case, computations based on seven cumulative subsets of the dimensions: 1, 1-2, 1-3, 1-6, 1-9, 1-12, 1-15. Thus for each of the three sets of posttest distances, seven correlations may be computed, or 21 correlations in total. Third, TESTLAW gives two sets of predicted

post-message inter-concept distances, one set computed from the exact equations presented in Chapter I, and a second set computed from those same equations only excluding inertial mass from the computations. The purpose of computing both sets of predictions was to see whether the inclusion of masses affects the accuracy of prediction. Thus 42 correlations could be computed. Fourth, these 42 correlations could each be computed for four interesting subsets of the inter-concept distances. These include, in addition to the whole set of 105 distances, the 36 unmanipulated distances, the 69 manipulated distances and the 66 indirectly manipulated distances. Thus 168 correlations could be computed. Fifth, the theory predicts that the inter-concept distances will not change except insofar as they are directly or indirectly affected by the input of information. It is of great importance to separate those two components--the stability component and the change component--to determine whether the theory successfully predicts both. If the theoretical predictions are accurate only in predicting stability then the theory is useless as a description of cognitive change. Thus the stability component should be removed from the analysis. This can be done by statistically controlling the pretest distances, which in turn can be done either by computing partial correlations or by correlating predicted with observed changes in distance. Thus 504 correlations in total might be computed: the 168 correlations discussed above and their counterpart first order partials and change score correlations. Some of these correlations, however, would not be meaningful. The partials and change score correlations need not be computed for the 36 unmanipulated distances because no change is predicted for those distances. That

eliminates 84 potential correlations. Nor would it be meaningful to compute change scores consisting of the difference between pretest distances computed on the basis of less than all of the dimensions and the actually observed posttest distances, which include, as it were, all of the dimensions. The change scores so derived would simply not represent any theoretically meaningful quantity. Thus 36 more potential correlations are ruled out. Actually, then, 384 distinct versions of the correlation of predicted with observed posttest inter-concept distances were computed. These 384 correlations did not at all constitute an equal number of independent tests of the theory. Quite to the contrary, the correlations are highly interdependent. Each, however, provides a unique point of view of the data.

A similar comment could be made regarding the third set of hypothesis tests which were performed. These involved correlating predicted with observed posttest coordinate values. Here again a large number of possible variations of the test were all computed. Again the two rotation procedures yielded distinct sets of "observed" posttest coordinates. There were, however, no "actually observed" coordinates aside from those given by the rotation procedures. Nor were there any "indirectly" manipulated coordinates--one could distinguish only between the coordinates of the manipulated concepts and those of the unmanipulated concepts. Nor was it meaningful to compute correlations based on less than two dimensions when they would have as few as five degrees of freedom. Thus, in short, the coordinate values yielded a much smaller set of correlations than did the inter-concept distances. In fact 180 correlations were computed. 76 of those were zero order correlations between predicted and observed coordinates based on two rotation procedures, two predictors,

seven subsets of the dimensions, three subsets of the concepts (all concepts, the manipulated concepts and the unmanipulated concepts), and excluding eight correlations that would have had too few degrees of freedom. 52 first order partials controlling the pretest coordinates were computed. These corresponded to the zero order correlations except for the 24 based on the unmanipulated concepts. Partials in those cases would not have been meaningful. Finally, 52 correlations of predicted with observed changes in coordinates were computed. These corresponded to the partials.

CHAPTER IV

RESULTS

This chapter presents the results of the study under the general headings of Multidimensional Scaling Analysis, Assessment of Measurement and Procedures and Tests of Hypothesis.

Multidimensional Scaling Analysis

The results of the metric MDS analysis are given in Tables 19 through 24 (Appendix C) and in Figures 1 through 6.

Table 19 is the coordinate matrix for the pretest data. Table 20 is the unrotated coordinate matrix for the posttest data. Fifteen roots were extracted from each distance matrix. This result would be theoretically impossible since n points can always be represented in n-1 or fewer dimensions. In each case, however, one dimension accounted for approximately none of the variance in the distance matrix. These coordinates, as Serota points out (1974, p. 64), " . . . are artificial and represent rounding error in the computer algorithm . . . ."

Three of the 14 valid roots extracted from the pretest matrix were negative, while two of the 14 valid posttest roots were negative. The negative roots accounted for about 6.7 percent of the total pretest inter-concept distances (the total of their eigenvalues was -11,553 as compared to a trace of 161,713 for the matrix). The negative roots accounted for about 2.7 percent of the total posttest inter-concept distances (the total of their eigenvalues was -4397 as compared to a trace of 161,192 for the matrix). Similar shrinkage of the imaginary dimensions has been noted in previous studies (e.g., Taylor, Barnett and Serota, 1975).

Table 21 gives the posttest coordinates matrix rotated (so as to be comparable to the pretest space) by the no stable concepts rotation procedure. Tables 22 and 23 give the unrotated pretest and posttest coordinate matrices translated to the centroid of the nine stable (unmanipulated) concepts. Table 24, finally, gives the results of the stable concepts rotation performed on the translated posttest matrix to make it comparable to the pretest space.

An examination of the coordinate matrices indicates that the two rotation procedures give somewhat different results. The data in Table 4 make the effect of the rotation procedures much clearer still. Table 4 gives the amount of change of each concept from pretest to posttest coordinate spaces as determined from the two rotation procedures. The mean changes for the no stable concepts rotation were 65.29 for the unmanipulated concepts and 53.30 for the manipulated concepts, while the mean changes for the stable concepts rotation were 29.99 for the unmanipulated concepts and 110.37 for the manipulated concepts. Thus the ratio of the mean changes of manipulated to unmanipulated concepts was about .8 for the no stable concepts rotation (the "stable" concepts changed more!), but the ratio was about 3.7 for the stable concepts rotation.

Plots of the MDS results are given in Figures 1 through 6. In all figures the pretest and posttest locations are plotted together, connected by lines. The pretest locations are indicated by the concept identification numbers. Figures 1 through 3 are of the results of the no stable concepts rotation procedure, and Figures 4 through 6 are of the results of the stable concepts rotation procedure. Figures 1 and 4 show the first two dimensions: X (the abscissa) is the first dimension and Y (the

Table 4. Effect of Rotation Procedure Upon Distances Moved by Concepts Between Pretest and Posttest.

	Distance Moved	
Concept	No Stable Concepts	Stable Concepts
1. China	86.421	31.025
2. Singapore#	46.534	96.377
3. Mexico	57.143	25.329
4. U.S.A.	69.008	40.956
5. Portugal#	45.951	110.364
6. Poland	68.218	27.125
7. India	38.269	17.480
8. Fiji#	82.820	119.441
9. W. Germany	65.002	46.909
10. Brazil#	40.340	113.628
11. C.A.R.	43.710	17.582
12. Greece	89.591	23.494
13. U.S.S.R.	70.270	39.977
14. Congo#	49.104	103.903
15. Guyana#	55.050	118.527

#Manipulated Concept.

ordinate) is the second dimension. Figures 2 and 5 show the first and third dimensions: X (the abscissa) is the first dimension and Z (the ordinate) is the third dimension. Figures 3 and 6 are three dimensional plots: X, the first dimension, runs from left "front" to right "rear"; Y, the second dimension, is vertical; and Z, the third dimension, runs from right "front" to left "rear."

Regardless of rotation or point in time, the X and Y dimensions are readily interpretable as Economic Development and Political Ideology, respectively. The first dimension runs from U.S.A. and West Germany at the high end through moderately developed European and Latin American countries to the least developed African and Asian countries to the low end. The second dimension runs from China and U.S.S.R. at one end through various Asian and European countries to the American nations at the low end--a general, although not entirely consistent trend from most radical to most conservative countries. These two dimensions are similar to the first two dimensions found in the nonmetric MDS analysis of nations by Wish, Deutsch and Biener (1972).

The third dimension is not so readily interpretable (nor was it in the Wish, et al. study). Regional clustering, however, is evident on the X-Z plane (Figures 2 and 5), with each quadrant corresponding roughly to a continental zone. The single important exception--the location of Guyana in the "African" quadrant--is discussed below.

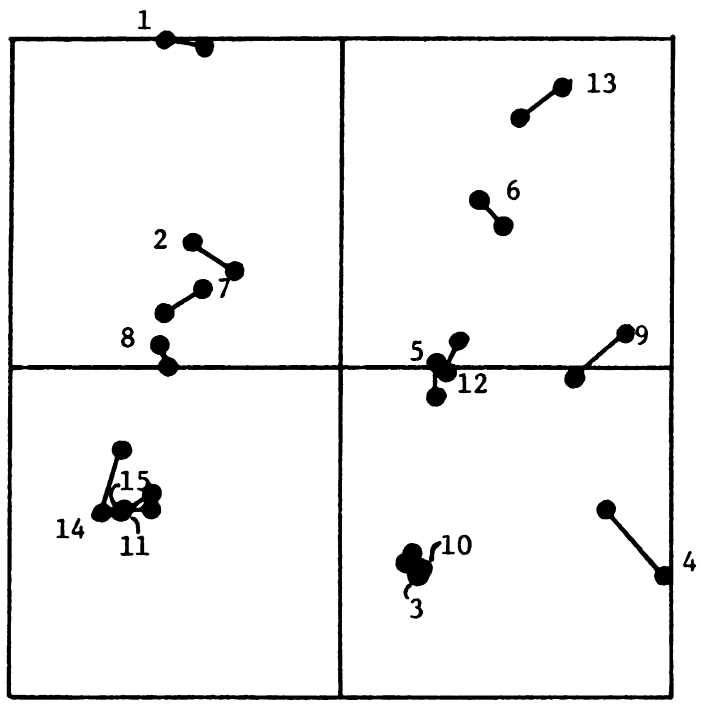

Figure 1. No Stable Concepts Rotation, X-Y Plane

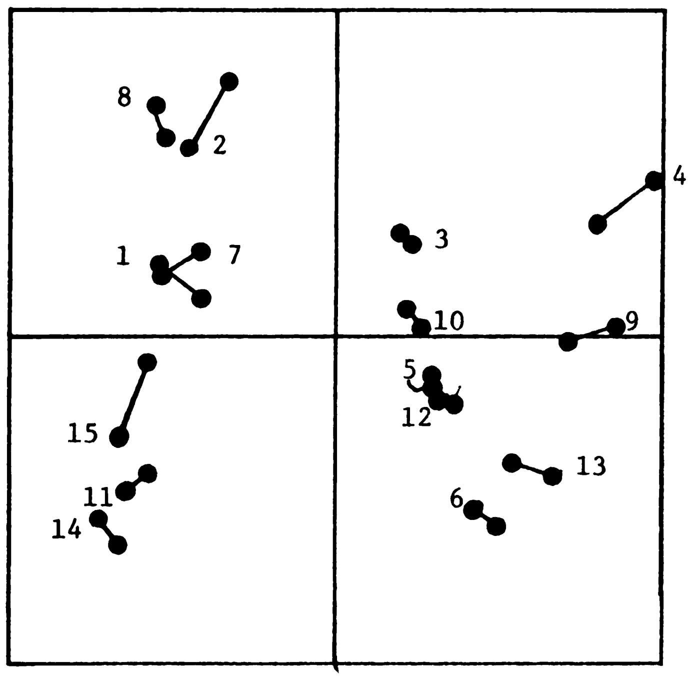

Figure 2. No Stable Concepts Rotation, X-Z Plane

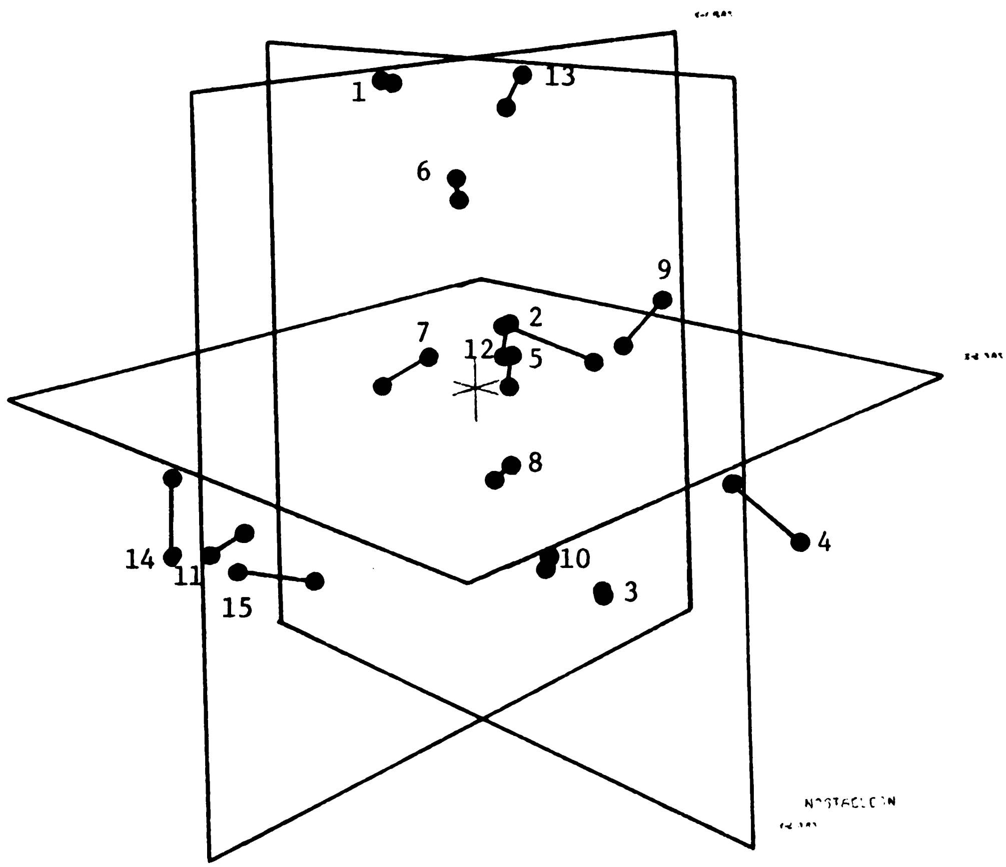

Figure 3. No Stable Concepts Rotation, First Three Dimensions

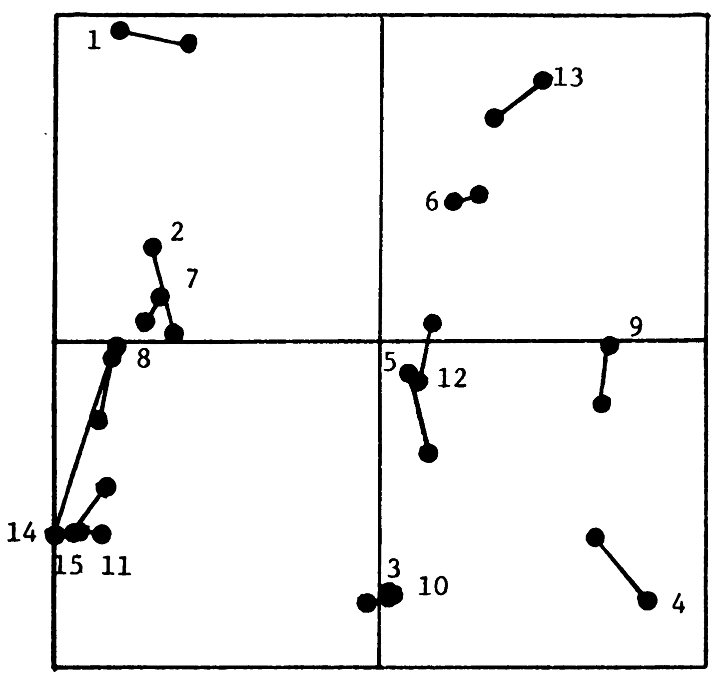

Figure 4. Stable Concepts Rotation, X-Y Plane

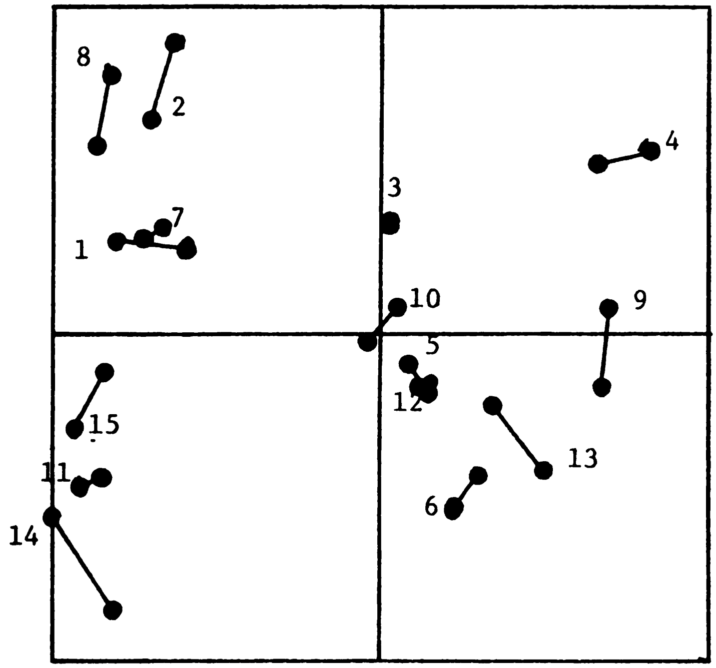

Figure 5. Stable Concepts Rotation, X-Z Plane

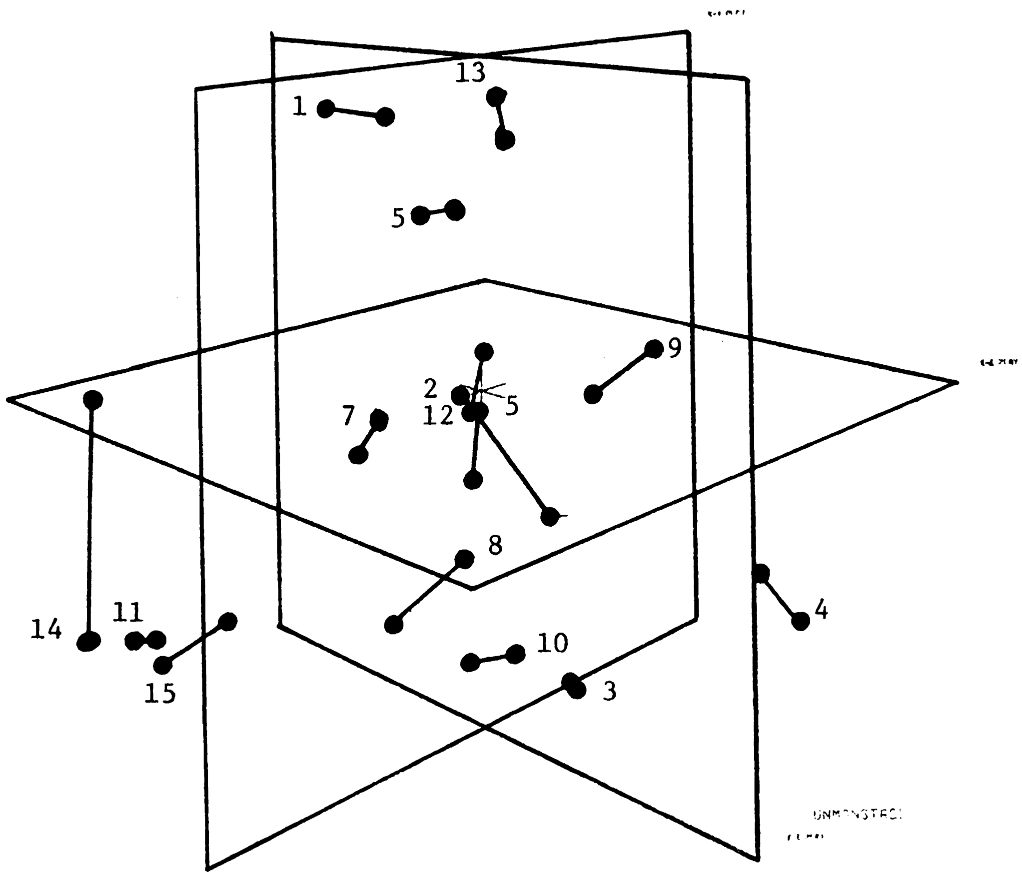

Figure 6. Stable Concepts Rotation, First Three Dimensions

Assessment of Measurement and Procedures

Reliability

Reliability was assessed in three ways, the first being test-retest comparisons of the raw (unaggregated) data. Tables 5, 6 and 7 contain the information relevant to this assessment. Table 5 gives, for the 105 inter-concept distances, the pretest and posttest means and standard deviations, the means of the pretest-to-posttest changes, the standard deviations of those changes, Pearson correlations of pretest with posttest scores, and t-tests for correlated means. Table 6 gives the same information for the 15 concept inertial mass estimates and Table 7 gives the same information for the three message content estimates.

The reliabilities of the inter-concept distances, as indicated by the Pearson correlations, were quite poor. Of the 105 correlations only 32 were statistically significant and only 7 were greater than .5. No correlation was negative. The concept mass reliabilities were higher but by no means absolutely high. Fourteen of the 15 correlations were significant; 11 were over .5; the highest was .64. The three message content estimates were quite unreliable. Only two of the three correlations were significant and none was as great as .4.

The second way of assessing reliability is by pretest-posttest comparison of the aggregate inter-concept distances--a correlation computed over the sample means. As was noted in Chapter III, we are interested in 60 different versions of this correlation. The results are given in Table 8.

Table 5. Means and Standard Deviations of Pretest Distances, Posttest Distances and Pretest-Posttest Changes in Distance; Pearson Correlations of Pretest with Posttest Distances; and *t*-tests for Correlated Means.

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
China-Singapore#	71.52 (72.31)	111.95 (84.70)	40.44 (91.66)	**.327	***3.53
China-Mexico	163.92 (131.37)	182.52 (165.32)	18.59 (195.26)	.149	.76
China-U.S.A.	232.44 (201.74)	197.20 (158.45)	-35.23 (174.70)	***.552	-1.61
China-Portugal#	154.28 (83.67)	166.27 (144.17)	11.98 (140.19)	**.337	.68
China-Poland	146.34 (101.14)	151.03 (103.13)	4.69 (104.08)	***.481	.36
China-India	112.20 (79.68)	137.58 (132.59)	25.38 (113.36)	***.524	1.79
China-Fiji#	128.95 (80.49)	156.25 (174.84)	27.30 (171.61)	*.270	1.27
China-W. Germany	183.86 (155.40)	178.38 (152.06)	-5.48 (122.24)	***.684	-.36
China-Brazil#	186.95 (176.88)	180.69 (169.48)	-6.27 (186.60)	***.420	-.27

Table 5. (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	r	t
China-C.A.R.	166.73 (149.67)	172.70 (146.38)	5.97 (178.28)	*.274	.27
China-Greece	181.41 (154.57)	164.70 (147.22)	-16.70 (167.96)	**.381	-.80
China-U.S.S.R.	109.86 (105.10)	126.83 (107.68)	16.97 (71.88)	***.772	1.89
China-Congo#	172.17 (163.23)	167.86 (146.03)	-4.31 (182.21)	*.310	-.19
Singapore#-Mexico	146.87 (130.73)	123.63 (67.48)	-23.24 (141.76)	.088	-1.30
Singapore#-U.S.A.	174.45 (151.79)	155.27 (99.99)	-19.19 (169.50)	.142	-.91
Singapore#-Portugal#	139.69 (78.52)	146.19 (127.72)	6.50 (135.40)	.207	.38
Singapore#-Poland	156.98 (81.37)	176.97 (159.72)	19.98 (167.65)	.155	.95
Singapore#-India	117.89 (72.67)	129.34 (71.45)	11.45 (120.13)	***.458	1.22
Singapore#-Fiji#	102.02 (55.67)	95.63 (108.06)	-6.39 (157.94)	.029	-.43

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
Singapore#-W. Germany	166.38 (110.02)	159.05 (146.93)	-7.33 (157.94)	.271	-.37
Singapore#-Brazil#	159.92 (136.16)	150.54 (133.82)	-9.38 (183.18)	.079	-.41
Singapore#-C.A.R.	153.55 (118.20)	165.55 (149.98)	12.00 (164.59)	*.264	.58
Singapore#-Greece	147.53 (89.74)	161.03 (131.55)	13.50 (143.28)	.205	.75
Singapore#-U.S.S.R.	168.11 (153.01)	159.42 (92.15)	-8.69 (147.55)	**.359	-.47
Singapore#-Congo#	151.20 (117.83)	169.05 (161.72)	17.84 (182.42)	.177	.78
Singapore#-Guyana#	139.14 (106.56)	152.47 (144.10)	13.33 (167.37)	.134	.64
Mexico-U.S.A.	95.48 (59.09)	108.78 (83.84)	13.30 (74.08)	***.508	1.44
Mexico-Portugal#	108.78 (126.19)	111.17 (114.35)	2.39 (156.10)	.160	.12

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	r	t
Mexico-Poland	159.06 (129.71)	153.84 (133.56)	-5.22 (178.19)	.084	-.23
Mexico-India	155.14 (133.93)	158.13 (131.65)	2.98 (174.14)	.140	.14
Mexico-Fiji#	157.67 (146.06)	151.24 (134.60)	-6.43 (181.78)	.163	-.28
Mexico-W. Germany	149.27 (134.90)	148.95 (128.12)	-.32 (184.10)	.021	-.01
Mexico-Brazil#	71.78 (45.97)	88.02 (47.96)	16.24 (59.40)	.201	*2.17
Mexico-C.A.R.	144.48 (138.65)	146.87 (129.26)	2.40 (174.59)	.152	.11
Mexico-Greece	132.89 (127.88)	145.13 (123.59)	12.23 (172.85)	.055	.57
Mexico-U.S.S.R.	181.90 (135.84)	180.10 (158.10)	-1.81 (204.39)	.039	-.07
Mexico-Congo#	148.98 (133.90)	165.08 (151.37)	16.09 (196.99)	.050	.65
Mexico-Guyana#	141.84 (128.70)	146.72 (132.69)	4.88 (183.64)	.013	.21

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	r	t
U.S.A.-Portugal#	160.00 (105.42)	157.42 (141.20)	-2.58 (161.83)	.163	-.13
U.S.A.-Poland	180.78 (141.94)	153.94 (120.31)	-26.84 (174.90)	.118	-1.23
U.S.A.-India	185.94 (154.55)	176.19 (125.89)	-9.75 (160.79)	**.357	-.49
U.S.A.-Fiji#	188.27 (171.45)	169.42 (152.60)	-18.84 (205.75)	.198	-.73
U.S.A.-W. Germany	101.31 (133.28)	100.72 (77.19)	-.59 (130.98)	**.319	-.04
U.S.A.-Brazil#	129.83 (94.78)	123.38 (70.32)	-6.45 (106.67)	.191	-.48
U.S.A.-C.A.R.	192.11 (158.65)	180.95 (167.57)	-11.16 (220.42)	.088	-.40
U.S.A.-Greece	160.47 (143.22)	151.97 (107.50)	-8.50 (143.47)	**.373	-.47
U.S.A.-U.S.S.R.	162.67 (152.84)	138.11 (89.45)	-24.56 (133.31)	***.497	-1.47
U.S.A.-Congo#	206.97 (170.22)	196.66 (172.43)	-10.31 (195.18)	**.351	-.42

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
U.S.A.-Guyana#	189.38 (161.40)	161.73 (140.04)	-27.64 (194.83)	.170	-1.13
Portugal#-Poland	103.13 (58.91)	122.41 (76.81)	19.28 (78.39)	**.356	1.97
Portugal#-India	142.42 (92.66)	150.17 (125.03)	7.75 (139.39)	.207	.44
Portugal#-Fiji#	148.73 (111.87)	147.55 (129.02)	-1.19 (155.81)	.169	-.06
Portugal#-W. Germany	124.66 (72.76)	119.48 (69.44)	-5.17 (81.61)	.342	-.51
Portugal#-Brazil#	105.78 (127.96)	76.17 (44.25)	-29.61 (131.33)	.096	-1.80
Portugal#-C.A.R.	152.88 (150.40)	137.59 (126.79)	-15.28 (184.75)	.120	-.66
Portugal#-Greece	105.72 (67.55)	105.48 (39.65)	-.23 (71.63)	.187	-.03
Portugal#-U.S.S.R.	134.52 (91.58)	135.64 (93.94)	1.13 (116.45)	.212	.08
Portugal#-Congo#	158.58 (128.08)	162.56 (144.58)	3.98 (173.11)	.198	.18

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
Portugal#-Guyana#	141.83 (88.30)	161.63 (154.91)	19.80 (171.83)	.083	.92
Poland-India	164.09 (105.10)	174.67 (149.90)	10.58 (168.65)	.161	.50
Poland-Fiji#	163.64 (132.48)	176.50 (157.02)	12.86 (193.10)	.118	.53
Poland-W. Germany	104.52 (68.20)	117.34 (66.98)	12.83 (85.44)	.201	1.20
Poland-Brazil#	148.00 (124.90)	157.20 (129.50)	9.20 (176.60)	.037	.42
Poland-C.A.R.	174.52 (130.12)	178.66 (152.43)	4.14 (188.72)	.115	.18
Poland-Greece	117.67 (73.43)	120.33 (90.94)	2.66 (112.98)	.067	.19
Poland-U.S.S.R.	74.95 (53.93)	90.02 (55.67)	15.06 (51.36)	***.561	*2.35
Poland-Congo#	161.50 (136.98)	160.16 (132.46)	-1.34 (175.93)	.148	-.06
Poland-Guyana#	152.21 (93.25)	163.83 (129.91)	11.62 (134.25)	*.312	.69

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
India-Fiji#	125.06 (76.38)	122.47 (60.98)	-2.59 (92.62)	.105	-.22
India-W. Germany	157.78 (115.69)	169.31 (133.46)	11.53 (165.12)	.127	.56
India-Brazil#	150.80 (129.94)	153.05 (131.18)	2.25 (175.57)	.096	.10
India-C.A.R.	143.95 (123.46)	146.88 (112.32)	2.92 (157.50)	.110	.15
India-Greece	133.42 (72.59)	136.75 (73.26)	3.33 (70.48)	***.533	.38
India-U.S.S.R.	165.72 (139.71)	154.23 (107.07)	-11.48 (152.96)	*.254	-.60
India-Congo#	132.95 (82.46)	133.52 (82.68)	.56 (95.13)	**.336	.05
India-Guyana#	145.44 (133.97)	127.27 (75.17)	-18.17 (128.85)	**.347	-1.13
Fiji#-W. Germany	174.08 (152.71)	160.19 (134.84)	-13.89 (184.75)	.179	-.60
Fiji#-Brazil#	156.73 (143.88)	145.09 (124.10)	-11.64 (187.02)	.032	-.50

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
Fiji#-C.A.R.	146.19 (134.73)	153.30 (135.28)	7.11 (185.25)	.059	.31
Fiji#-Greece	156.33 (102.07)	164.27 (139.12)	7.94 (153.78)	.216	.41
Fiji#-U.S.S.R.	208.28 (164.60)	185.02 (155.59)	-23.27 (180.16)	**.368	-1.03
Fiji#-Congo#	166.64 (153.61)	165.02 (161.69)	-1.63 (187.34)	*.295	-.07
Fiji#-Guyana#	143.45 (147.07)	124.77 (81.43)	-18.69 (161.93)	.085	-.92
W. Germany-Brazil#	145.58 (130.72)	140.20 (122.84)	-5.38 (173.54)	.064	-.25
W. Germany-C.A.R.	187.63 (149.86)	166.52 (135.45)	-21.11 (176.98)	.234	-.95
W. Germany-Greece	130.64 (100.98)	127.38 (102.82)	-3.27 (137.43)	.091	-.19
W. Germany-U.S.S.R.	124.45 (87.93)	134.84 (117.22)	10.39 (126.58)	*.264	.66
W. Germany-Congo#	186.11 (163.75)	175.48 (134.71)	-10.63 (191.74)	.186	-.44

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	r	t
W. Germany-Guyana#	181.66 (158.58)	166.80 (147.21)	-14.86 (206.05)	.093	-.58
Brazil#-C.A.R.	137.16 (134.23)	156.19 (150.27)	19.03 (199.31)	.022	.76
Brazil#-Greece	139.84 (132.91)	132.13 (72.41)	-7.71 (137.24)	.212	-.45
Brazil#-U.S.S.R.	169.73 (135.98)	162.52 (139.27)	-7.22 (185.51)	.092	-.31
Brazil#-Congo#	144.89 (139.79)	151.16 (145.44)	6.27 (191.81)	.096	.26
Brazil#-Guyana#	147.78 (143.68)	136.08 (134.26)	-11.70 (190.88)	.058	-.49
C.A.R.-Greece	151.94 (97.10)	170.48 (166.87)	18.55 (177.53)	.178	.84
C.A.R.-U.S.S.R.	173.66 (147.83)	178.61 (157.93)	4.95 (198.23)	.161	.20
C.A.R.-Congo#	76.34 (71.89)	116.89 (143.40)	40.55 (150.67)	.147	*2.15
C.A.R.-Guyana#	84.28 (64.79)	132.73 (156.74)	48.45 (164.08)	.091	*2.36

Table 5 (continued)

Pair of Nations	S_{ij} Mean (S.D.)	S'_{ij} Mean (S.D.)	$(S'_{ij}-S_{ij})$ Mean (S.D.)	*r*	*t*
Greece-U.S.S.R.	139.66 (129.89)	133.53 (69.98)	-6.13 (135.84)	.182	-.36
Greece-Congo#	157.95 (109.25)	153.27 (97.78)	-4.69 (128.11)	.238	-.29
Greece-Guyana#	162.33 (108.48)	166.72 (148.09)	4.39 (173.25)	.115	.20
U.S.S.R.-Congo#	200.84 (187.95)	177.56 (164.29)	-23.28 (240.66)	.071	-.77
U.S.S.R.-Guyana#	203.34 (186.76)	188.92 (184.45)	-14.42 (251.84)	.079	-.46
Congo#-Guyana#	99.23 (131.37)	140.55 (135.30)	41.31 (177.28)	.116	1.86

#Manipulated Concept
* $p<.05$, two-tailed test, d.f.=63
** $p<.01$, two-tailed test, d.f.=63
*** $p<.001$, two-tailed test, d.f.=63

Table 6. Means and Standard Deviations of Pretest Masses, Posttest Masses and Pretest-Posttest Changes in Mass; Pearson Correlations of Pretest with Posttest Mass; and *t*-tests for Correlated Means.

Nation	n_i Mean (S.D.)	n'_i Mean (S.D.)	$(n'_i - n_i)$ Mean (S.D.)	*r*	*t*
China	94.39	108.75	14.36		
	(66.54)	(42.54)	(58.44)	***.498	1.97
Singapore#	64.17	77.97	13.80		
	(117.82)	(53.57)	(126.71)	.055	.87
Mexico	96.95	115.31	18.36		
	(39.48)	(48.25)	(43.86)	***.515	***3.35
U.S.A.	198.52	225.86	27.34		
	(193.88)	(211.28)	(184.65)	***.588	1.18
Portugal#	63.20	87.91	24.70		
	(40.11)	(42.59)	(40.11)	***.531	***4.93
Poland	59.19	80.41	21.22		
	(38.06)	(49.54)	(40.51)	***.600	***4.19
India	91.70	91.27	-.44		
	(104.48)	(45.15)	(85.91)	***.591	-.04
Fiji#	44.53	62.50	17.97		
	(38.34)	(40.54)	(41.94)	***.436	***3.43
W. Germany	86.34	102.42	16.08		
	(39.60)	(48.67)	(45.74)	***.478	**2.81
Brazil#	74.31	92.34	18.03		
	(42.43)	(45.43)	(43.67)	***.508	**3.30
C.A.R.	46.80	58.75	11.95		
	(43.14)	(37.09)	(38.26)	***.554	*2.50
Greece	71.13	92.27	21.14		
	(39.14)	(60.70)	(48.35)	***.606	***3.50
U.S.S.R.	101.17	112.77	11.59		
	(48.24)	(51.31)	(49.02)	***.516	1.89

Table 6. (continued)

Nation	n_i Mean (S.D.)	n'_i Mean (S.D.)	$(n'_i - n_i)$ Mean (S.D.)	*r*	*t*
Congo#	61.78 (45.56)	80.50 (63.69)	18.72 (48.90)	***.645	**3.06
Guyana#	35.09 (40.44)	67.34 (56.27)	32.25 (43.65)	***.636	***5.91

\# Manipulated Concept
* p<.05, two-tailed test, d.f.=63
** p<.01, two-tailed test, d.f.=63
*** p<.001, two-tailed test, d.f.=63

Table 7. Means and Standard Deviations of Pretest Message Content Estimates, Posttest Message Content Estimates, and Pretest-Posttest Changes in Message Content Estimates; Pearson Correlations of Pretest with Posttest Message Values; and *t*-tests for Correlated Means.

Message	$\tilde{S}_{ij}$ Mean (S.D.)	$\tilde{S}'_{ij}$ Mean (S.D.)	$\tilde{S}'_{ij} - \tilde{S}_{ij}$ Mean (S.D.)	*r*	*t*
Singapore-Fiji	45.66 (42.58)	43.42 (41.53)	-2.23 (49.14)	*.318	-.36
Congo-Guyana	165.31 (95.94)	169.92 (143.56)	4.61 (138.95)	**.381	.27
Portugal-Brazil	57.86 (52.81)	70.39 (129.82)	12.53 (133.56)	.132	.75

* p<.05, two-tailed test, d.f.=63
** p<.01, two-tailed test, d.f.=63

Table 8. Pearson Correlations* of Mean Pretest Inter-concept Distances (S_{ij}) with Mean Posttest Inter-concept Distances (S'_{ij}).

Method of Deriving S'_{ij}	Dimensions Included in Calculations	All Distances (N=105)	Unmanipulated Distances Only (N=36)	Manipulated Distances Only (N=69)	Indirectly Changed Distances Only (N=66)
No Stable Concepts Rotation	1	.964	.949	.973	.972
	1-2	.954	.933	.964	.963
	1-3	.921	.918	.925	.919
	1-6	.877	.880	.891	.875
	1-9	.837	.845	.842	.836
	1-12	.863	.887	.858	.860
	1-15	.835	.862	.823	.825
Stable Concepts Rotation	1	.973	.968	.976	.975
	1-2	.903	.945	.880	.876
	1-3	.918	.955	.904	.905
	1-6	.838	.922	.808	.788
	1-9	.811	.912	.779	.770
	1-12	.824	.901	.800	.795
	1-15	.804	.929	.759	.752
Observed S'_{ij}	--	.865	.914	.835	.848

* All correlations are significant ($p<.001$, one-tailed test).

All of the correlation coefficients were positive and statistically significant (they were, of course, highly interdependent); and the correlations were, in absolute terms, quite within the range of reliability usually considered acceptable. No computation yielded a correlation below .75; 27 of the 60 correlations were greater than .9 and 54 were greater than .8.

The correlations tended to decline as more dimensions were included in the analysis, a result which indicates that measurement errors were concentrated in the smaller, "residual" dimensions.

The effect of rotation procedures on the results is also evident in Table 8. For the no stable concepts rotation there was no noticable difference between the reliabilities of unmanipulated and manipulated distances. For the stable concepts rotation, however, the unmanipulated distances were consistently more reliable--an intended outcome of the rotation procedure. Particularly important are the coefficients for the directly observed posttest distances, for these were undistorted by rotation of the coordinate system. Here the reliability of unmanipulated distances was .914 while that of the manipulated distances was .835. Thus the stable concepts rotation gives results more in line with those of the actually observed distances than does the no stable concepts rotation.

The third way of assessing reliability is by examination of the stability of the coordinate system. This is done by correlating the pretest coordinates with the posttest coordinates for each dimension. These correlations are given in Table 9.

Although complete correlation matrices were computed, only the correlation of each dimension with itself over time is given in the table. In principle all other correlations should have equalled either unity or zero. The correlation of each coordinate with itself within a given time period is necessarily perfect. The correlation of each coordinate with each other coordinate in the same time period should be null as a consequence of the orthogonality of the MDS solution. This was true for the pretest coordinates. Slight correlations were observed among the posttest coordinates and among non-corresponding pretest and posttest coordinates, however. The correlations among the posttest coordinates presumably resulted from rounding errors during rotation, while those among non-corresponding pretest and posttest coordinates presumably resulted both from rounding errors and from change in the coordinates over time. With a few, isolated exceptions, these correlations were less than .1--too low to be of any concern.

Turning now to the correlations in Table 9, one can conclude, in general, that all but the smallest dimensions were quite stable. The outstanding exception was the fourth coordinate for the no stable concepts rotation, whose correlation was essentially zero. The correlations for the first three dimensions compare favorably with those reported in previous studies (Cf. Gillham, 1972; Barnett, n.d.; Danes and Woelfel, 1975).

Validity

Validity of measurement was assessed in two ways. The first method was to observe the pattern of t-tests for correlated means computed on the raw (unaggregated) data (see Tables 5, 6 and 7).

Table 9. Pretest-Posttest Pearson Correlations of MDS Coordinates.

Dimension	No Stable Concepts Rotation	Stable Concepts Rotation
1	***.987	***.990
2	***.978	***.925
3	***.946	***.942
4	-.070	**.697
5	***.944	**.619
6	***.951	*.469
7	**.631	*.541
8	*.554	.101
9	***.745	**.699
10	***.790	.327
11	.406	*.445
12	-.011	.263
13	**.638	***.786
14	**.597	*.524
15	***.895	***.777

* $p<.05$, two-tailed test, d.f. = 14
** $p<.01$, two-tailed test, d.f. = 14
*** $p<.01$, two-tailed test, d.f. = 14

Only five of the changes in the 105 inter-concept distances were significantly different from zero. Of the five significant changes, four were manipulated distances. The fact that only one change occurred among the unmanipulated distances is consistent with the assumptions of the experiment, but the fact that only four of the 69 manipulated distances changed is not. The very high variances of the changes seem to preclude statistically significant t-ratios in most cases.

There was a general tendency for the concept mass estimates to increase from pretest to posttest--10 of the 15 underwent statistically significant changes, all positive. 5 of the 10 significant changes were of those among the 6 manipulated concepts. That is consistent with the fact that information (mass) about the manipulated concepts was given in the experiment. None of the changed masses had a pretest value greater than 90; while only one concept with a pretest mass of less than 90 (Singapore--a manipulated concept) failed to change. This is generally (except for the failure of Singapore to change) consistent with the concept of inertial mass: lower masses should be more susceptable to change by the addition of information over a short period of time. The general increase in masses is also consistent with the idea of mass, which is supposed to accumulate. In the present case, however, it may be as reasonable to attribute the changes to some undetermined feature of the experimental situation.

None of the three message content estimates changed significantly, nor was there any recognizable pattern in the observed changes. This is as expected if message content is a stable quantity.

The second way of assessing validity was to observe the pattern of means to determine whether the aggregate measurements correspond with what one would expect intuitively, based on general knowledge.

The inter-concept distances are most conveniently examined in the form of plots of the multidimensional scaling results (Figures 1 through 6). Figures 1 through 3 are plots of the results of the no stable concepts rotation procedure, and Figures 4 through 6 are plots of the results of the stable concepts rotation procedure. Examination of the plots, or of the data in Table 5, confirms that the observed distances are generally reasonable. One apparent exception is the greater closeness of Guyana to the African nations of Congo and Central African Republic than to the Latin American nations of Mexico and Brazil. That apparent misplacement, however, is consistent with what the author has informally observed: that uninformed people frequently assume that Guyana is in Africa because its name "sounds" African (four students informally interviewed prior to the study all located Guyana in Africa). Among the largest distances at both pretest and posttest measurements were those of China-U.S.A., Congo-U.S.A., Fiji-U.S.S.R., Congo-U.S.S.R. and Guyana-U.S.S.R. None of these would be expected to be a small distance. Among the smallest distances at both times are Mexico-Brazil, Poland-U.S.S.R. and U.S.A.-West Germany. These, too, are reasonable. Another indication of the validity of the measurements of inter-concept distances is the overall similarity of the present results to those obtained by Wish, Deutsch and Biener (1972) in another study of nations.

Turning now to the inertial mass data, the question is whether the means appear to correspond in general to the prominence of the

nations. The four greatest masses at both points in time are those of U.S.A., Mexico, U.S.S.R. and China; while smallest masses are those of Fiji, Central African Republic and Guyana. The higher mass countries are all ones about which Americans would be expected to know something because of their physical proximity or international importance; while the lower mass countries seem relatively unimportant or at least unpublicized.

Finally the three message content estimates indicate, as expected, that the message arguing that Congo and Guyana are "very different" was thought to place those countries at greater distance than average, and at about three times the distances at which Singapore-Fiji and Portugal-Brazil were placed by their messages.

Procedures

Three checks were made of the experimental procedures. The first was whether the manipulated concepts were, as intended, of low to moderate mass and at moderate distances from each other within the manipulated pairs.

The mean mass of all concepts at both points in time was 88.2 and the standard deviation 39.0. The mean of the six manipulated concept masses was 67.6. The highest mean mass among the manipulated concepts was Brazil's 83.3. Thus the six manipulated concepts were of low to moderate inertial mass.

The grand mean of the 105 pretest inter-concept distances was 148.9 and the standard deviation 30.8. The grand posttest mean was 149.8 and the standard deviation 24.3. The pretest distances of the three manipulated pairs were: 102.0 (Singapore-Fiji), 105.8 (Portugal-Brazil),

and 99.2 (Congo-Guyana). Thus the three manipulated mean distances were all quite similar, but were all nearly two standard deviations below the grand mean. A regression artifact would tend to increase these distances. Two of the three experimental messages, however, argued for a decrease in distance.

A second precedural check was whether the messages, as measured by the message content estimates, actually advocated the intended changes in distance. Comparing the means in Table 7 to the corresponding pretest means in Table 5, it is evident that the messages did advocate the intended changes. The first message argued (45.7) that Singapore and Fiji (102.0) are similar. The second message argued (165.3) that Congo and Guyana (99.2) are different. The third message argued (57.9) that Brazil and Portugal (105.8) are similar.

The third procedural check was whether the experimental messages had the intended direct effects--whether, that is, the three manipulated distances actually changed in the intended directions. All three of the observed mean changes (as given in Table 5) were in the advocated directions. The distance of Singapore from Fiji changed from 102.0 to 95.6 for a decrease of -6.39. The distance of Congo from Guyana changed from 99.2 to 140.5 for an increase of 41.3. The distance of Portugal from Brazil changed from 105.8 to 76.2 for a decrease of 29.6. None of these changes was statistically significant, although the latter two approached significance ($p<.08$ for Portugal-Brazil; $p<.07$ for Congo-Guyana). At the individual level of analysis, then, the manipulations cannot be claimed to have succeeded. At the aggregate level it is perhaps of more importance that the mean of the three manipulated absolute changes was 25.8 as compared to a mean absolute change of 12.2 for all 105 inter-concept distances.

Hypothesis Tests

The main hypothesis of the study was tested by three sets of procedures. First, the mean changes were directly examined. Second, the correlations of predicted with observed inter-concept distances were examined. Third, the correlations of predicted with observed coordinates were examined.

Test One: Mean Changes

The questions to be answered by a direct examination of the mean distances are whether the three kinds of changes (direct, indirect and no change) occurred as predicted and whether the overall pattern of changes (as visible in the plots of the MDS analysis) is interpretable in a way consistent with the hypothesis.

The mean of the absolute changes of the three directly changed distances was 25.8. The mean of the absolute changes of the 66 indirectly changed distances was 12.3. The mean of the absolute changes of the 36 no change distances was 10.8. This pattern is consistent with the hypothesis.

Turn now to the plots and coordinate matrices of the MDS analysis. Examine the motions of the manipulated concepts pair by pair, considering all views and rotations. While the net change in each case was as predicted, the motion was not, as assumed by the theory, directly along the lines connecting the pairs. The slight net convergence of Singapore and Fiji resulted mostly from changes along dimensions not plotted. The two countries actually diverged on the first and third dimensions (in the latter case bypassing one another) and converged on the second dimension only because of Singapore's greater velocity: Fiji moved in the direction opposite to that predicted. Again, Congo and Guyana's net divergence

resulted from movements at large angles to the directions predicted. Regardless of rotation procedure one of the most prominent changes was Congo's movement, contrary to prediction, along the second dimension. The divergence of the two nations on the third dimension was about as expected, but their lock-step motion on the first dimension was quite opposite to that predicted. Finally, Portugal and Brazil's net convergence occurred despite Brazil's movements opposite to predictions on the first and third dimensions and Portugal's opposite movement on the first and second dimensions. Net convergence on the second and third dimensions occurred only because the country moving in the "right" direction tended to overtake the other country.

There are evident in the plots other changes that are not interpretable in terms of the hypothesis. Even in Rotation #2, which was designed to minimize their change, several unmanipulated nations exhibited apparently substantial movements. One noticeable tendency was for the more extreme countries to move inwards in the general direction of the origin--a pattern suggestive of the phenomonon of regression toward the mean. The specific observed changes are not interpretable in terms of facts known to the investigator.

Test Two: Inter-concept Distances

The second hypothesis test was by means of a correlation between predicted and observed inter-concept distances. As discussed in Chapter III, the study provided many distinct bases upon which such a correlation may be computed. The results are presented in Tables 10 through 13.

In Table 10 are the zero order Pearson correlations between the posttest inter-concept distances (s'_{ij}) and those predicted by the theory,

either including concept masses in the computations ($\hat{s}m_{ij}$) or excluding concept masses from the computations ($\hat{s}_{ij}$). All of the correlations (which, of course, were highly interdependent) were statistically highly significant. Most were greater than .8. Several general patterns in these correlations may be noted. First, there was a tendency for the correlations for the "computed" posttest distances to increase in magnitude as less dimensions were included in the computations. This would be expected since the larger (lower) dimensions are more stable. The correlations for the actually observed posttest distances, however, fit an opposite pattern, yielding higher correlations for predictions based on more dimensions. This also would be expected, however, since the predictions based on only a few dimensions are not truly comparable to the actually observed posttest distances, which are, as it were, based on all dimensions. Second, different patterns resulted from the different rotation procedures. The stable concepts rotation displayed a pattern, for all but computations based on only the first dimension, of higher correlations for unmanipulated distances than for manipulated distances. The no stable concepts rotation produced no such pattern. The pattern of correlations for the actually observed posttest distances was more similar to the stable concepts than to the no stable concepts rotation --a fact which may suggest the greater validity of the stable concepts procedure. Finally, there was no clear pattern of differences between correlations involving predictions taking account or not taking account of the concept masses. Thus inertial mass, as measured in the present study, did not clearly contribute to the theory's predictive power.

Table 10. Pearson Correlations* of S'_{ij} with $\hat{S}m_{ij}$ and $\hat{S}_{ij}$, Broken Down by Number of Dimensions Included in Computations, by Method of Obtaining S'_{ij}, and by Subsets of Cases.

Distances Included in the Analysis	Dimensions Included in Computations	Predictor A=$\hat{S}m_{ij}$ B=$\hat{S}_{ij}$	S'_{ij} Comp. From No Stable Concepts Rotation	S'_{ij} Comp. From Stable Concepts Rotation	Actually Observed S'_{ij}
All (N=105)	1-15	A	.836	.804	.866
		B	.858	.815	.885
	1-12	A	.864	.825	.867
		B	.878	.831	.885
	1-9	A	.838	.812	.866
		B	.854	.822	.882
	1-6	A	.888	.838	.841
		B	.883	.838	.858
	1-3	A	.921	.917	.821
		B	.922	.922	.828
	1-2	A	.954	.903	.757
		B	.953	.904	.763
	1	A	.964	.973	.619
		B	.964	.973	.619
Unmanipulated Distances Only (N=36)	1-15	A	.862	.929	.914
		B	.862	.929	.914
	1-12	A	.887	.901	.889
		B	.887	.901	.889
	1-9	A	.845	.912	.881
		B	.845	.912	.881
	1-6	A	.878	.922	.857
		B	.878	.922	.857
	1-3	A	.918	.955	.806
		B	.918	.955	.806
	1-2	A	.933	.945	.814
		B	.933	.945	.814
	1	A	.949	.968	.594
		B	.949	.968	.594

Table 10. (continued)

Distances Included in the Analysis	Dimensions Included in Computations	Predictor $A=\hat{S}m_{ij}$ $B=\hat{S}_{ij}$	S'_{ij} Comp. From No Stable Concepts Rotation	S'_{ij} Comp. From Stable Concepts Rotation	Actually Observed S'_{ij}
All Manipulated Distances (N=69)	1-15	A	.824	.759	.836
		B	.862	.773	.867
	1-12	A	.859	.801	.858
		B	.885	.810	.887
	1-9	A	.843	.780	.864
		B	.870	.796	.890
	1-6	A	.891	.808	.847
		B	.898	.807	.872
	1-3	A	.925	.904	.831
		B	.928	.912	.843
	1-2	A	.964	.880	.736
		B	.963	.881	.746
	1	A	.973	.976	.631
		B	.973	.975	.631
Indirectly Changed Distances (N=66)	1-15	A	.826	.752	.849
		B	.837	.747	.851
	1-12	A	.860	.795	.870
		B	.861	.788	.869
	1-9	A	.836	.770	.874
		B	.844	.768	.873
	1-6	A	.876	.788	.855
		B	.877	.785	.860
	1-3	A	.919	.905	.856
		B	.919	.910	.856
	1-2	A	.963	.876	.765
		B	.960	.876	.762
	1	A	.972	.975	.616
		B	.972	.975	.616

* All correlations in this table are significant, $p<.001$, one-tailed test.

In Table 11 are the first order partial correlations controlling for the pretest interconcept distances (s_{ij}). These correlations were substantially lower than the zero order correlations, demonstrating that much of the accuracy of prediction displayed in Table 10 was due simply to the stability over time of the aggregate cognitive space, a stability rightly assumed by the theory. Three additional facts about this table are worth noting. First, several of the partials were large enough to be statistically significant (the meaning of this, however, is complicated by the interdependence of the correlations). Second, the correlations were lowest when restricted to the 66 indirect changes, although a few (including, however, none of those for the actually observed posttest distances) were still large enough to be significant. Third, negative partials were observed for correlations based on the first dimension only, and those correlations are among the largest in the table in absolute magnitude. The negative correlations are clearly contrary to the theory.

In Tables 12 and 13 are the zero order correlations of predicted with observed changes in distance. The use of change scores is a second way of controlling for the pretest distances. The pattern of these correlations was much like that of the partial correlations: they were substantially lower than the correlations in Table 9; many of them were large enough to be statistically significant; the correlations for the indirect changes were substantially smaller than those for all manipulated distances; and negative correlations were observed for computations based on the first dimension only.

Overall the correlations between predicted and observed interconcept distances were not strongly supportive of the theory.

Table 11. First Order Partial Correlations (Controlling S_{ij}) of S'_{ij} with $\hat{S}m_{ij}$ and $\hat{S}_{ij}$, Broken Down by Number of Dimensions Included in Computations, by Method of Obtaining S'_{ij}, and by Subsets of Cases.

Distances Included in the Analysis	Dimensions Included in Computations	Predictor A=$\hat{S}m_{ij}$ B=$\hat{S}_{ij}$	S'_{ij} Comp. From No Stable Concepts Rotation	S'_{ij} Comp. From Stable Concepts Rotation	Actually Observed S'_{ij}
All (N=105)	1-15	A	*** .346	* .209	*** .336
		B	*** .358	** .230	*** .370
	1-12	A	*** .317	* .212	*** .331
		B	*** .330	* .225	*** .360
	1-9	A	** .294	** .228	*** .315
		B	*** .311	** .237	*** .341
	1-6	A	* .186	.057	*** .334
		B	* .200	.091	*** .356
	1-3	A	.142	** .280	** .275
		B	.137	** .260	** .256
	1-2	A	.017	.078	* .194
		B	.051	.120	* .180
	1	A	-.120	***-.346	.060
		B	-.144	***-.317	.032
All Manipulated Distances (N=69)	1-15	A	*** .444	* .224	*** .385
		B	*** .455	* .244	*** .425
	1-12	A	*** .414	* .239	*** .412
		B	*** .425	* .249	*** .444
	1-9	A	*** .388	* .262	*** .402
		B	*** .405	* .264	*** .430
	1-6	A	* .238	.059	*** .420
		B	* .253	.094	*** .450
	1-3	A	* .207	** .357	*** .373
		B	.196	** .325	** .347
	1-2	A	.006	.072	* .261
		B	.050	.116	* .234
	1	A	-.171	***-.436	.074
		B	*-.204	***-.402	.040

Table 11. (continued)

Distances Included in the Analysis	Dimensions Included in Computations	Predictor $A=\hat{S}m_{ij}$ $B=\hat{S}_{ij}$	S'_{ij} Comp. From No Stable Concepts Rotation	S'_{ij} Comp. From Stable Concepts Rotation	Actually Observed S'_{ij}
Indirectly Changed Distances (N=66)	1-15	A	* .242	.062	.150
		B	* .249	.079	.183
	1-12	A	.171	.066	.149
		B	.179	.074	.173
	1-9	A	.204	.094	.137
		B	* .216	.093	.155
	1-6	A	.112	-.021	.165
		B	.126	.024	.187
	1-3	A	.114	* .255	.082
		B	.105	* .227	.052
	1-2	A	-.054	.026	.006
		B	-.004	.080	-.033
	1	A	-.153	***-.424	-.035
		B	-.190	***-.386	-.066

* $p<.05$, one-tailed test
** $p<.01$, one-tailed test
*** $p<.001$, one-tailed test

Table 12. Pearson Correlations of ΔS_{ij} with $\Delta \hat{S}m_{ij}$ and $\Delta \hat{S}_{ij}$, Broken Down by Number of Dimensions Included in Computations, by Method of Obtaining S'_{ij}, and by Subsets of Cases.

Distances Included in the Analysis	Dimensions Included in Computations	Predictor $A=\Delta \hat{S}m_{ij}$ $B=\Delta \hat{S}_{ij}$	$\Delta S'_{ij}$ Computed From No Stable Concepts Rotation	S'_{ij} Comp. From Stable Concepts Rotation
All (N=105)	1-15	A	** .297	* .198
		B	** .301	* .213
	1-12	A	** .258	* .199
		B	** .260	* .206
	1-9	A	** .254	* .210
		B	** .262	* .212
	1-6	A	* .206	.095
		B	* .219	.125
	1-3	A	.112	* .224
		B	.126	* .225
	1-2	A	.017	.071
		B	.081	.138
	1	A	-.099	**-.291
		B	-.139	**-.287
All Manipulated Distances (N=69)	1-15	A	** .374	* .219
		B	** .373	* .234
	1-12	A	** .329	* .233
		B	** .323	* .236
	1-9	A	** .328	* .247
		B	** .329	* .241
	1-6	A	* .257	.104
		B	* .270	.136
	1-3	A	.171	.290
		B	.184	** .286
	1-2	A	.033	.084
		B	.115	.157
	1	A	-.124	**-.357
		B	-.178	**-.356

Table 12. (continued)

Distances Included in the Analysis	Dimensions Included in Computations	Predictor $A=\Delta\hat{S}m_{ij}$ $B=\Delta\hat{S}_{ij}$	$\Delta S'_{ij}$ Computed From No Stable Concepts Rotation	S'_{ij} Comp. From Stable Concepts Rotation
Indirectly Changed Distances (N=66)	1-15	A	* .219	.072
		B	* .220	.086
	1-12	A	.147	.071
		B	.144	.075
	1-9	A	.186	.101
		B	.188	.096
	1-6	A	.190	.064
		B	* .216	.115
	1-3	A	.138	* .251
		B	.162	* .259
	1-2	A	.042	.081
		B	.135	.166
	1	A	-.090	**-.335
		B	-.152	**-.333

* $p<.05$, one-tailed test
** $p<.01$, one-tailed test

Table 13. Pearson Correlations of Δs_{ij} with $\Delta \hat{s}m_{ij}$ and $\Delta \hat{s}_{ij}$, Δs_{ij} Computed from Actually Observed s'_{ij}, and $\hat{s}m_{ij}$ and $\hat{s}_{ij}$ Computed from Fifteen Dimensions, Broken-down by Subsets of Cases.

Distances Included in the Analysis	Predictor A= $\hat{s}m_{ij}$ B= $\hat{s}_{ij}$	r
All (N=105)	A	**.267
	B	**.286
All Manipulated Distances	A	**.314
	B	**.334
Indirectly Changed Distances	A	.139
	B	.159

Test Three: Coordinates

The third hypothesis test was by means of a correlation between predicted and observed spacial coordinates. The several versions of this correlation as a function of predictor, rotation procedure, dimensions considered, concepts considered and statistical control of the pretest coordinates are given in Tables 14 through 16.

In Table 14 are the zero order Pearson correlations between the posttest coordinates (f'_{ik}) and those predicted by the theory, either including concept masses in the computations ($\hat{f}m_{ik}$) or excluding concept masses from the computations ($\hat{f}_{ik}$). All of the correlations were statistically highly significant (recall that they are statistically interdependent). The pattern of these correlations was much like that of the inter-concept distance correlations. The magnitudes of the correlations were greater when fewer dimensions were considered in the computations,

Table 14. Pearson Correlations* of F'_{ik} with $\hat{F}m_{ik}$ and $\hat{F}_{ik}$ for Two Rotations, Cases Broken Down by Cumulative Dimensions and Experimental Groups.

Concepts Included in the Analysis	Dimensions Included in the Analysis	N	Predictor $A=\hat{F}m_{ik}$ $B=\hat{F}_{ik}$	No Stable Conc. Rotation	Stable Conc. Rotation
All	1-15	225	A	.834	.784
			B	.839	.789
	1-12	180	A	.846	.793
			B	.851	.797
	1-9	135	A	.812	.814
			B	.877	.817
	1-6	90	A	.909	.861
			B	.911	.859
	1-3	45	A	.973	.957
			B	.973	.959
	1-2	30	A	.983	.962
			B	.983	.962
	1	15	A	.987	.990
			B	.987	.990
Unmanipulated Concepts Only	1-15	135	A	.821	.960
			B	.821	.960
	1-12	108	A	.832	.967
			B	.832	.967
	1-9	81	A	.861	.978
			B	.861	.978
	1-6	54	A	.893	.980
			B	.893	.980
	1-3	27	A	.975	.982
			B	.975	.982
	1-2	18	A	.982	.986
			B	.982	.986

Table 14. (continued)

Concepts Included in the Analysis	Dimensions Included in the Analysis	N	Predictor A=$\hat{F}m_{ik}$ B=$\hat{F}_{ik}$	No Stable Conc. Rotation	Stable Conc. Rotation
Manipulated Concepts Only	1-15	90	A	.855	.559
			B	.867	.568
	1-12	72	A	.868	.578
			B	.880	.587
	1-9	54	A	.889	.617
			B	.905	.623
	1-6	36	A	.943	.695
			B	.947	.688
	1-3	18	A	.973	.911
			B	.975	.915
	1-2	12	A	.977	.860
			B	.975	.858

* All correlations in this table are significant, $p<.001$, one-tailed test.

Table 15. First Order Partial Correlations (Controlling F_{ik}) of F'_{ik} with $\hat{F}m_{ik}$ and $\hat{F}_{ik}$ for Two Rotations, Cases Broken Down by Cumulative Dimensions and Experimental Groups.

Concepts Included in the Analysis	Dimensions Included in the Analysis	N	Predictor A=$\hat{F}m_{ik}$ B=$\hat{F}_{ik}$	No Stable Conc. Rotation	Stable Conc. Rotation
All	1-15	225	A	* .152	.113
			B	* .151	.135
	1-12	180	A	** .168	.111
			B	** .166	.135
	1-9	135	A	.206	.102
			B	.205	.124
	1-6	90	A	.137	-.061
			B	.119	-.039
	1-3	45	A	.166	.207
			B	.150	.201
	1-2	30	A	.066	.088
			B	.072	.101
	1	15	A	-.174	-.372
			B	-.199	-.348
Manipulated Concepts Only	1-15	90	A	** .273	.113
			B	** .275	.131
	1-12	72	A	** .299	.111
			B	** .300	.130
	1-9	54	A	** .368	.104
			B	** .370	.119
	1-6	36	A	* .292	-.069
			B	.259	-.050
	1-3	18	A	.336	.234
			B	.320	.224
	1-2	12	A	.092	.001
			B	.103	.008

Table 16. Pearson Correlations of ΔF_{ik} with $\Delta \hat{F}m_{ik}$ and $\Delta \hat{F}_{ik}$ for Two Rotations, Cases Broken Down by Cumulative Dimensions and Experimental Groups.

Concepts Included in the Analysis	Dimensions Included in the Analysis	N	Predictor A=$\Delta \hat{F}m_{ik}$ B=$\Delta \hat{F}_{ik}$	No Stable Conc. Rotation	Stable Conc. Rotation
All	1-15	225	A	** .157	* .121
			B	** .162	* .147
	1-12	180	A	* .172	.119
			B	** .176	* .146
	1-9	135	A	** .204	.109
			B	** .209	.133
	1-6	90	A	.129	-.052
			B	.120	-.026
	1-3	45	A	.204	.237
			B	.191	.233
	1-2	30	A	.147	.152
			B	.157	.167
	1	15	A	-.070	-.218
			B	-.113	-.245
Manipulated Concepts Only	1-15	90	A	** .284	.134
			B	** .291	.158
	1-12	72	A	** .308	.130
			B	** .314	.155
	1-9	54	A	** .371	.121
			B	** .378	.140
	1-6	36	A	* .289	-.053
			B	.264	-.027
	1-3	18	A	.370	.283
			B	.357	.278
	1-2	12	A	.277	.179
			B	.300	.198

* $p<.05$, one-tailed test
** $p<.01$, one-tailed test

reflecting again the greater stability of the larger dimensions. Again, the stable concepts rotation produced higher correlations for the unmanipulated concepts' coordinates than for those of the manipulated concepts; while the no stable concepts rotation produced no such difference. And again, there was no clear difference between predictions including or excluding the concept masses from the computations. If anything the predictor excluding concept masses produced slightly better predictions.

Table 15 gives the first order partial correlations controlling the pretest coordinates (f_{ik}). The partials were substantially lower than the zero order correlations, demonstrating again that the theory's accuracy of prediction rested mainly upon the stability of the coordinate system. Once again several of the partials for the manipulated concepts were large enough to be statistically significant, but only for the no stable concepts rotation. Unlike the inter-concept distances, the coordinates cannot be partitioned into direct and indirect changes. Consequently the effect noted for the inter-concept distances--lower partials for the indirect changes--cannot be observed here. No consistent differences emerged between predictions including or excluding concept masses in the computations. Finally, there were small, observed negative partials for the first and the first six coordinates. Thus the theoretical predictions were in the wrong direction for some dimensions.

Table 16 presents the zero order correlations between predicted and observed changes in coordinates. The pattern of these correlations was very similar to that of the partials, except that these correlations were slightly higher.

Overall, then, one may conclude that the correlations between predicted and observed coordinates, like those between predicted and observed inter-concept distances, were not strongly supportive of the hypothesis.

CHAPTER V

DISCUSSION

This chapter discusses the findings of the study in relation to the theory of linear motion and to the adequacy of the study as a test of that theory, and draws implications for further research. The chapter begins by evaluating the measurement and procedures of the study, then evaluates the overall degree of support which the study gives to the theory of linear motion, and then closely examines several alternative explanations of the results. The chapter closes with a summary and conclusion of the dissertation.

Evaluation of Measurement and Procedures

Measurement reliability in this study was at least adequate at the aggregate level of analysis, but was poor at the individual level of analysis. Since the hypothesis tests were conducted with aggregated data, the adequate degree of reliability achieved at the aggregate level is of primary importance. Measured reliability of the aggregated data was somewhat higher than the best results achieved by Barnett in his study of the reliability of metric MDS techniques. Since the size and homogeneity of the subject sample and the number and homogeneity of the concepts scaled in this study were similar to Barnett's studies, the higher measured reliabilities in this study may be attributed to its shorter (one week) interval between measurements. Thus the reliabilities reported by Barnett may still be regarded as typical for the conditions.

Questions of measurement validity and the success of experimental procedures are less straightforwardly answerable than is the question of

reliability. Our data were tested against several *a priori* criteria. Again, the criteria were quite well satisfied whenever the test involved aggregated data, but were not so well satisfied when the tests involved individual-level data. One can view this finding in several ways. The finding is perfectly reasonable given the findings concerning reliability, and given the theoretical principle that reliability is a necessary condition for validity. And again, since the hypothesis tests were conducted with aggregated data, the positive results for the aggregated data may be of prime importance. On the other hand, the criteria for the aggregated data were generally less formal, more intuitive. One cannot, in these circumstances, rule out the possibility that wishful thinking by the experimenter might influence his interpretations. Furthermore, the assessment of validity of measurement and procedures becomes involved in a delicate balance between theory and data. If one strongly believes one's theory, then the failure of theory-testing studies may, in the absence of external criteria of construct validity, be attributed to invalid measurement and procedures. After repeated use over a period of time, of course, such an argument must begin to wear thin. In any case, there seems no strong and self-evident reason to reject this study on the ground of invalidity alone.

As an aside to the discussion of measurement we should mention the interesting tendency for the inertial mass estimates to increase between pretest and posttest. The explanation that the subjects' information about the experimental concepts actually increased during the study seems too facile; yet no other explanation comes readily to mind. The further fact that measured inertial mass did not relate to cognitive change in

the theoretically expected manner suggests that we must search further for a valid explanation of its behavior.

Evaluation of Results

The results of this study do not appear to support the hypothesis. The first test, the inspection of mean changes in distance, disclosed several anomalies. The second and third tests, the correlations of predicted with observed inter-concept distances and coordinates, showed that the theory predicts very well, but only because it predicts the general stability of the cognitive structure. When the change component is isolated by statistically controlling the pretest scores or by correlating predicted with observed changes, the predictive power of the theory is quite poor in absolute terms: seldom does it account for as much as five percent of the variance in the dependent variable. Isolated correlations might appear promising, but the overall pattern does not.

Certain results are strongly negative in their implications. Were the theory correct, one would expect better results for the stable concepts rotation than for the no stable concepts rotation, since the former assumes the success of the experiment. The reliability tests found that the stable concepts rotation gave results which were more like those for the actually observed distances than did the no stable concepts rotation. Yet the no stable concepts rotation, in the hypothesis tests, gave results which were, if anything, slightly <u>more</u> supportive of the hypothesis than did the presumably more valid stable concepts rotation. This suggests that whatever apparent success the theory may have had in some instances was accidental. Even more disturbing are the negative results on the first dimension. Some of the strongest partial correlations are <u>negative</u>

correlations for computations based on the first dimension only. These correlations are contrary to the theory. It is clear from inspection of the plots how this result occurred, but it is not at all clear why it occurred.

Perhaps the most rigorous single test of the hypothesis is in the correlations at the bottom of Table 13, the correlations for indirect changes in the inter-concept distances based on the actually observed posttest distances. These correlations are unaffected by the uncertain meanings of rotation procedures and computed "observations." The correlations are .139 for the predictor including inertial mass and .159 for the predictor excluding mass. Neither of these correlations is statistically significant. Some indication of the insubstantial nature of these correlations is given by comparing them to those immediately above them, which differ only in including the three direct changes. The correlations including the three direct changes are almost .2 higher than those not including the direct changes. The addition of only three cases (which are trivially consistent with the theory) doubles the magnitude of the correlations. One cannot consider the correlations as indications of a reliable trend in the data.

Alternative Explanations

If the results of this study are not explicable by the hypothesis, then how may they be explained? This chapter suggests and evaluates seven possible responses to that question. In considering each of seven alternative explanations of the results we will both present whatever facts in the present study might fall under the explanation, and discuss features that might be incorporated in future studies to test the explanations.

The first three alternative explanations all have in common the implication that this study failed to support the theory only because it failed adequately to control the information to which the subjects were exposed.

The first alternative hypothesis is that the experiment failed, not because the theory is false, but because of a failure of the experimental manipulations to work. This hypothesis holds that the experimental messages simply had no systematic effect on the aggregate cognitive structure. If the messages had been "stronger"--if more, or more credible information had been provided, or if more powerful techniques of persuasion had been employed--then the resulting cognitive change might have conformed to the theory of linear motion. This hypothesis cannot strictly be ruled out, because none of the direct changes in distance supposedly induced by the messages were statistically significant; although we have argued that the overall pattern of mean changes suggests that the manipulations did work. A future study designed to rule out the hypothesis would have to have three features. First, the messages would be strengthened, perhaps by adding information or by adding redundancy, as in a multi-media presentation. Second, the messages would be more thoroughly pretested to ensure their effectiveness prior to the main study. Third, a separate control group of subjects would be used so that treatment-control comparisons could be made of the same inter-concept distances (rather than only between manipulated and unmanipulated distances as in the present study).

A second alternative explanation is that the messages were powerful enough to bring about cognitive change, but the contents of the messages were not those which the experimenter intended. The messages, in other

words, were noisy; they contained "unintended" information, and so moved the concepts in unintended directions.

Here we confront a serious dilemma which no future experiment of this sort can ignore. A realistic and credible message concerning a particular pair of concepts must, it would seem, make references to many "third" concepts by way of introducing points of comparison or contrast between the experimental concepts. In comparing Fiji and Singapore, for example, we said that both were small, tropical, former British colonies, recently independent, and parliamentary democracies. Perhaps the weakest aspect of this study, in retrospect, was its assumption that the information incorporated in the messages would exert force only along the line directly connecting the pairs of manipulated concepts. In retrospect it would have been just as reasonable, and perhaps more reasonable to assume, for example, that saying that Singapore and Fiji are both parliamentary democracies not only would move Singapore and Fiji toward each other but also would move both Singapore and Fiji toward the concept of "parliamentary democracies." This, then, is the dilemma: on the one hand, we want realistic, credible messages; on the other hand, we can only include a limited number of concepts in the multidimensional scaling analysis. It seems that we must choose either ineffective or invalid manipulations.

The dilemma might be avoided if we had a truly adequate spacial model of message content. More immediately, the dilemma might be avoided by thorough pretesting of the messages in several pilot studies which would incorporate, in overlapping parts, all of the concepts referred to in the messages. The meaning of the message would then not be measured, as it was in this study, by a single item referring to the single pair

of experimental concepts. Rather the meaning would be measured by a set of items referring to a set of reference concepts common to all of the pretest studies and the main study. And the movement of the manipulated concepts would not be predicted to occur along the lines connecting the pairs; nor would the force of the message be assumed divided equally between the two experimental concepts. Rather, the movement of each concept would be predicted as a linear function of its predicted movements with respect to the whole set of reference concepts. The theoretical prediction of "indirect" changes would then be based on a set of concepts included in the main study but not in any of the pilot studies.

By comparison to this ideal set of procedures the messages used in this study were little better than shots in the dark. Can the apparently chaotic movements apparently induced by the experimental messages be explained by assuming that the messages were noisy? The answer, in general, is trivially "yes." Less trivially and more concretely, certain unpredicted changes do seem directly attributable to certain unintended message contents. The example of Singapore and Fiji is a case in point. Both countries, which were said to be parliamentary democracies having capitalist economies, moved toward the "conservative" end of the second dimension, which seemed to represent political ideology. Another case concerns Congo. It was mentioned earlier that Congo's movement toward the "radical" end of the second dimension was one of the most prominent changes in the study. This movement, which was not at all predicted, is not at all surprising in view of the assertions, in the message about Congo and Guyana, that Congo has a socialist economy and a one-party government, and is a self-proclaimed "communist" state. Perhaps we could

even explain Brazil's movement toward the African cluster as a consequence of the reference in the message to Brazil as a former colony. Perhaps we could explain Guyana's movement in a general "European" direction as a result of references to it as a parliamentary democracy or as a member of the British Commonwealth of Nations.

These *post hoc* explanations must be viewed with appropriate skepticism. They do, however, support the general contention that the noisiness of the experimental messages cannot be ruled out as an alternative explanation which preserves the basic character of the theory of linear motion.

A third alternative hypothesis is that the observed movements of concepts were affected by messages other than the experimental messages, such as news reported in the mass media during the interval between pretest and posttest measurements. This hypothesis, like the previous two, holds that the theory is correct but that the experiment failed to control adequately the information inputs to the subjects. Information such as mass media news was treated as environmental noise in the design of this study--uncontrolled and assumed to be randomly distributed among the 105 inter-concept distances. If a separate control group of subjects had been included in this study, then the environmental noise might have been controlled statistically. Wisely or not, the experimenter decided not to allocate scarce subjects in that fashion. A future study might do so and might achieve superior results. On the other hand, an unsystematic review of mass media references to the fifteen nations during the week of the study failed to identify any apparent relationships with the movements of concepts.

The fourth and fifth alternative explanations both raise the issue of control of time. Both explanations could more easily be ruled out by a study which took measurements at three or more points in time.

The fourth explanation holds that the theory may be correct but not enough time was allowed for equilibrium to be established in cognitive space following the messages. This explanation might have been ruled out had a second posttest been administered. If the results failed to improve from first to second posttest, then the hypothesis would be false. Even the presently available data, however, rule out this hypothesis as a *sufficient* explanation. The hypothesis seems to require, even in the short run, that all changes would be in the predicted *direction*; but that clearly was not the case in this study.

The fifth explanation is Woelfel's proposed cognitive Law of Motion, or something like it: the idea that concepts have resistance not to velocity but to *acceleration* in cognitive space, and that, consequently, one cannot predict the effect of a message without knowing the velocity of the affected concepts *prior* to the message. The posttest distances would be a result of the prior velocities and the message inputs. Under this hypothesis, failure to take account of prior velocities could lead to just the sort of apparently chaotic results found in this study. Statistical control of velocities prior to the messages would require that a second pretest be administered. Prior velocity would be measured by change occurring between the two pretests.

A thorough consideration of the fourth and fifth alternative explanations, in short, would require that observations be made at at least four points in time, including two pretests and two posttests.

The last two alternative explanations raise even more complex issues than did the first five, for they raise the specter of a heterogeneous cognitive space.

The sixth explanation is that not all concepts or sets of concepts in cognitive space behave lawfully, and that the concepts in this study failed to behave lawfully because there were too many of them, or because they, or some of them, were not meaningful. Two factors are involved in this explanation. First is the notion of information processing capacity. People can handle only a limited amount of information in a given period of time. If the environment presents information beyond this limit, then excess information is simply not processed systematically. By rough analogy with experiments on short term memory we might suppose that in an experiment such as ours the maximum number of concepts that would behave lawfully would be about seven (Miller, 1960). The second possible factor is meaningfulness. Perhaps we cannot expect a concept to behave lawfully just because it is included in an MDS instrument; perhaps we must know, in addition, whether the concept meant anything to the subjects prior to administration of the instrument. How many subjects in our study had ever heard of Guyana or Fiji? Can we claim to have measured the meaning of these concepts, or must we admit to having merely created an apparent meaning by including them along with the rest of the concepts? And can we expect such pseudo-cognitions, if they exist in the study, to behave lawfully?

These two factors point to the concept of "domain," a set of concepts that behave together as a unit, or are, in Scott's (1969) terms, "functionally equivalent." Under this explanation the laws of motion do

not apply to just any set of concepts; the concepts must compose a domain. There may be an upper limit to the size of domains. Spaces including more than that number of concepts would not behave lawfully. If the limit is around seven, then this study, with fifteen concepts, exceeds the limit. Or again, there may be some "critical mass" that a concept must attain before it can function as part of a domain. The theory of linear motion has assumed that mass is important only as resistance to motion: the more mass the more resistance. Now we must wonder whether nearly massless concepts are at all capable of lawful motion.

The data of this study were examined from several standpoints in an effort to test this alternative hypothesis. Particular attention was focused on subsets of about seven concepts that might, for one or another reason, constitute a domain. Predictions of distances involving the seven highest mass concepts, and predictions of the smallest third of the inter-concept distances, were examined and found to be no better than predictions for the whole set of distances. Thus the present study offers no direct support for the contention that concepts can belong to a domain only if they have a certain critical mass or if they are close to each other in cognitive space.

A third subset of distances, however, was found to conform more closely to the theory than did the data as a whole. These were the distances among the six manipulated concepts: fifteen distances, or if the three directly changed distances are excluded, twelve distances. Table 17 displays the partial correlations (controlling pretest distances) of predicted with observed posttest distances for the twelve indirectly changed distances among the six manipulated concepts. These partials

are, on the whole, substantially higher in absolute magnitude than the corresponding partials in Table 11. Few of them are statistically significant, but then it must be considered that they have only nine degrees of freedom. Had these partials appeared in Table 11 they would have been touted as strong support for the theory, this despite some anomolies among them, most notably the (now even stronger) negative correlations for the first dimension. Three factors seem to favor the theory. The first is the large magnitude of the partials. The second is that the best results are achieved with the stable concepts rotation, which assumes the success of the experiment. The third favorable factor is that the correlations "peak" around the middle of the range of cumulative dimensions (2 through 6 dimensions), which presumably include the greatest proportion of reliable information.

One must, of course, view post hoc analyses with some skepticism. Still we can ask whether this particular subset of the concepts falls under the alternative explanation. Do they compose a "domain" in a sense that the whole set of concepts does not? One interpretation is that the six manipulated concepts constitute a domain just in consequence of being manipulated, which entails both being mentioned in connection with each other and being infused with information in the form of experimental messages that might create the needed "critical mass." This interpretation is interesting, but it should not be taken too seriously until the finding has been replicated. The sixth alternative explanation might be ruled out by a future study which experimentally varied the number of concepts scaled.

Table 17. First Order Partial Correlations (Controlling S_{ij}) of S'_{ij} with $\hat{S}m_{ij}$ and $\hat{S}_{ij}$ for Indirectly Changed Distances Among Manipulated Concepts Only.

Dimensions Included in Computations	Predictor A=$\hat{S}m_{ij}$ B=$\hat{S}_{ij}$	S'_{ij} Computed From No Stable Concepts Rotation	S'_{ij} Computed From Stable Concepts Rotation	Actually Observed S'_{ij}
1-15	A	.436	.359	.359
	B	.449	.402	.402
1-12	A	.384	.392	.403
	B	.397	.424	.444
1-9	A	.322	.416	.352
	B	.357	.436	.414
1-6	A	.336	* .532	.511
	B	.321	* .528	* .523
1-3	A	.335	.466	.165
	B	.362	.437	.163
1-2	A	.333	** .775	-.213
	B	.474	** .793	-.138
1	A	-.490	-.512	.004
	B	*-.553	-.484	-.027

* $p<.05$, one-tailed test, d.f. = 9
** $p<.01$, one-tailed test, d.f. = 9

The seventh and final alternative explanation to be considered here is that the results of this study seem unsystematic because a radically inappropriate model has been applied; the mind is not at all space-like but is instead a network.

A network model views the mind as a set of concepts which are or are not connected by various sorts of links. The mathematical model is a set of nodes or points connected by lines which may or may not be directional (asymmetrical) and labeled (Harary, et al., 1965). For example, "A likes B" might be represented as A $\xrightarrow{+}$ B, or more abstractly as A ___ B. The former expression is directed and signed, while the latter expression says only that there is some connection between A and B. A network model focuses attention on the kinds of links and on higher-level phenomena that emerge when links are composed into larger networks. Network models may be fairly simple. Balance theory (Heider, 1958), for example, considers only two kinds of links--unit relations and sentiment relations, each of which may only be positive or negative. Network models may, however, be astonishingly complex, as a recent paper by Frederiksen (1975) well shows.

Network and spacial models make radically differently assumptions about how the mind is organized. The heart of the matter is that under the strong spacial assumptions of theorists like Osgood and Woelfel (and Craig) all cognitive objects are comparable, for all are scalable in cognitive space. If we regard psychological distance as a kind of relation or connection, then a "network" defined on that relation has highly determined structural properties. First, the network necessarily is completely interconnected, in that any scaled object necessarily is

some distance from every other scaled object. Second, the relation necessarily is symmetrical, in that s_{ij}, the distance from i to j, is necessarily identical to s_{ji}, the distance from j to i. Third, the relation necessarily is intransitive, in that s_{ij} and s_{jk} puts only a loose restriction on s_{ik} (assuming a real, multidimensional space--in imaginary space there is no restriction at all). In short, the key structural variables of network models, such as continuity, direction, symmetry and transitivity of relations, and connectedness, integration and structural differentiation of networks, are all invariants, and thus essentially meaningless, in spacial models.

Spacial models assume that cognitive space exists as a kind of "medium" in which objects are located, regardless of whether or not the subject is aware of the medium as such. Network models, in contrast, focus upon the question of explicit cognitive connections between things, and thus do not assume that such connections exist. In a network model cognitive elements may not be connected. Concepts may be "similar" yet unrelated; or concepts may be quite different or distant, and yet be highly related by an asymmetric relation. Thus the crucial structural assumption of "distance" in the spacial model is meaningless or paradoxical from the standpoint of a network model; unrelated concepts have no distance, and the various kinds of connections seem to have no clear translation into distance. Robert Abelson (1968) has distinguished between "maximalist" and "minimalist" positions on cognitive structure. The spacial model, with its highly restrictive assumptions, necessarily takes a maximalist position; it assumes a great deal of structure.

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Under the assumption that the mind is "really" structured like a network rather than like a space, some apparently unsystematic features of our results become plausible. In a network model change in a single relation is not generally expected to change the relations between the two elements involved and all other elements in the network, if only because it is not generally expected that all such possible relations exist. Nor does a network model require that change in a single relation would leave unchanged relations at more than one step remove from the changed relation. Rather, such implicational change is a function of whatever higher-order structural principles (such as balance) are operative. The spacial model, in contrast, requires both that a change in distance between two concepts changes the distances between each of those concepts and all other concepts scaled and that the distances among the unmanipulated concepts are unaffected. This reasoning would suggest that the present study supports a network model of cognitive structure, since neither of the mentioned requirements of the spacial model is strongly evident in the data. Such reasoning, however, would be spurious, because the "evidence" for the network model is entirely negative; the network hypothesis becomes, in effect, the null hypothesis.

Can any feature of our data be used to test the network hypothesis more forthrightly? No direct test can be designed because we have no very good basis for assuming what kinds of connections, if any, are present among the concepts. Two indirect tests, however, were tried.

The first test requires that the cognitive network is ruled by the higher-order principle of cognitive balance. Phillips (1967) has shown that a cognitive network can be represented as a matrix of

relations, and that the matrix can be factored. Thus it is mathematically possible to represent a network as a multidimensional space, assuming that the network is completely connected and is composed of continuous (i.e. numerical) relations. Phillips has also shown that a perfectly balanced cognitive network would be unidimensional (i.e. one factor would perfectly account for the relational matrix). Thus a tendency toward cognitive balance might appear in our data as a tendency for the cognitive "space" to become unidimensional. A glance at the tables in Appendix C will confirm that no such tendency was present in the data. The dimensions, if anything, become more equal in importance over time as indicated by the relative sizes of their eigenvalues.

The second indirect test of the network hypothesis requires that we assume that the spacial concept of psychological distance is identical to the network concept of "relatedness." Then we must further assume that a "balance" tendency operates such that when we change a concept's relation to some other concept (as by transmitting an experimental message), then concepts highly related to the changed concept will tend to "change along" with it, while unrelated concepts will not be affected by its motion. One might imagine the more tightly connected concepts being "dragged along by their connections" when we "move" a concept. It follows from this that the closer (more related) a concept is to a "moved" concept the less the <u>change</u> in relatedness of that concept should be to the moved concept. In other words, for distances involving a <u>manipulated</u> concept there should be a strong positive correlation between magnitude of distance and absolute change of distance, while for distances involving

an unmanipulated concept, any change in which is assumed to be random, the correlation would not necessarily be strongly positive.

Table 18 displays the correlations between distance and absolute change in distance computed separately for each of the fifteen concepts. Manipulated and unmanipulated concepts are listed in separate columns to facilitate comparison. If the above reasoning is correct, then the network model is false, since the pattern of correlations, if there is a pattern, is just the opposite of that expected.

The author has imagined several interpretations of these correlations, only one of which is credible enough to mention here. The interpretation is that the negative correlations for the manipulated concepts indicate that the experimental manipulations had systematic effect only in the regions nearby the manipulated concepts. Thus large absolute changes occurred between the manipulated concepts and nearby concepts but not between the manipulated concepts and far away concepts. This suggests a "domain" interpretation of the study, with domains comprising local regions of cognitive space. Unfortunately, as was noted several paragraphs above, there was no detectable tendency for the theory of linear motion to make more accurate predictions of small distances than of large distances. If, in other words, our interpretation of the correlations in Table 18 is correct, we still have not saved the theory of linear motion. We imply instead that some other "law of motion" governs the movement of concepts within regional cognitive domains.

The two indirect tests attempted do not, in any case, support a network interpretation of the present study. The author has not devised a means by which a future study might rule out the hypothesis of network

Table 18. Pearson Correlations of Distance From Each Concept with Absolute Change of Distance From that Concept.

MANIPULATED CONCEPTS		UNMANIPULATED CONCEPTS	
Concept No.	r	Concept No.	r
2	-.417	1	-.347
5	-.256	3	-.203
8	.332	4	* .581
10	*-.582	6	-.072
14	*-.576	7	-.136
15	**-.618	9	* .489
		11	***-.750
		12	* .596
		13	.173

* $p<.05$, one-tailed test, d.f. = 12
** $p<.01$, one-tailed test, d.f. = 12
*** $p\leq.001$, one-tailed test, d.f. = 12

structure. Continued failure of spacial models, however, would suggest that we move toward the network model as an alternative.

Summary and Conclusion

The working assumption of this study was that models of cognitive structure may fruitfully be elaborated into general models of information which describe the structure of messages and constrain theories of the cognitive effects of communication. Because of its intuitive appeal and mathematical convenience, and because of its prominence in several disciplines, the spacial model of cognitive structure was selected for study. A model of message structure and a theory of linear motion were elaborated from the general spacial model by strict deduction from explicit definitions and assumptions. Previous research bearing on several aspects of the theory of linear motion was discussed. It was concluded that the theory of linear motion was plausible (though not at all proven), and that research on such a theory would be a reasonable next step from several points of view.

An empirical study was conducted in an attempt to test the theory of linear motion. The study employed a pretest-manipulation-posttest, within-subjects experimental design. Subjects were presented with information designed to change directly three of the 105 pairwise distances among fifteen concepts. The hypothesis was that the messages would bring about cognitive change as predicted by the theory of linear motion.

The results were basically negative; the theory was not supported, except insofar as it correctly assumed the general stability over time of cognitive space. The observed changes in location of concepts generally were inexplicable from the standpoint of the theory.

Several alternative explanations of the results were considered. Several of these "save" the theory by indicting the experiment. Others suggest alternative theories. One general indictment of the experiment is that it may have failed to control adequately the information to which subjects were exposed (used "weak" messages; included extraneous (or merely unaccounted for) information in the messages; failed to control for information from the environment beyond the experiment). The experiment may also have failed to control adequately the variable of time (failed to allow sufficient time for the theoretical effects to occur; failed to take measurements at enough points in time to allow observation of accelerations). The theory may have failed to take adequate account of the concept of cognitive domain--a set of functionally equivalent concepts. Thus the experiment may have included a number of concepts which exceeded the information processing capacities of the subjects, or it may have included meaningless concepts that could not be expected to behave lawfully. Some evidence suggests that the theory might have been successful had predictions been restricted to a domain comprising the manipulated concepts. Finally, the theory may be false because it makes a radically false assumption about cognitive structure. If, for example, the mind is "really" a network rather than a space, a study such as ours would be expected to produce apparently unsystematic results. No specific evidence was found in these data to support a network interpretation, however. Future research should be directed toward resolving the issues raised by these alternative explanations.

As we pointed out in Chapter I, a test of a particular theory is not equivalent to a test of the general spacial model. If this study

has not been entirely decisive regarding the theory of linear motion, much less has it been decisive concerning the general spacial model. If the theory of linear motion is false, some other cognitive "law of motion," perhaps more complex, may ultimately be found true.

The results of this study, all considered, do not vindicate the working assumption; but neither is the failure of a single experiment sufficient to warrant rejecting a general strategy of inquiry. Our investigation must be considered as only a step along the way to answering the broad questions which stimulated it.

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APPENDICES

APPENDIX A

PRETEST QUESTIONNAIRE AND POSTTEST COVER LETTER

Dear Participant,

This is a study of human information processing. We hope to learn more about how people understand and structure information. A second part of the experiment will be administered in a few days. At that time we will more fully explain the purpose of the study.

Please follow the instructions carefully. Answer all questions. Leaving blanks unfilled may make your questionnaire unusable. Always put down an answer, even if you have to guess. Complete each page before going on to the next.

If for any reason you do not wish to participate in this study, just do not fill out the questionnaire.

Thank you very much for your cooperation.

Sincerely yours,

Robert T. Craig

What is your date of birth? ______ ___ ____
Month Day Year

What is your sex? ______ Male
0

______ Female
1

PLEASE DO NOT WRITE IN THIS SPACE
(Card 1)

No. __ __ __
1 2 3

Gp. __ __ Wv 1
4 5 6

Card 0 1
7 8

Yr, Sx __ __ __
9 10 11

The following set of questions asks you to guess how much information you have--how much you know--about each of fifteen countries. Consider all that you know about each country, from whatever source.

If zero (0) represents the complete absence of knowledge, and 100 represents an average amount of information, how much do you know about each country?

Remember, if you feel that you have less than an average amount of information about a country, write a number less than 100. If you have more than average information about a country, write a number larger than 100. You may write any number you want.

COUNTRY	AMOUNT OF INFORMATION		
China	______	(12-15)	(Card 01)
Singapore	______	(16-19)	
Mexico	______	(20-23)	
U.S.A.	______	(24-27)	
Portugal	______	(28-31)	
Poland	______	(32-35)	
India	______	(36-39)	
Fiji	______	(40-43)	
West Germany	______	(44-47)	
Brazil	______	(48-51)	
Central African Republic	______	(52-55)	
Greece	______	(56-59)	
U.S.S.R.	______	(60-63)	
Congo	______	(64-67)	
Guyana	______	(68-71)	

The following set of questions asks you how different (or in other words "far apart") you perceive the countries to be. Differences in concepts are measured in units, so that the more different two concepts are, the more units apart they are from each other. To help you know how big a unit is, assume that Italy and England are 100 units apart.

If you think that two countries are more different from each other than Italy and England, write a number larger than 100. If you think that two countries are less different from each other than Italy and England, write a number less than 100. If you think that two countries are exactly the same, that you see no difference at all between them, write a zero (0). Remember, the more different the countries are from each other, the higher the number you should write. You may write any number you want.

Please answer all questions. Even if you feel unsure of your answer, take a guess.

Work as quickly as you comfortably can. Once you "get going" each answer will take only a few seconds.

How far apart are each of the following?

			COUNTRIES	UNITS APART
(Card 01)	72-80	0102	China & Singapore	________
(Card 02)	9-17	0103	China & Mexico	________
Dup 1-6	18-26	0104	China & U.S.A.	________
02 7-8	27-35	0105	China & Portugal	________
	36-44	0106	China & Poland	________
	45-53	0107	China & India	________
	54-62	0108	China & Fiji	________
	63-71	0109	China & West Germany	________
	72-80	0110	China & Brazil	________

How far apart are each of the following?

			COUNTRIES	UNITS APART
(Card 03)	9-17	0111	China & Central African Republic . .	________
Dup 1-6	18-26	0112	China & Greece	________
03 7-8	27-35	0113	China & U.S.S.R.	________
	36-44	0114	China & Congo	________
	45-53	0115	China & Guyana	________
	54-62	0203	Singapore & Mexico	________
	63-71	0204	Singapore & U.S.A.	________
	72-80	0205	Singapore & Portugal	________
(Card 04)	9-17	0206	Singapore & Poland	________
Dup 1-6	18-26	0207	Singapore & India	________
04 7-8	27-35	0208	Singapore & Fiji	________
	36-44	0209	Singapore & West Germany	________
	45-53	0210	Singapore & Brazil	________
	54-62	0211	Singapore & Central African Republic	________
	63-71	0212	Singapore & Greece	________
	72-80	0213	Singapore & U.S.S.R.	________
(Card 05)	9-17	0214	Singapore & Congo	________
Dup 1-6	18-26	0215	Singapore & Guyana	________
05 7-8	27-35	0304	Mexico & U.S.A.	________
	36-44	0305	Mexico & Portugal	________
	45-53	0306	Mexico & Poland	________
	54-62	0307	Mexico & India	________
	63-71	0308	Mexico & Fiji	________
	72-80	0309	Mexico & West Germany	________
(Card 06)	9-17	0310	Mexico & Brazil	________
Dup 1-6	18-26	0311	Mexico & Central African Republic . .	________
06 7-8	27-35	0312	Mexico & Greece	________
	36-44	0313	Mexico & U.S.S.R.	________
	45-53	0314	Mexico & Congo	________
	54-62	0315	Mexico & Guyana	________
	63-71	0405	U.S.A. & Portugal	________
	72-80	0406	U.S.A. & Poland	________

Remember: ITALY and ENGLAND are 100 UNITS apart

How far apart are each of the following?

			COUNTRIES	UNITS APART
(Card 07)	9-17	0407	U.S.A. & India	________
Dup 1-6	18-26	0408	U.S.A. & Fiji	________
07 7-8	27-35	0409	U.S.A. & West Germany	________
	36-44	0410	U.S.A. & Brazil	________
	45-53	0411	U.S.A. & Central African Republic . .	________
	54-62	0412	U.S.A. & Greece	________
	63-71	0413	U.S.A. & U.S.S.R.	________
	72-80	0414	U.S.A. & Congo	________
(Card 08)	9-17	0415	U.S.A. & Guyana	________
Dup 1-6	18-26	0506	Portugal & Poland	________
08 7-8	27-35	0507	Portugal & India	________
	36-44	0508	Portugal & Fiji	________
	45-53	0509	Portugal & West Germany	________
	54-62	0510	Portugal & Brazil	________
	63-71	0511	Portugal & Central African Republic .	________
	72-80	0512	Portugal & Greece	________
(Card 09)	9-17	0513	Portugal & U.S.S.R.	________
Dup 1-6	18-26	0514	Portugal & Congo	________
09 7-8	27-35	0515	Portugal & Guyana	________
	36-44	0607	Poland & India	________
	45-53	0608	Poland & Fiji	________
	54-62	0609	Poland & West Germany	________
	63-71	0610	Poland & Brazil	________
	72-80	0611	Poland & Central African Republic . .	________
(Card 10)	9-17	0612	Poland & Greece	________
Dup 1-6	18-26	0613	Poland & U.S.S.R.	________
10 7-8	27-35	0614	Poland & Congo	________
	36-44	0615	Poland & Guyana	________
	45-53	0708	India & Fiji	________
	54-62	0709	India & West Germany	________
	63-71	0710	India & Brazil	________
	72-80	0711	India & Central African Republic . .	________

How far apart are each of the following?

			COUNTRIES	UNITS APART
(Card 11)	9-17	0712	India & Greece	________
Dup 1-6	18-26	0713	India & U.S.S.R.	________
11 7-8	27-35	0714	India & Congo	________
	36-44	0715	India & Guyana	________
	45-53	0809	Fiji & West Germany	________
	54-62	0810	Fiji & Brazil	________
	63-71	0811	Fiji & Central African Republic . . .	________
	72-80	0812	Fiji & Greece	________
(Card 12)	9-17	0813	Fiji & U.S.S.R.	________
Dup 1-6	18-26	0814	Fiji & Congo	________
12 7-8	27-35	0815	Fiji & Guyana	________
	36-44	0910	West Germany & Brazil	________
	45-53	0911	W. Germany & Central African Republic	________
	54-62	0912	West Germany & Greece	________
	63-71	0913	West Germany & U.S.S.R.	________
	72-80	0914	West Germany & Congo	________
(Card 13)	9-17	0915	West Germany & Guyana	________
Dup 1-6	18-26	1011	Brazil & Central African Republic . .	________
13 7-8	27-35	1012	Brazil & Greece	________
	36-44	1013	Brazil & U.S.S.R.	________
	45-53	1014	Brazil & Congo	________
	54-62	1015	Brazil & Guyana	________
	63-71	1112	Central African Republic & Greece . .	________
	72-80	1113	Central African Republic & U.S.S.R. .	________
(Card 14)	9-17	1114	Central African Republic & Congo . .	________
Dup 1-6	18-26	1115	Central African Republic & Guyana . .	________
14 7-8	27-35	1213	Greece & U.S.S.R.	________
	36-44	1214	Greece & Congo	________
	45-53	1215	Greece & Guyana	________
	54-62	1314	U.S.S.R. & Congo	________
	63-71	1315	U.S.S.R. & Guyana	________
	72-80	1415	Congo & Guyana	________

Please read carefully the short messages on the following three pages. Each message is about a pair of countries and consists of a set of facts taken from the Encyclopedia Britannica. After you have read each message, you will be asked to estimate how different the two countries are according to the message.

Differences between concepts are measured in units, so that the more different two concepts are, the more units apart they are from each other. To help you know how big a unit is, assume that Italy and England are 100 units apart.

If you think that according to the message two countries are more different from each other than Italy and England, write a number larger than 100. If you think that according to the message two countries are less different from each other than Italy and England, write a number less than 100. If you think that according to the message the countries are exactly the same, write a zero (0). Remember, the more different the message says two countries are from each other, the higher the number you should write. You may write any number you want.

FACTS ABOUT SINGAPORE AND FIJI

Fiji and Singapore are remarkably similar countries.

Both Singapore and Fiji are small, tropical island countries in the Eastern Hemisphere (Singapore at the tip of the Malay Peninsula, and Fiji in the South Pacific north of New Zealand). Both countries have tropical climates--hot, humid and quite uniform in temperature.

Fiji and Singapore are both former British colonies which have attained independence within the past decade. Both countries are relatively stable parliamentary democracies, with multiple political parties and legal systems rooted in the British tradition. Fiji and Singapore are both members of the British Commonwealth of Nations.

In each of the two countries the majority of citizens are non-European, but are not racially native to the country. This is due to migration during the colonial period. The majority of Singapore is Chinese, although the native population of the islands is Malay. In Fiji the descendants of emmigrants from India outnumber the native Fijians. So both countries have non-native majorities.

Another unusual feature is that both Singapore and Fiji can claim an achievement that is the envy of many other developing countries: successful family planning programs have substantially reduced birth rate in both countries. That should facilitate improved standards of living in the future.

(Card 15) Remember: ITALY and ENGLAND are 100 UNITS apart.
Dup 1-6
15 7-8

How far apart are Singapore and Fiji according to the message?

9-12 ____________ UNITS APART

FACTS ABOUT CONGO AND GUYANA

Guyana and Congo are two very different countries.

Congo is a former French colony located in Central Africa. France continues to control much of the economy of Congo, and French is the official language of the country.

The governments of Congo since 1960 have become increasingly militaristic and authoritarian. The country is ruled by a single political party, and there is no national assembly or parliament. Congo, in addition, is a self-proclaimed Communist state which intends to develop a socialist economy.

The citizens of Congo are predominantly the same black peoples who inhabited the region before the arrival of the French. Immigration from abroad during the colonial period was relatively low.

Guyana, located in Northeastern South America, is a former British colony, and is a member of the British Commonwealth of Nations. The economy and culture of Guyana are still strongly influenced by the British. English is the official language of the country.

Guyana is a parliamentary democracy, with several political parties and a British-based legal system. Guyana has a private enterprise economy, such that there is only minimal government participation and control.

The largest racial group in Guyana is East Indian. The native American Indians are a small minority of the population.

(Card 15) Remember: ITALY and ENGLAND are 100 UNITS apart.

How far apart are Congo and Guyana according to the message?

13-16 ____________ UNITS APART

FACTS ABOUT PORTUGAL AND BRAZIL

Portugal and Brazil are closely related nations.

Brazil is made up of the former Portuguese colonies in South America. Alone among the nations of South America, Brazil has adopted Portuguese as the official language. Along with the Portuguese language, Brazil has imported much of the culture of Portugal--for example, the tradition of a patriarchal family structure. Both countries are overwhelmingly Roman Catholic. Over the years, the bulk of immigrants to Brazil have been from Portugal.

During the colonial period the ties between Portugal and Brazil were remarkably strong. In fact, Brazil became the seat of the Portuguese monarchy and government for a period of fourteen years during and shortly after the Napoleonic wars.

Soon after, Brazil became independent, but the two countries have retained close ties and many similar traits. The two countries have become urbanized and industrialized in roughly parallel fashion; while agriculture in both countries has remained highly traditional and inefficient.

At the present moment, as has rather frequently been true in their modern histories, both Brazil and Portugal are ruled by military-dominated governments.

(Card 15) Remember: ITALY and ENGLAND are 100 UNITS apart.

How far apart are Brazil and Portugal according to the message?

17-20 ____________ UNITS APART

Dear Participant,

This is the second part of a study of human information processing. The purpose of the study will be explained more fully after the questionnaires have been collected.

Please follow the instructions carefully. Answer all questions. Leaving blanks unfilled may make your questionnaire unusable. Always put down an answer, even if you have to guess. Complete each page before going on to the next.

If for any reason you do not wish to participate in this study, just do not fill out the questionnaire.

Thank you very much for your cooperation.

Sincerely,

Robert T. Craig

What is your date of birth? ______ Month ____ Day ____ Year

What is your sex? ______ Male (0)

______ Female (1)

PLEASE DO NOT WRITE IN THIS SPACE
(Card 1)

No. __ __ __ (1 2 3)

Gp. __ __ (4 5) Wv 2 (6)

Card 0 1 (7 8)

Yr, Sx __ __ __ (9 10 11)

APPENDIX B

PROGRAM TESTLAW

```
TESTLAW                                        CDC 6500 FTN V3.0-P380 OPT=1  08/25/75

      PROGRAM TESTLAW (INPUT,OUTPUT,TAPE60=INPUT,TAPE61=OUTPUT,PUNCH)

C        THIS PROGRAM ACCEPTS TIME ONE INTER-CONCEPT DISTANCES AND
C           CONCEPT COORDINATE VALUES FROM GALILEO SYSTEM OUTPUT,
C           ALONG WITH CONCEPT MASSES AND INCOMING INFORMATION, AND
C           OUTPUTS PREDICTED TIME TWO INTER-CONCEPT DISTANCES AND
C           OTHER VARIABLES BASED ON SEVERAL SETS OF ASSUMPTIONS.
C           OUTPUT IS SUITABLE FOR SPSS INPUT.
C
C     KEY TO VARIABLE NAMES
C
C           ST1(I,J,K)=TIME ONE DISTANCE OF CONCEPT I (COL) FROM
C              ANMA.OS 7 T>NVHZ ANLODS./ P9U./ NM /RL.MJRNMU NM.
C              SG*NO(S J-
C           US17RZPHESR_. SVN *KUS9MA. NI ANMA.OS R 7ANFH I>NL ANMA.OS
C              E C)NVH-
C           US1A3FPRZ7ZJH SRL. SVN )RJS9MA. NI ANMA.OS R I>NL ANMA.OS
C              J, COMPUTED BASED ON DIMENSIONS ONE THROUGH K.
C           SCFT1(I,J)=PROJECTION OF CONCEPT I (ROW) ON DIMENSION
C              J (COL) AT TIME ONE.
C           SCFT2(I,J)=PROJECTION OF CONCEPT I (ROW) ON DIMENSION
C              J (COL) AT TIME TWO.
C           NCONS=NUMBER OF CONCEPTS.
C           NDIMEN=NUMBER OF DIMENSIONS (ASSUMED ORTHOGONAL).
C           NREALDM=NUMBER OF REAL DIMENSIONS (ROOTS) TIME ONE.
C           NRELDM2=NUMBER OF REAL DIMENSIONS (ROOTS) TIME TWO.
C           NMESAG=NUMBER OF PAIRS OF CONCEPTS ABOUT WHICH INFORMATION
C              HAS BEEN RECEIVED.
C           SM(I,J)=DISTANCE BETWEEN CONCEPT I AND CONCEPT J PROPOSED
C              BY MESSAGES. IF NO MESSAGE THEN SM(I,J)=ST1(I,J).
C           NM(I,J)=THE NUMBER OF MESSAGES LINKING CONCEPTS I AND J.
C           AMASS(I)=MASS OF CONCEPT I.
C           LINK(I)=ID OF CONCEPT TO WHICH CONCEPT I IS LINKED BY
C              INCOMING MESSAGES.  IF NO MESSAGE THEN LINK(I)=0.
C           SMF(I,K)=THE PROJECTION OF CONCEPT I ON DIMENSION K AS
C              PROPOSED BY INCOMING MESSAGES.
C           SPF(I,K)=THE PREDICTED PROJECTION OF CONCEPT I ON DIMENSION
C              K AT TIME TWO.
C           SPFM(I,K)=THE PREDICTED PROJECTION OF CONCEPT I ON
C              DIMENSION K AT TIME TWO, EXCLUDING AMASS(I) FROM THE
C              COMPUTATION.
C           SP(I,J,K)=THE PREDICTED TIME TWO DISTANCE BETWEEN CONCEPTS
C              I AND J, BASED ON PREDICTED PROJECTIONS OF I AND J ON
C              DIMENSIONS ONE THROUGH K.
C           SPM(I,J,K)=THE PREDICTED TIME TWO DISTANCE BETWEEN CONCEPTS
C              I AND J, BASED ON PREDICTED PROJECTIONS OF I AND J ON
C              DIMENSIONS ONE THROUGH K, EXCLUDING AMASS(I) AND
C              AMASS(J) FROM COMPUTATIONS.
C           CH(I,K)=CHANGE (MOTION IN SPACE) OF CONCEPT I,BASED ON
C              CHANGES ALONG DIMENSIONS ONE THROUGH K.
C           JU=NUMBER OF CONCEPTS NOT AFFECTED BY INCOMING INFORMATION
C              (UNMOVED CONCEPTS).
C           JM=NUMBER OF CONCEPTS AFFECTED BY INCOMING INFORMATION
C              (MOVED CONCEPTS).
C           UNMOV(J)=JTH UNMOVED CONCEPT.
C           MOVECON(J)=JTH MOVED CONCEPT.
C           DISTM(I,J)=TIME ONE DISTANCE BETWEEN CONCEPT I AND
C              MOVECON(J).
C           TOTDISM(I)=TOTAL OF DISTANCES BETWEEN CONCEPT I AND MOVED
C              CONCEPTS.
C           CHDISTM(I,J)=CHANGE IN DISTANCE BETWEEN CONCEPT I AND
C              MOVECON(J).
C           TOTCHDM(I)=TOTAL OF CHANGES IN DISTANCE BETWEEN CONCEPT I
C              AND MOVED CONCEPTS.
C           DISTU(I,J)=TIME ONE DISTANCE BETWEEN CONCEPT I AND UNMOV(J)
C           TOTDISU(I)=TOTAL OF DISTANCES BETWEEN CONCEPT I AND UNMOVED
C              CONCEPTS.
C           CHDISTU(I,J)=CHANGE IN DISTANCE BETWEEN CONCEPT I AND
C              UNMOV(J).
C           TOTCHDU(I)=TOTAL OF CHANGES IN DISTANCE BETWEEN CONCEPT I
C              AND UNMOVED CONCEPTS.
C
C     REQUIRED INPUT (IN REQUIRED ORDER)
C
C           RUNNAME (4A10, ANY NAME UP TO 40 CHARACTERS)
C           NCONS,NMESAG,NDIMEN,NREALDM,NRELDM2 (5I4, LIMIT 15 EACH)
C           ST1(I,J,NDIMEN) (8F10.4, NEW CARD FOR NEW ROW OF MATRIX)
C           ST2(I,J) (8F10.4, NEW CARD FOR NEW ROW OF MATRIX)
```

```
C               SCFT1(I,K) (8F10.4, NEW CARD FOR NEW ROW OF MATRIX)
C               SCFT2(I,K) (8F10.4, NEW CARD FOR NEW ROW OF MATRIX)
C               I,J,SM(I,J) (2I2,F10.4, ONE CARD FOR EACH SM(I,J) NOT
C                   EQUAL TO 0)
C               I,AMASS(I),LINK(I) (I2,F10.4,I4, ONE CARD PER CONCEPT,
C                   CARDS IN ORDER OF CONCEPT NUMBERS)
C
      DIMENSION ST1(15,15,15),ST2(15,15),SCFT1(15,15),SCFT2(15,15),
     1SM(15,15),NM(15,15),AMASS(15),LINK(15),SMF(15,15),SPF(15,15),
     2SPFM(15,15),SP(15,15,15),SPM(15,15,15),CH(15,15),JNMOV(15),
     3MOVECON(15),DISTM(15,15),TOTDISM(15),CHDISTM(15,15),TOTCHDM(15),
     4DISTJ(15,15),TOTDISJ(15),CHDISTU(15,15),TOTCHDU(15),
     5ST2CAL(15,15,15)
C
C          READ PARAMETERS AND DATA
C
      READ(60,1)RUNAME1,RUNAME2,RUNAME3,RUNAME4
    1 FORMAT(4A10)
      WRITE(61,2)RUNAME1,RUNAME2,RUNAME3,RUNAME4
    2 FORMAT(*1*,10X,*RUN NAME - *,4A10/////)
      READ(60,3)NCONS,NMESAG,NDIMEN,NREALDM,NRELDM2
    3 FORMAT(5I4)
      WRITE(61,4)NCONS,NMESAG,NDIMEN,NREALDM,NRELDM2
    4 FORMAT(* NUMBER OF CONCEPTS IS *,I2/* NUMBER OF MESSAGES IS *,I2/*
     1 NUMBER OF DIMENSIONS IS *,I2/* NUMBER OF REAL DIMENSIONS TIME ONE
     2 IS *,I2/* NUMBER OF REAL DIMENSIONS TIME TWO IS *,I2)
      DO 10 J=1,NCONS
      READ(60,5)(ST1(I,J,NDIMEN),I=1,NCONS)
    5 FORMAT(8F10.4)
   10 CONTINUE
      DO 20 J=1,NCONS
      READ(60,6)(ST2(I,J),I=1,NCONS)
    6 FORMAT(8F10.4)
   20 CONTINUE
      DO 30 I=1,NCONS
      READ(60,7)(SCFT1(I,K),K=1,NDIMEN)
    7 FORMAT(8F10.4)
   30 CONTINUE
      DO 40 I=1,NCONS
      READ(60,8)(SCFT2(I,K),K=1,NDIMEN)
    8 FORMAT(8F10.4)
   40 CONTINUE
      DO 50 I=1,NCONS
      DO 50 J=1,NCONS
      SM(I,J)=ST1(I,J,NDIMEN)
      NM(I,J)=0
   50 CONTINUE
      WRITE(61,9)
    9 FORMAT(*-*,15X,*MESSAGES*/*  I J   DISTANC    NM(I,J)    SM(I,J)*/)
      DO 60 K=1,NMESAG
      READ(60,11)I,J,DISTANC
   11 FORMAT(2I2,F10.4)
      PRESUM=SM(I,J)*NM(I,J)
      NM(I,J)=NM(I,J)+1
      SM(I,J)=(PRESUM+DISTANC)/NM(I,J)
      SM(J,I)=SM(I,J)
      NM(J,I)=NM(I,J)
      WRITE(61,12)I,J,DISTANC,NM(I,J),SM(I,J)
   12 FORMAT(* *,2I2,F10.4,I6,4X,F10.4)
   60 CONTINUE
      WRITE(61,13)
   13 FORMAT(*- I  AMASS(I)  LINK(I)*/)
      DO 70 I=1,NCONS
      READ(60,14)AMASS(I),LINK(I)
   14 FORMAT(2X,F10.4,I4)
      WRITE(61,15)I,AMASS(I),LINK(I)
   15 FORMAT(* *,I2,F10.4,3X,I2)
   70 CONTINUE
C
C          COMPUTE ST1(I,J,K) AND ST2CAL(I,J,K)
C
      SUMST1=0.
      SUMST2=0.
      DO 960 I=1,NCONS
      DO 950 J=1,NCONS
      DO 960 K=1,NDIMEN
      DO 950 L=1,K
```

```
      IF(L-NREALDM)45,45,46
   45 SUMST1=SUMST1+((SCFT1(I,L)-SCFT1(J,L))**2)
      GO TO 47
   46 SUMST1=SUMST1-((SCFT1(I,L)-SCFT1(J,L))**2)
   47 IF(L-NREALDM2)48,48,49
   48 SUMST2=SUMST2+((SCFT2(I,L)-SCFT2(J,L))**2)
      GO TO 950
   49 SUMST2=SUMST2-((SCFT2(I,L)-SCFT2(J,L))**2)
  950 CONTINUE
      ST1(I,J,K)=SQRT(SUMST1)
      ST2CAL(I,J,K)=SQRT(SUMST2)
      SUMST1=0.
      SUMST2=0.
  960 CONTINUE
C
C          COMPUTE SMF(I,K)
C
      WRITE(61,701)
  701 FORMAT(*-*,6X,*SMF(I,1)*/)
      DO 100 I=1,NCONS
      J=LINK(I)
      IF(J)71,72,81
   71 WRITE(61,16)I
   16 FORMAT(*1WARNING - NEGATIVE VALUE ENCOUNTERED FOR LINK *,I2)
      GO TO 1000
   72 DO 80 K=1,NDIMEN
      SMF(I,K)=SCFT1(I,K)
   80 CONTINUE
      GO TO 91
   81 DO 90 K=1,NDIMEN
      IF(SCFT1(I,K)-SCFT1(J,K))82,82,83
   82 SMF(I,K)=SCFT1(I,K)-(((SCFT1(I,K)-SCFT1(J,K))**2)/(ST1(I,J,NDIMEN)
     1             **2)*.5*(SM(I,J)-ST1(I,J,NDIMEN)))
      GO TO 90
   83 SMF(I,K)=SCFT1(I,K)+(((SCFT1(I,K)-SCFT1(J,K))**2)/(ST1(I,J,NDIMEN)
     1             **2)*.5*(SM(I,J)-ST1(I,J,NDIMEN)))
   90 CONTINUE
   91 WRITE(61,17)I,SMF(I,1)
   17 FORMAT(* SMF(*,I2,*,1)  =*,F10.4)
  100 CONTINUE
C
C          COMPUTE SPF(I,K) AND SPFM(I,K)
C
      DO 110 I=1,NCONS
      DO 110 K=1,NDIMEN
      SPF(I,K)=SCFT1(I,K)+((1./AMASS(I))*(SMF(I,K)-SCFT1(I,K)))
      SPFM(I,K)=SMF(I,K)
  110 CONTINUE
C
C          COMPUTE SP(I,J,K)  AND SPM(I,J,K)
C
      SUM=0.
      SUMM=0.
      NCONSDO=NCONS-1
      DO 130 I=1,NCONSDO
      MDO=I+1
      DO 130 J=MDO,NCONS
      DO 130 K=1,NDIMEN
      DO 120 L=1,K
      IF(L-NREALDM)118,118,119
  118 SUM=SUM+((SPF(I,L)-SPF(J,L))**2)
      SUMM=SUMM+((SPFM(I,L)-SPFM(J,L))**2)
      GO TO 120
  119 SUM=SUM-((SPF(I,L)-SPF(J,L))**2)
      SUMM=SUMM-((SPFM(I,L)-SPFM(J,L))**2)
  120 CONTINUE
      SP(I,J,K)=SQRT(SUM)
      SPM(I,J,K)=SQRT(SUMM)
      SUM=0.
      SUMM=0.
  130 CONTINUE
C
C          COMPUTE CH(I,K)
C
      SUMCH=0.
      DO 150 I=1,NCONS
      DO 150 K=1,NDIMEN
      DO 140 L=1,K
```

```
      SUMCH=SUMCH+((SCFT2(I,L)-SCFT1(I,L))**2)
  140 CONTINUE
      CH(I,K)=SQRT(SUMCH)
      SUMCH=0.
  150 CONTINUE
C
C
C       THE NEXT SECTIONS COMPUTE VARIABLES NEEDED FOR A TEST OF THE
C           ≠NETWORK≠ MODEL PREDICTION THAT STRONGLY CONNECTED (CLOSE)
C           CONCEPTS TEND TO MOVE SIMILARLY.  IN ORDER TO SEPARATE THE
C           HYPOTHESIZED PHENOMENON FROM THE KNOWN TENDENCY OF LARGER
C           PAIRWISE DISTANCES TO BE LESS RELIABLE WE MUST CORRELATE TIME
C           ONE DISTANCE WITH CHANGE OF DISTANCE SEPARATELY FOR MANIP-
C           ULATED AND UNMANIPULATED CONCEPTS.  THIS PROCEDURE IS AN
C           ATTEMPT TO SEPARATE TRUE MOTION FROM MEASUREMENT ERROR.
C
C           IDENTIFY SETS OF MANIPULATED AND UNMANIPULATED CONCEPTS
C
      JU=0
      JM=0
      DO 160 I=1,NCONS
      IF(LINK(I))158,158,159
  158 JU=JU+1
      UNMOV(JU)=I
      GO TO 160
  159 JM=JM+1
      MOVECON(JM)=I
  160 CONTINUE
C
C           COMPUTE DISTM(I,J),DISTU(I,J),TOTDISM(I),TOTDISU(I),
C           CHDISTM(I,J),CHDISTU(I,J),TOTCHDM(I),TOTCHDU(I).
C
      DO 190 I=1,NCONS
      TOTDISM(I)=0.
      TOTCHDM(I)=0.
      IF(JM.EQ.0)GO TO 171
      DO 170 J=1,JM
      K=MOVECON(J)
      DISTM(I.J)=ST1(I.K,NDIMEN)
      TOTDISM(I)=TOTDISM(I)+DISTM(I,J)
      CHDISTM(I,J)=SQRT((ST2(I,K)-ST1(I,K,NDIMEN))**2)
      TOTCHDM(I)=TOTCHDM(I)+CHDISTM(I,J)
  170 CONTINUE
  171 TOTDISU(I)=0.
      TOTCHDU(I)=0.
      IF(JU.EQ.0)GO TO 190
      DO 180 J=1,JJ
      K=UNMOV(J)
      DISTU(I,J)=ST1(I,K,NDIMEN)
      TOTDISU(I)=TOTDISU(I)+DISTU(I,J)
      CHDISTU(I,J)=SQRT((ST2(I,K)-ST1(I,K,NDIMEN))**2)
      TOTCHDU(I)=TOTCHDU(I)+CHDISTU(I,J)
  180 CONTINUE
  190 CONTINUE
C
C           OUTPUT DECK ONE-COORDINATE VALUES-SCFT1(I,K),SCFT2(I,K),SPF(I,K),
C     -         SPFM(I,K)
C
      PUNCH 18
   18 FORMAT(30X,*COORDINATE VALUES*)
      WRITE(61,19)
   19 FORMAT(*-*,30X,*COORDINATE VALUES*//* I K SCFT1(I,K) SCFT2(I,K)
     1SPF(I,K)   SPFM(I,K)*/)
      DO 200 I=1,NCONS
      DO 200 K=1,NDIMEN
      PUNCH 21,I,K,SCFT1(I,K),SCFT2(I,K),SPF(I,K),SPFM(I,K)
      WRITE(61,21)I,K,SCFT1(I,K),SCFT2(I,K),SPF(I,K),SPFM(I,K)
   21 FORMAT(* *,2I2,4F11.4)
  200 CONTINUE
C
C           OUTPUT DECK TWO-PREDICTED AND OBSERVED PAIRWISE DISTANCES-
C               ST1(I,J),ST2(I,J),SP(I,J,K),SPM(I,J,K)
C
      PUNCH 22
   22 FORMAT(19X,*PREDICTED AND OBSERVED PAIRWISE DISTANCES*)
      WRITE(61,23)
   23 FORMAT(*-*,20X,*PREDICTED AND OBSERVED PAIRWISE DISTANCES*/* K I J
     1 ST1(I,J,K) ST2CAL(I,J,K)  SP(I,J,K) SPM(I,J,K)*)
```

```
TESTLAW                                                CDC 6600 FTN V3.0-P330 OPT=1
      LM=(NDIMEN/3)+2
      DO 210 I=1,NCONSDO
      JMIN=I+1
      DO 210 J=JMIN,NCONS
      DO 9210 L=1,LM
      IF(L.GE.1.AND.L.LE.3)K=L
      IF(L.GT.3)K=(L-2)*3
      WRITE(61,824)K,I,J,ST1(I,J,K),ST2CAL(I,J,K),SP(I,J,K),SPM(I,J,K)
  824 FORMAT(* *,3I2,4F11.3)
      PUNCH 24,K,I,J,ST1(I,J,K),ST2CAL(I,J,K),SP(I,J,K),SPM(I,J,K)
   24 FORMAT(* *,3I2,4F10.3)
 9210 CONTINUE
      WRITE(61,924)I,J,AMASS(I),AMASS(J),ST2(I,J)
      PUNCH 924,I,J,AMASS(I),AMASS(J),ST2(I,J)
  924 FORMAT(* 99*,2I2,3F10.4)
  210 CONTINUE
C
C     OUTPUT DECK THREE-CONCEPT VARIABLES-CH(I,K),DISTM(I,K),
C          CHDISTM(I,K),DISTU(I,K),CHDISTU(I,K),TOTDISM(I),TOTDISU(I),
C          TOTCHDM(I),TOTCHDU(I),AMASS(I)
C
      DO 270 I=1,NCONS
      WRITE(61,25)I
   25 FORMAT(*-FOLLOWING ARE VARIABLES FOR CONCEPT *,I2)
      II=NDIMEN/9
      JJ=NDIMEN-(II*9)
      WRITE(61,26)II,JJ
   26 FORMAT(*0II=*,I3,10X,*JJ=*,I3,10X,*FOLLOWING ARE CH(I,K)*)
      IF(II)223,221,219
  219 DO 220 J=1,II
      KS=((J-1)*9)+1
      KM=J*9
      WRITE(61,27)I,(CH(I,K),K=KS,KM)
      PUNCH 27,I,(CH(I,K),K=KS,KM)
   27 FORMAT(* I=*,I2,3X,9F8.3)
  220 CONTINUE
  221 IF(JJ)223,223,222
  222 KS=(II*9)+1
      WRITE(61,27)I,(CH(I,K),K=KS,NDIMEN)
      PUNCH 27,I,(CH(I,K),K=KS,NDIMEN)
C
  223 KK=JM/9
      LL=JM-((JM/9)*9)
      WRITE(61,28)KK,LL
   28 FORMAT(*0KK=*,I3,10X,*LL=*,I3,10X,*FOLLOWING ARE DISTM(I,K)*)
      IF(KK)233,231,229
  229 DO 230 J=1,KK
      KS=((J-1)*9)+1
      KM=J*9
      WRITE(61,29)I,(DISTM(I,K),K=KS,KM)
      PUNCH 29,I,(DISTM(I,K),K=KS,KM)
   29 FORMAT(* I=*,I2,3X,9F8.3)
  230 CONTINUE
  231 IF(LL)233,233,232
  232 KS=(KK*9)+1
      WRITE(61,29)I,(DISTM(I,K),K=KS,JM)
      PUNCH 29,I,(DISTM(I,K),K=KS,JM)
C
  233 WRITE(61,31)
   31 FORMAT(*0*,32X,*FOLLOWING ARE CHDISTM(I,K)*)
      IF(KK)243,241,239
  239 DO 240 J=1,KK
      KS=((J-1)*9)+1
      KM=J*9
      WRITE(61,32)I,(CHDISTM(I,K),K=KS,KM)
      PUNCH 32,I,(CHDISTM(I,K),K=KS,KM)
   32 FORMAT(* I=*,I2,9F8.3)
  240 CONTINUE
  241 IF(LL)243,243,242
  242 KS=(KK*9)+1
      WRITE(61,32)I,(CHDISTM(I,K),K=KS,JM)
      PUNCH 32,I,(CHDISTM(I,K),K=KS,JM)
C
  243 MM=JU/9
      NN=JU-((JU/9)*9)
      WRITE(61,33)MM,NN
   33 FORMAT(*0MM=*,I3,10X,*NN=*,I3,10X,*FOLLOWING ARE DISTU(I,K)*)
      IF(MM)253,251,249
```

```
  249 DO 250 J=1,MM
      KS=((J-1)*9)+1
      KM=J*9
      WRITE(61,34)I,(DISTU(I,K),K=KS,KM)
      PUNCH 34,I,(DISTU(I,K),K=KS,KM)
   34 FORMAT(* I=*,I2,9F8.3)
  250 CONTINUE
  251 IF(NN)253,253,252
  252 KS=(KK*9)+1
      WRITE(61,34)I,(DISTU(I,K),K=KS,JJ)
      PUNCH 34,I,(DISTU(I,K),K=KS,JU)
C
  253 WRITE(61,35)
   35 FORMAT(*0*,32X,*FOLLOWING ARE CHDISTU(I,K)*)
      IF(MM)263,261,259
  259 DO 260 J=1,MM
      KS=((J-1)*9)+1
      KM=J*9
      WRITE(61,36)I,(CHDISTU(I,K),K=KS,KM)
      PUNCH 36,I,(CHDISTU(I,K),K=KS,KM)
   36 FORMAT(* I=*,I2,9F8.3)
  260 CONTINUE
  261 IF(NN)263,263,262
  262 KS=(MM*9)+1
      WRITE(61,36)I,(CHDISTU(I,K),K=KS,JU)
      PUNCH 36,I,(CHDISTU(I,K),K=KS,JU)
C
  263 WRITE(61,37)
   37 FORMAT(*0    FOLLOWING ARE TOTDISM(I),TOTDISU(I),TOTCHDM(I),TOTCHDU
     1(I),AMASS(I)*)
      WRITE(61,38)I,TOTDISM(I),TOTDISU(I),TOTCHDM(I),TOTCHDU(I),AMASS(I)
      PUNCH 38,I,TOTDISM(I),TOTDISU(I),TOTCHDM(I),TOTCHDU(I),AMASS(I)
   38 FORMAT(* I=*,I2,5F10.3)
C
  270 CONTINUE
C
 1000 CONTINUE
      WRITE(61,39)
   39 FORMAT(*1*)
      END
```

APPENDIX C

COORDINATE MATRICES FROM GALILEO

Table 19. Pretest Coordinate Matrix.

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 1

NORMAL SOLUTION

		1	2	3	4	5	6	7	8
1	CHINA	-54.162	99.985	22.751	-39.284	20.642	-.648	-5.990	-1.850
2	SINGAPOR	-44.846	37.795	57.840	-7.045	-5.912	-12.073	14.593	-35.968
3	MEXICO	23.726	-62.264	28.516	-30.129	41.942	8.505	-1.565	-15.503
4	USA	97.413	-63.000	48.220	-30.015	-36.611	-10.672	12.208	-6.475
5	PORTUGAL	28.463	1.681	-12.317	29.625	53.932	.525	-7.327	-8.818
6	POLAND	42.073	51.210	-52.627	29.211	12.762	-36.446	-11.839	2.233
7	INDIA	-42.575	23.654	25.737	9.874	-31.837	58.896	-34.234	4.763
8	FIJI	-55.944	6.899	70.130	44.121	.626	-25.800	12.941	39.836
9	W GERMAN	85.923	10.053	3.223	19.017	-45.797	-19.910	-28.058	6.028
10	BRAZIL	25.049	-60.919	3.607	-12.864	44.138	15.022	-20.166	26.606
11	C AFR RE	-64.637	-43.026	-47.096	-27.037	-17.537	3.343	35.785	29.146
12	GREECE	31.693	-.446	-19.097	58.776	-1.338	46.569	41.568	-17.672
13	USSR	66.895	85.727	-42.571	-44.078	-5.179	8.762	17.907	11.726
14	CONGO	-72.496	-43.977	-55.932	-4.465	-22.043	11.713	-24.598	-13.841
15	GUYANA	-66.575	-43.371	-30.385	4.292	-7.787	-47.787	-1.224	-20.212

	1	2	3	4	5	6	7	8
EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--	49874.925	39331.236	23973.248	13170.571	12574.309	11094.830	7063.233	5915.262
NUMBER OF ITERATIONS TO DERIVE THE ROOT--	12	6	7	17	17	7	13	8
PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--	28.785	22.700	13.836	8.005	7.257	6.403	4.076	3.414
CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--	28.785	51.485	65.321	73.326	80.583	86.986	91.063	94.477
CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--	30.841	55.163	69.987	78.565	86.340	93.201	97.569	101.227

TRACE 161713.803

Table 19. (continued)

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 1

NORMAL SOLUTION

		9	10	11	12	13	14	15
1	CHINA	-1.738	10.868	-5.873	-.117	1.426	-13.088	48.454
2	SINGAPOR	20.626	-24.863	5.815	-.097	.335	17.252	-18.818
3	MEXICO	-.648	30.670	-11.850	.051	.551	13.939	-29.514
4	USA	-3.719	-.397	4.102	.210	-2.344	-6.714	36.098
5	PORTUGAL	-24.641	-25.629	-18.872	.061	-1.624	-2.342	6.900
6	POLAND	14.276	15.077	11.855	.091	-1.525	26.735	17.062
7	INDIA	-23.822	3.408	10.323	-.092	-1.062	14.428	-6.135
8	FIJI	6.831	8.867	-4.961	-.121	-1.204	-12.091	-18.180
9	W GERMAN	.281	-4.977	-16.137	.186	3.301	1.513	-7.810
10	BRAZIL	17.215	-16.238	21.976	.054	1.600	-6.691	4.701
11	C AFR RE	-7.414	-9.062	-9.802	-.140	.757	24.788	13.473
12	GREECE	5.708	9.607	4.881	.068	1.424	-10.511	12.302
13	USSR	-3.355	-2.648	4.235	.145	-.997	-15.036	-45.712
14	CONGO	31.610	.635	-12.779	-.157	-1.629	-17.570	-1.760
15	GUYANA	-31.208	4.681	17.085	-.144	.992	-14.613	-11.060

EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--

4236.252	3143.681	2189.805	-.233	-36.170	-3303.244	-8213.903

NUMBER OF ITERATIONS TO DERIVE THE ROOT--

11	7	4	4	4	39	18

PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--

2.445	1.814	1.264	-.000	-.021	-1.906	-4.741

CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--

96.922	98.736	100.000	100.000	99.979	98.073	93.332

CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--

103.846	105.790	107.144	107.144	107.122	105.079	100.000

TRACE 161713.803

Table 20. Unrotated Posttest Coordinate Matrix

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 2

NORMAL SOLUTION

		1	2	3	4	5	6	7	8
1	CHINA	-29.531	96.831	35.139	11.649	-32.473	-7.249	16.677	-1.710
2	SINGAPOR	-40.133	13.401	80.626	15.832	-19.968	1.157	-9.458	25.866
3	MEXICO	9.459	-71.632	20.227	23.436	-33.786	-26.459	12.668	17.682
4	USA	65.878	-51.452	40.173	-54.727	-7.822	-30.467	-17.965	-3.475
5	PORTUGAL	32.229	-20.587	-18.993	63.567	-4.631	33.148	.814	-23.319
6	POLAND	67.019	44.442	-32.247	-12.377	1.627	16.876	48.215	16.558
7	INDIA	-58.771	27.158	3.855	2.735	45.575	-33.391	-30.827	-25.747
8	FIJI	-61.187	-11.730	51.773	-2.443	32.574	47.507	3.476	6.687
9	W GERMAN	66.652	-11.850	2.316	-36.004	13.641	41.271	-29.084	18.401
10	BRAZIL	15.328	-63.419	-4.215	37.942	.176	-18.308	20.424	-18.213
11	C AFR RE	-56.014	-19.986	-58.740	-16.225	-51.417	28.587	-33.620	-22.319
12	GREECE	40.207	13.427	-26.954	37.811	52.829	-12.863	-17.956	16.529
13	USSR	65.279	75.353	-.173	-13.370	-15.193	-14.633	-8.209	-30.463
14	CONGO	-56.987	10.533	-80.215	-8.028	-6.777	-23.716	-6.032	45.736
15	GUYANA	-59.429	-30.488	-12.571	-49.798	25.645	-1.461	50.877	-22.212

EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--

1	2	3	4	5	6	7	8
40112.708	32068.920	24646.590	15289.903	12373.260	10237.516	9546.532	7477.045

NUMBER OF ITERATIONS TO DERIVE THE ROOT--

1	2	3	4	5	6	7	8
12	9	7	9	11	28	11	8

PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--

1	2	3	4	5	6	7	8
24.224	19.366	14.884	9.234	7.472	6.182	5.765	4.515

CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--

1	2	3	4	5	6	7	8
24.224	43.590	58.475	67.708	75.180	81.363	87.128	91.643

CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--

1	2	3	4	5	6	7	8
24.885	44.780	60.070	69.555	77.231	83.583	89.505	94.144

TRACE 161192.507

Table 20. (continued)

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 2

NORMAL SOLUTION

		9	10	11	12	13	14	15
1	CHINA	-1.407	31.637	-2.044	-13.884	.264	8.307	.135
2	SINGAPOR	-2.020	-.542	-1.253	20.100	.037	-9.683	-12.682
3	MEXICO	-28.057	-11.394	14.546	-5.982	-.195	-1.140	22.997
4	USA	2.470	-3.470	-11.270	-4.534	-.140	17.595	-17.657
5	PORTUGAL	3.531	.531	9.975	8.060	-.056	25.658	-4.890
6	POLAND	-12.555	-21.797	11.047	-3.401	.121	-8.961	-20.104
7	INDIA	-5.348	-9.244	29.098	-3.739	.074	-3.603	-8.040
8	FIJI	13.573	-26.750	-13.453	-11.446	-.032	3.392	8.395
9	W GERMAN	9.987	28.365	19.728	-.144	-.032	-7.624	11.182
10	BRAZIL	39.250	12.426	-6.663	-4.915	-.173	-20.518	-7.077
11	C AFR RE	-20.527	-2.393	-10.496	-2.989	-.055	-10.635	-7.961
12	GREECE	-30.617	11.527	-26.771	.069	.037	-3.245	1.800
13	USSR	14.836	-21.509	-9.176	8.525	.206	-4.575	22.769
14	CONGO	29.762	-5.047	-.101	2.842	.029	11.105	3.161
15	GUYANA	-12.878	17.660	-3.167	11.439	-.083	3.925	7.979

EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--

5453.045	4316.995	2948.225	1119.326	.239	-1999.200	-2398.596

NUMBER OF ITERATIONS TO DERIVE THE ROOT--

10	7	10	4	8	6	14

PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--

3.293	2.607	1.780	.676	.000	-1.207	-1.449

CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--

94.936	97.543	99.324	100.000	100.000	98.793	97.344

CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--

97.527	100.205	102.034	102.728	102.728	101.488	100.000

TRACE 161192.507

Table 21. Rotated Posttest Coordinate Matrix, No Stable Concepts Rotation.

THE COORDINATES OF SPACE NUMBER 2

		1	2	3	4	5	6	7	8
1	CHINA	-40.699	97.460	11.976	-36.227	9.316	-5.129	3.275	-9.287
2	SINGAPOR	-33.086	29.753	78.243	-8.128	1.790	-12.342	13.459	-27.952
3	MEXICO	20.247	-58.716	31.568	-28.138	41.264	-1.801	8.910	-15.834
4	USA	80.110	-42.507	35.141	-31.053	-42.581	-20.921	6.349	-9.176
5	PORTUGAL	29.025	-8.293	-15.281	11.318	61.958	13.012	-8.844	3.891
6	POLAND	49.285	43.134	-57.693	29.025	8.705	-34.397	-12.463	-4.443
7	INDIA	-53.532	16.926	16.792	4.429	-30.172	57.085	-26.831	2.740
8	FIJI	-52.462	.781	61.116	33.135	-3.686	-27.926	3.440	28.816
9	W GERMAN	70.794	-2.537	-1.500	23.708	-39.088	-18.095	-12.572	16.103
10	BRAZIL	21.409	-55.313	9.266	-6.189	50.560	8.274	-15.739	14.275
11	C AFR RE	-56.946	-37.896	-41.541	-19.351	-14.584	2.831	46.111	30.742
12	GREECE	35.774	8.512	-20.507	51.375	11.243	54.656	17.345	-24.806
13	USSR	54.205	76.247	-38.040	-32.026	-17.132	3.989	12.623	4.773
14	CONGO	-66.691	-24.791	-63.820	-3.014	-20.916	23.975	-20.482	-5.653
15	GUYANA	-57.434	-42.759	-7.720	6.134	-16.677	-43.211	-14.581	-6.119

THE COORDINATES OF SPACE NUMBER 2

		9	10	11	12	13	14	15
1	CHINA	6.667	8.788	-2.638	-3.033	15.013	-10.239	31.415
2	SINGAPOR	22.236	-16.677	-7.004	-2.313	3.575	13.429	-7.621
3	MEXICO	12.254	32.303	-12.472	.919	6.689	24.772	-22.275
4	USA	1.752	5.101	17.837	2.058	-18.921	-3.735	13.606
5	PORTUGAL	-25.870	-33.051	-28.862	6.498	-18.574	5.330	1.926
6	POLAND	16.050	23.276	15.806	-2.309	-11.166	24.458	11.170
7	INDIA	-26.786	5.842	25.938	-2.305	-7.636	7.427	-10.351
8	FIJI	-5.926	-3.069	-8.492	2.883	-23.243	-20.125	-24.254
9	W GERMAN	-3.622	-11.031	-38.646	-1.145	29.420	-2.029	3.499
10	BRAZIL	12.310	-28.467	29.823	-7.216	14.527	-14.149	-.261
11	C AFR RE	-15.043	-21.373	-25.064	7.630	4.538	38.350	11.434
12	GREECE	-3.671	15.990	.434	-3.606	2.813	-21.628	10.282
13	USSR	-.548	-6.477	19.239	-2.947	-9.922	-12.368	-23.432
14	CONGO	50.553	3.557	-17.215	4.172	-5.059	-10.905	3.450
15	GUYANA	-40.357	25.288	31.317	.714	17.948	-18.587	1.413

Table 22. Pretest Coordinate Matrix Translated to Stable Concepts Centroid.

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 1

SOLUTION TRANSLATED TO STABLE CONCEPTS CENTRIOD

		1	2	3	4	5	6	7	8
1	CHINA	-74.867	38.663	26.412	-33.321	27.637	-7.137	-8.854	-3.227
2	SINGAPOR	-65.551	26.473	61.500	-1.082	1.082	-18.561	11.728	-37.345
3	MEXICO	3.626	-73.585	32.176	-24.166	48.936	2.016	-4.429	-16.881
4	USA	76.708	-74.321	51.880	-24.053	-29.516	-17.150	9.344	-7.852
5	PORTUGAL	7.758	-3.640	-8.657	35.588	60.927	-5.963	-10.192	-10.195
6	POLAND	21.368	34.889	-48.966	35.174	19.757	-42.935	-14.704	.856
7	INDIA	-63.280	12.332	29.397	15.837	-24.842	52.407	-37.099	3.386
8	FIJI	-76.650	-4.423	73.791	50.084	7.521	-32.289	10.077	38.459
9	W GERMAN	65.217	-1.268	6.884	24.980	-38.803	-26.399	-30.923	4.651
10	BRAZIL	4.344	-72.241	7.268	-6.901	51.132	8.533	-23.030	25.228
11	C AFR RE	-85.342	-54.347	-43.436	-21.075	-10.542	-3.146	32.920	27.768
12	GREECE	13.989	-11.768	-15.437	64.733	5.657	40.080	38.703	-13.049
13	USSR	46.189	74.405	-38.910	-39.115	1.815	2.274	15.042	10.348
14	CONGO	-93.201	-55.299	-52.271	1.498	-15.349	5.224	-27.463	-15.218
15	GUYANA	-87.260	-54.692	-26.724	10.255	-.792	-54.275	-4.089	-21.589

EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--

1	2	3	4	5	6	7	8
56305.635	41253.843	24174.225	14403.868	13308.212	11726.395	7186.319	5943.717

PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--

1	2	3	4	5	6	7	8
30.516	22.359	13.102	7.807	7.213	6.355	3.895	3.221

CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--

1	2	3	4	5	6	7	8
30.516	52.875	65.977	73.783	80.996	87.351	91.246	94.468

CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--

1	2	3	4	5	6	7	8
32.644	56.562	70.578	78.929	86.644	93.443	97.609	101.055

TRACE 172481.749

Table 22. (continued)

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 1

SOLUTION TRANSLATED TO STABLE CONCEPTS CENTRIOD

		9	10	11	12	13	14	15
1	CHINA	.532	5.029	-4.955	-.162	1.256	-17.094	44.208
2	SINGAPOP	22.895	-33.701	6.733	-.142	.165	13.246	-23.364
3	MEXICO	1.622	24.831	-10.932	.007	.381	9.933	-33.760
4	USA	-1.449	-6.236	5.020	.166	-2.514	-10.720	31.352
5	PORTUGAL	-22.371	-31.468	-17.954	.017	-1.794	-6.348	2.654
6	POLAND	16.545	9.239	12.774	.046	-1.695	22.729	12.916
7	INDIA	-21.552	-2.430	11.242	-.137	-1.232	10.422	-10.392
8	FIJI	9.101	3.028	-4.042	-.165	-1.374	-16.097	-22.427
9	W GERMAN	2.551	-13.816	-15.219	.141	3.130	-2.493	-12.056
10	BRAZIL	19.495	-22.076	22.894	.009	1.430	-10.697	.454
11	C AFR RE	-5.144	-14.900	-8.884	-.184	.586	20.792	9.227
12	GREECE	7.979	3.769	5.800	.024	1.254	-14.517	8.055
13	USSF	-1.085	-3.486	5.153	.100	-1.167	-19.042	-49.959
14	CONGO	33.881	-5.203	-11.961	-.201	-1.799	-21.376	-6.006
15	GUYANA	-26.932	-1.157	18.003	-.189	.922	-18.619	-15.306
	EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--							
		4313.562	3655.004	2202.452	.263	36.604	-3543.972	-8484.378
	PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--							
		2.339	1.981	1.194	.000	.020	-1.921	-4.598
	CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--							
		96.805	93.786	99.980	99.980	100.000	98.079	93.481
	CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--							
		103.556	105.675	106.952	106.952	106.974	104.919	100.000

TRACE 172481.749

Table 23. Unrotated Posttest Coordinate Matrix Translated to Stable Concepts Centroid.

GALILEO COORDINATES OF 15 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 2

SOLUTION TRANSLATED TO STABLE CONCEPTS CENTRIOD

		1	2	3	4	5	6	7	8
1	CHINA	-43.439	85.465	36.962	17.990	-29.471	-2.991	23.355	-.094
2	SINGAPOR	-59.042	2.035	82.449	22.174	-16.966	5.416	-2.780	27.482
3	MEXICO	-9.450	-82.998	22.050	29.777	-30.784	-22.200	19.346	19.298
4	USA	46.969	-62.818	41.995	-48.386	-4.820	-26.208	-11.287	-1.859
5	PORTUGAL	13.321	-31.953	-17.171	69.908	-1.629	37.406	7.492	-21.703
6	POLAND	48.110	33.077	-30.424	-6.035	4.629	21.135	54.893	18.174
7	INDIA	-77.680	15.792	5.677	9.076	48.578	-29.132	-24.149	-24.131
8	FIJI	-80.095	-23.095	53.595	3.898	35.576	51.766	10.154	8.303
9	W GERMAN	47.744	-23.215	4.138	-29.663	16.643	45.530	-22.407	20.017
10	BRAZIL	-3.581	-74.784	-2.392	44.283	3.179	-14.050	27.102	-16.597
11	C AFR RE	-74.923	-31.351	-56.917	-9.883	-48.415	32.846	-26.942	-20.703
12	GREECE	21.299	2.061	-25.131	44.153	55.831	-8.604	-11.278	18.145
13	USSR	46.371	63.987	1.650	-7.029	-12.190	-10.375	-1.531	-28.847
14	CONGO	-75.895	-.833	-78.392	-1.686	-3.775	-19.457	.646	47.352
15	GUYANA	-78.338	-41.853	-10.749	-43.457	28.547	2.798	57.555	-20.596

	1	2	3	4	5	6	7	8
EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--	45475.843	34006.546	24696.424	15893.091	12508.458	10509.548	10215.450	7516.219
PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--	25.873	13.348	14.051	9.042	7.117	5.979	5.812	4.276
CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--	25.873	45.221	59.272	68.314	75.430	81.410	87.222	91.498
CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--	26.543	46.392	60.807	70.084	77.385	83.519	89.481	93.868

TRACE 171326.655

Table 23. (continued)

GALILEO COORDINATES OF 15 VARIABLES IN 4 METRIC MULTIDIMENSIONAL SPACE FOR DATA SET 2

SOLUTION TRANSLATED TO STABLE CONCEPTS CENTRIOD

		9	10	11	12	13	14	15
1	CHINA	6.565	31.445	-3.674	-10.986	.233	9.849	-.434
2	SINGAPOR	5.893	-.733	-2.882	22.997	.306	-8.140	-13.251
3	MEXICO	-20.144	-11.585	12.917	-3.084	-.226	.403	22.428
4	USA	10.383	-3.661	-12.899	-1.636	-.171	19.137	-18.226
5	PORTUGAL	11.444	.340	8.346	10.959	-.387	27.201	-5.467
6	POLAND	-4.641	-21.988	9.419	-.503	.093	-7.419	-20.673
7	INDIA	2.565	-9.435	27.469	-.841	.043	-2.061	-8.609
8	FIJI	21.486	-26.941	-15.082	-8.549	-.063	4.935	7.926
9	W GERMAN	17.900	28.174	18.098	2.753	-.063	-6.082	10.613
10	BRAZIL	47.163	12.235	-8.293	-2.017	-.204	-18.976	-7.646
11	C AFR RE	-12.614	-2.584	-12.125	-.091	-.086	-9.092	-9.530
12	GREECE	-22.704	11.336	-28.400	2.967	.006	-1.703	1.231
13	USSR	22.749	-21.701	-10.805	11.422	.175	-3.032	22.200
14	CONGO	37.675	-5.233	-1.730	5.740	-.002	12.649	2.593
15	GUYANA	-4.965	17.469	-4.796	14.336	-.114	5.467	7.410

EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--

6392.301	4317.544	2988.035	1245.272	.253	-2034.878	-2403.452

PERCENTAGE OF DISTANCE ACCOUNTED FOR BY INDIVIDUAL VECTOR--

3.637	2.456	1.700	.708	.000	-1.158	-1.367

CUMULATIVE PERCENTAGES OF REAL DISTANCE ACCOUNTED FOR--

95.135	97.591	99.291	100.000	100.000	98.842	97.475

CUMULATIVE PERCENTAGES OF TOTAL (REAL AND IMAGINARY) DISTANCE ACCOUNTED FOR--

97.599	100.120	101.864	102.590	102.591	101.403	100.000

TRACE 171326.655

Table 24. Rotated, Translated Posttest Coordinate Matrix, Stable Concepts Rotation.

THE COORDINATES OF SPACE NUMBER 2

		1	2	3	4	5	6	7	8
1	CHINA	-54.855	84.464	24.122	-30.267	19.909	-.579	-11.975	2.642
2	SINGAPOR	-59.042	2.035	82.449	22.174	-16.966	5.416	-2.790	27.482
3	MEXICO	2.565	-71.761	31.213	-10.532	60.399	.910	-3.254	-17.485
4	USA	61.829	-55.819	48.537	-22.980	-22.010	-26.935	7.278	-13.489
5	PORTUGAL	13.321	-31.953	-17.171	69.908	-1.529	37.406	7.492	-21.703
6	POLAND	27.685	41.930	-40.147	31.864	19.612	-46.340	-3.120	-4.128
7	INDIA	-67.364	5.596	26.940	12.242	-33.786	52.791	-33.660	-3.903
8	FIJI	-80.096	-23.095	53.595	3.898	35.575	51.766	10.154	8.303
9	W GERMAN	63.058	-18.132	-15.318	14.199	-31.309	-16.966	-24.613	17.472
10	BRAZIL	-3.581	-74.784	-2.392	44.283	3.179	-14.050	27.102	-16.597
11	C AFR RE	-79.603	-54.987	-40.729	-24.528	-9.535	-6.934	25.940	32.940
12	GREECE	14.419	5.225	-13.741	65.132	2.545	43.380	30.421	-18.605
13	USSR	32.325	63.484	-20.877	-35.129	-5.926	.674	13.082	4.556
14	CONGO	-75.896	-.833	-78.392	-1.686	-3.775	-19.457	.646	47.352
15	GUYANA	-78.338	-41.853	-10.749	-43.457	28.647	2.798	57.555	-20.596

THE COORDINATES OF SPACE NUMBER 2

		9	10	11	12	13	14	15
1	CHINA	-.703	1.850	-19.319	-.136	4.021	-20.352	32.095
2	SINGAPOR	5.893	-.733	-2.882	-22.997	.006	-8.140	-13.251
3	MEXICO	2.262	27.906	-16.948	.067	1.742	12.895	-17.633
4	USA	5.244	-3.032	24.056	1.825	-5.565	-8.326	10.019
5	PORTUGAL	11.444	.340	8.346	-10.958	-.087	27.201	-5.467
6	POLAND	16.266	7.726	27.560	-1.037	-5.770	20.711	-.944
7	INDIA	-23.745	-.623	19.462	-.087	-1.305	9.463	-12.069
8	FIJI	21.486	-26.941	-15.082	8.549	-.063	4.935	7.926
9	W GERMAN	2.219	-9.791	-37.497	1.669	7.130	-2.802	8.350
10	BRAZIL	47.163	12.235	-8.293	2.017	-.204	-18.976	-7.646
11	C AFR RE	-4.977	-17.344	-19.793	1.123	3.572	25.956	7.859
12	GREECE	1.913	5.936	-1.982	-1.843	2.018	-16.099	1.338
13	USSR	1.522	-13.628	24.460	-1.531	-5.843	-21.445	-29.515
14	CONGO	37.675	-5.238	-1.730	-5.740	-.302	12.648	2.593
15	GUYANA	-4.965	17.469	-4.796	-14.336	-.114	5.467	7.410