FREQUENCY OF OCCURRENCE AS AN ESTIMATE OF INERTIAL MASS: PIGS IN SPACE[1]

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Many communication scholars have described the field of communication as preparadigmatic (Rossiter, 1977; Fisher, 1978). Over the last few years a paradigm indiginous to communication science has emerged. Known as the Galileo$_{TM}$ System, it was developed by Joseph Woelfel and his associates (Woelfel & Fink, 1980). It combines a powerful explanatory theory and a comprehensive set of methods. Although this paradigm cannot be applied to all the issues with which communication deals, several dozen scholars in the field have adopted the Galileo$_{TM}$ System (Barnett, 1980 [Appendix 1]) and their research proceeds in a manner Kuhn labels normal science (Kuhn, 1962). This chapter represents an attempt to more precisely determine the relationship between the Woelfel-Saltiel attitude theory (Woelfel & Saltiel, 1979 Chapter 3) and semantics. Specifically, it examines the semantic structures of synonyms to determine if a word's frequency of occurrence can be used to estimate a concept's inertial mass.

Theory

Semantics and Synonyms

The formal theory behind the use of metric multidimensional scaling (MMDS) for the measurement of meaning and linguistic processes has been described elsewhere (Barnett, 1976, 1977a, b; Woelfel, 1975, 1980). Rather than attempt a similarly detailed discussion, a brief description will be provided which should sufficiently acquaint the reader with the theoretic foundations of this research.

Consistent with association models, the meaning of any word may be defined by its pattern of relationship or degree of dissimilarity from all other words. The definition of a word at any single point in time may be precisely represented by a 1 x n vector, $s_{11}, s_{12}, s_{13}, \ldots, s_{1n}$, where s_{1k} represents the distance or dissimilarity between words 1 and k; and the meaning of any set of n words by matrix **S**, where any entry s_{ij} represents the measured distance between words i and j. Typically, **S** represents the average of a representative sample of users of a language to take into account the consensual nature of the code system. **S** may be generated at known intervals in time to record the processual nature of language.

This matrix has certain mathematical properties which make it amenable MMDS. It is a square symmetric matrix. The diagonal elements are zero because the dissimilarity of a word and itself equals zero by definition. Off diagonal elements may be any positive real number. This final property makes the precise measurement of meaning possible.

A theoretical problem arises when dealing with synonyms, i.e., words with equivalent meaning.[2] Because the discrepancy of any word and itself is zero, it logically follows that if two words are synonyms, they refer to the identical referent, their discrepancy should also be zero (Ogden & Richards, 1946). In terms of word substitution, if two words are semantically identical, then the latter may replace the former without any alteration in the interrelationships among the words (matrix **S**). If the words are not synonyms the first cannot be replaced by the second without altering the structure of the relations (Osgood, et al., 1957). The greater the dissimilarity between the words, the more change will result from such a substitution.

The study of synonyms represents a fertile area for linguistics and communication research. Because they refer to the same object, synonyms act as built in experimental control in natural language. While they designate the same referent, synonyms differ in other linguistic properties such as phonics. As a result, through the study of the semantic properites of synonyms we may gain insights into the nature of meaning, in specific, and language and communication in general. We may learn how these other properties affect meaning. For these reasons, this research focuses on synonyms.

Thus, it is expected that the differences among semantic structures generated with synonyms should be zero. That is, $\mathbf{S}_i$ should be equivalent to $\mathbf{S}_j$, where, matrix $\mathbf{S}_i$ is the semantic structure generated with a set of words including i, and $\mathbf{S}_j$, the semantic structure generated with the same set but including word j. Words i and j are synonyms.

However, Wittgenstein (1953) has pointed out that meaning is dependent on how a word is used. Also, empirical investigations using MMDS have shown that one's behavior effects semantic structure, such that the more frequently one performs a behavior the closer that word is to a concept of self within the space which describes the semantic structure (Barnett, et al., 1974, 1976; Marlier, 1975; Barnett & McPhail, 1980; Woelfel, et al., 1980). Linguistically, the more frequently people speak or write a word the closer it will be to a concept of self. Additionally, synonyms may be used selectively with different domains such that one word is used in one semantic domain and its synonym exclusively in another. Yes, they refer to the same referent. But while two words may be considered synonyms, they may in fact have different meanings and a different semantic structure depending on their use. Indeed, Barnett (1979) found that semantic structures generated with synonyms were not congruent and that the word's distance to the self covaried with its frequency of use.

Attitude Theory

The Woelfel-Saltiel attitude theory argues that messages constitute forces which cause an attitude toward a given object to move to some intermediate position between the expressed position of the source and the receiver's attitude (Woelfel & Saltiel, 1978 (chapter 3); Saltiel & Woelfel, 1975). It is a balance formulation defining an attitude's position as the mean of all advocated positions.

The Woelfel-Saltiel theory differs from traditional theories of attitude change (Heider, 1945; Newcomb, 1965; Festinger, 1957; Osgood, et al., 1957) because it suggests that an attitude may be conceptualized as a continuously scaled least-squares balance point. The point is a locus in a multidimensional space which minimizes the squared distance between a point representing a concept of a word and all other points. An attitude toward any single concept is the measured distance between the concept and the self. Because this locus is dynamic, changing as a function of the information individuals receive, the theory is appropriate to discussions of attitude change.

The Woelfel-Saltiel theory specifies the relationship between message volume, the significance of the source, and attitude mass. Message volume in the quantity of information input to a receiver, operationalized as the number of messages received. Attitude mass is that attribute of an attitude which makes it resistant to change. It is a function of the number of messages a person has previously received about the concept. Thus, the more information a person has about a concept the more difficult it will be to change attitudes about it.

The Woelfel-Saltiel theory argues that four factors are causally related to attitude change:

(1) the number of messages
(2) the number of messages comprising the initial balance point,
(3) the amount of discrepancy between the old attitude and the mean position advocated by the new messages, and
(4) the credibility or significance of the source and/or the salience of the information for the receiver.

They state:

> ...the amount of attitude change is directly related to the product of the average discrepancy between incoming information and the old attitude (average change advocated) and the number of such messages, and inversely related to the sum of the number of messages out of which the change message and the original message is composed (1978:4-5).

The theory implies that attitudes must be measured longitudinally rather than as a discrete event and change treated as motion in multidimensional space. Attitudes may be treated as a set of interrelationships which define any word's proximity to all other words. That is, the attribution of value to any symbol will be done on the basis of what other symbols are associated with it and the attributed relationships among those symbols. These relations are viewed as a function of the information individuals receive. This information acts to alter associations among the words in the message with the other words in those individuals' semantic structure.

Inertial Mass and Synonyms

While synonyms should have an equivalent set of relations with a common domain of symbols, indicative of congruent semantic structures, it would be expected that they would vary in their inertial mass, i.e., resistance to change. This would be due to their difference in information history or their variance in their frequency of use. The synonym which occurs as the greatest frequency should be the most resistant to change and should be located closest to a concept of self. Both distance from self and resistance to change should be monotonically and inversely related to the frequency of occurrence in language.

This suggests that word's frequency of occurrence may be a indicator of its inertial mass. Inertial mass is a function of both frequency of occurrence (number of messages) and the content of those messages (average discrepancy of the messages from a neutral point). However, if one assumes that all messages are of equal strength (equation 1), i.e., they advocate an equally discrepant message by expressing the same relations among the words in the semantic domain, then the frequency of occurrence and inertial mass seems equivalent.

Hypotheses

Based on the above discussion, the following hypotheses seem justified:

> H_1: The semantic structures $\mathbf{S}_i$ and $\mathbf{S}_j$ will be significantly different. $\mathbf{S}_i$ and $\mathbf{S}_j$ are multidimensional spaces generated with equivalent worcs except that $\mathbf{S}_i$ contains word i and $\mathbf{S}_j$, word j. I and j are synonyms.

> H_2: The semantic structures generated by synonyms will be systematically distorted from equivalence such that the synonym that occurs more frequently in language will be significantly closer to a self than its synonym which occurs less frequently.

These two hypotheses represent a replication of Barnett (1979) who found that semantic structures generated by synonyms were not equivalent and that the word's frequency of occurrence varied inversely with the measured distance from self.

> H_3: A word's resistance to attitude change is positively related to its frequency of occurrence in language. Alternatively, attitude change is inversely related to the frequency of occurence in language, such that, the greater the frequency of occurrence the less the attitude change.

Methods

The semantic structure of an individual may be measured through the use of MMDS. The method takes a matrix of dissimilarities (or distances) such as matrix **S** and converts the data to a series of loadings on a set of underlying dimensions. Mathematically, the process is analogous to converting a matrix of intercity distances to a graphic representation such as a map. In that special case, a n x n matrix of cities (n = the number of cities) would be reduced to a two-dimensional configuration with little loss of information.

Hypotheses Operationalized

Theoretical hypothesis 1 may be operationalized as follows:

> H_1: The multidimensional spaces $\mathbf{S}_i$ and $\mathbf{S}_j$ will be significantly different.

H_2 may be tested in the following manner. Generate two or more multidimensional spaces from a series of identical words with the exception of a single word--the synonym. It would vary across conditions ($\mathbf{S}_i$ and $\mathbf{S}_j$). Next, minimize the departure from congruence between the spaces. Then, through the use of t-test, using the words as the unit of analysis, determine if the differences among the spaces can be attributed to the synonym or the other words. Is the difference between the synonyms significantly greater than the differences among the remaining concepts?[3] When a number of spaces need to be compared it would be more parsimonious to use the spaces as the unit of analysis.[4]

> H_2: The multidimensional spaces generated by synonyms will be systematically distorted from congruence such that the synonym that is used more frequently will be significantly closer to a concept of self than its synonym that is used less frequently.

H_2 may be tested as follows: One criterion for the selection of scaled synonyms should be their variance in frequency of occurrence in English (assuming that the subjects are English speakers). This may be determined by consulting any of the standard references on word frequency (Thorndike & Lorge, 1944; Carroll, et al., 1971). These references represent stable estimates of the frequency of occurrence of these words. They were determined through content analysis of printed materials. Because of the time span over which these materials were published they may be taken as a general linguistic indicator.

A second procedure would be to ask subjects to estimate how frequently they hear and how often they see these words appear in print (decoding). And, at what frequency do they use these words in conversation and in their writing (encoding). These estimates may be used rather than the published estimates for two reasons. One, published in 1944 Thorndike and Lorge's word counts were based on documents published prior to that date. Language changes over time and thus those estimates may lead to erroneous conclusions. Two, the use of the publisheo estimates does not provide a measure of the frequency at which the actual subjects use these words. However, these estimates may be instable and for that reason the published estimates may prove more useful.

Besides the synonyms, some concept of self, such as "myself", will be scaled. The mean pair-wise distance estimate between each synonym and the self concept will be used to test H_2. The word which is used more frequently should be closer to the self concept. A simple one tailed t-test may be used to test for significance between the individual conditions. However, to test the overall order among a number of conditions linear trend analysis will be used (Hays, 1973). The significance test will be performed on the correlations between the predicted rank order and the distance between the synonyms and the self or with the actual frequencies of occurrence and the distance estimates.

> H_3: A concept's resistance to attitude change is positively related to its frequency of occurrence in language.

The third hypothesis may be tested through a straight forward (N x 2) experiment (N = the number of different synonyms). Half of the subjects will be given a message designed to change the attitude toward one of the N synonyms and the other half of the subjects will serve as the N control groups. Through post-test measures one can examine the direction and magnitude of the attitude change of each group relative to each other condition and through regression analysis evaluate the hypothesis. The actual design will be described later.

Instrumentation

The instrument used to test the above hypotheses was composed of 66 direct pair-comparisons based on 12 different words, using a criterion standard (metric) or red and white as 50 "Galileos" apart. The questions were asked in the following form: "If red and white are 50 Galileos apart, how far apart are (sheep and goats)?" This process was repeated for all pairs. In this manner, a 12 by 12 dissimilarity matrix was generated. This matrix was then averaged across subjects producing a mean distance matrix which would be converted into a multidimensional space to examine the meaning of the words presented below.

1. Bad	5. Dog	9. Sheep
2. Myself	6. Horse	10. Attractive
3. Cow	7. Cat	11. Goat
4. Beneficial	8. Good	12. Pig or a synonym

These words were chosen for a number of reasons. First, was the selection of a referent which has a variety of synonyms that sufficiently varied in their frequency of occurrence in English. The concept "pig" and its synonyms, "hog", "boar" and "swine" met this criterion. According to Thorndike and Lorge (1944), "pig" occures 44 times per million words, "hog" 14 times, "boar" 11 and "swine" 8.

As evidence that these words are synonyms their definitions according to Webster's Third New International Dictionary are presented. Each definition makes reference to at least one other of the words.

Boar--the uncastrated male of <u>swine</u>: a wild <u>hog</u>....

Hog---a domestic <u>swine</u>: a <u>pig</u>, sow, <u>boar</u>....

Pig---a young <u>swine</u> of either sex that has not reach sexual maturity: a wild or domestic <u>swine</u>....

Swine-any of various animals that constitute the family Suidae....A domesticated member of the species that includes the European wild <u>boar</u>....[By permission. From <u>Webster's Third New International Dictionary</u> 1986 by Merriam-Webster Inc., Publisher of the Merriam-Webster Dictionaries.]

Further evidence is provided under the entry "suines" in <u>Van Nostrand's Scientific Encyclopedia</u> (Considine, 1976). Suines are the group of mammals which includes pigs, boars, hogs and peccaries of the order **artiodactyla** (even-toed hooved mammals).

> In connection with domesticated <u>pigs</u>, certain terminology requires clarification. The term a <u>pig</u> and a <u>swine</u> are generally considered synonyms in most parts of the world, but in the United States, <u>swine</u> usually refers to <u>pigs</u> that are under three months of age. In England, Canada, and Australia, <u>pigs</u> are <u>swine</u> of any age or weight. Informally, untamed wild <u>pigs</u> are sometimes refered to a wild <u>swine</u>. Adult animals are often refered to as <u>hogs</u>, pariticularly the marketable and commercial animals. <u>Hogs</u> also refer to a castrated <u>boar</u>. ...A <u>boar</u> is a well-developed male used for breeding services. A <u>boar pig</u> is a male animal under breeding are (usually less than six months old)...(p. 2115-2116).

Additionally, the words appear to be used interchangeably. In an article on pigs in <u>National Geographic</u>, the author used all four words to refer to the same referent. Their frequency of occurrence in this article were: "pig", 104; "hog", 22; "swine", 11; "boar", 6 (Britt, 1978).

Second, the domain of animal names (cow, dog, horse, cat, sheep and goat) was chosen because theoretically valid results have been obtained with these words (Henley, 1969). Additionally, as Woelfel and Barnett (1982) and Woelfel and Fink (1980) have shown, a symbol's meaning is dependent on the domain in which it is scaled. The "pig" concept could have been scaled in a different domain, such as political terms, producing an entirely different solution. Further, the frequencies reported by Thorndike and Lorge were generated while these words were used in the animal domain rather than in some other context. Thus, the frequencies of occurrence estimates may have less predictive validity if the synonyms were scaled in some other domain.

Third, a number of attributes (bad, beneficial, good and attractive) were also scaled to define the synonyms. Cody (1976) has shown that the scaling of objects relative to evaluative adjectives provides theoretically important results. Finally, a concept of self, "myself", was included to test H_2.

The twelve individual concepts were placed in random order and then the pairs were ordered as specified by the Ross Matrix (Ross, 1939). The Ross procedure optimizes the order of presentation for words in the method of pair comparison. The method does so by maximizing the distance between a word and itself in the order of presentation and equalizes the number of times it appears as the first or second member of the pair. In this way, the effects of order are minimized.

In addition to the pair-comparisons, subjects estimated their frequency of use [encoding (speaking or writing) and ecoding (hearing or reading)] for the eleven words other than myself, estimated the attractiveness and benefit of the animals and answer a few deographic questions. The encoding and decoding estimates were in the form, "If 50 is once a week and 0 is never, on the average, how often do you ([say or write][hear or read]) these words?

Design and Subjects

Four alternative instruments were developed. They varied only in terms of which synonym was presented to the subjects. In every instance where the word "pig" was presented in one condition, it was replaced in the different conditions to "hog", "swine" or "boar". Besides the four alternative instruments, there were two different sets of treatments. Thus, the experimental design was 2 x 4. All measurements were post-test only. The printed message presented below was given to half the subjects. Only the animal name varied among the conditions. The word "pig" was replaced with "hog", "swine" or "boar" in the manipulation. In the four control conditions, the sentence, "For example," said Dr. Staltman, 'did you know that pigs are beneficial and attractive." was not included. Otherwise, the message remained the same. Thus, the potential confounding effects of the credibility of the source were controlled (Woelfel, et al., 1980).

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NEWS RELEASE

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Gene Shallit may not recommend this book for its literary merits but it will be the most important volume to be published this year," said Dr. Margaret Staltman. Staltman is director of a task force appointed by the U.S. Department of Agriculture to compile the latest data on animal husbandry and livestock management. This volume will be invaluable to farmers with an investment in livestock. "This volume on livestock managaement will be full of interesting and practical facts, figures and forecasts." "For example," said Dr. Staltman, "did you know that pigs are beneficial and attractive?"

The volume will be entitled, A Modern Guide to Animal Husbandry and Livestock Management, and will be published in June, 1979.

This message was generated by the procedures described by Woelfel, et al., 1976 [Chapter 12] and Serota, et al., (1977). These procedures use vector addition to identify the optimal message to alter a word's potition in a multidimensional space. A vector is constructed between a start concept and the locations of all the other words. The combination which results in the vector which correlated highest with a vector between the start and target alter the position of the synonym (the start concept) in the direction of myself (the target). Data from Barnett (1979) were entered into the optimal message generation procedures producing five sets of messages, one for each synonym and another for the combined data set. The message with the highest correlations with the pig-myself vector across all five conditions was, "(pigs) are benficial and attractive." This message would move each synonym along that vector which departs least from the direction of myself.

A test booklet containing either the manipulation or control message, the pair-comparisons and the other items was administered in the spring of 1979 to classes of undergraduates at an eastern technological university. Subjects were systematically assigned to one of the eight conditions, such that every ninth subject was assigned to the same condition. The administration took about 30 minutes. The groups' sample sizes ranged from 28 to 30. In total, 231 subjects participated in the experiment.

Results

Table 1 presents the mean distance of all the groups combined (N = 231), along with 8 additional vectors. These represent the distance of the synonym from the other 11 words.

The reported values were obtained after certain extreme values were removed via a smoothing operation. Any value greater than three times the standard deviation of the largest distance in the data set plus its mean was removed. The smoothing algorithm is presented in formula 3.

$$\text{If } X_i > (X_{max} + 3 \text{ S.D.}), \text{ then delete } X_i \qquad (3)$$

Three percent (3%) of the 488 estimates were removed from a total of 15, 864. the mean per cent relative error of these data for the 27 pair-comparisons not involving the concepts in the manipulation was 9.3%. This result is considerably better than one could obtain with Likert-type items. For a complete discussion of this statistic see Woelfel, et al., (1980).

These 8 matrices were transformed to spatial coordinates using Galileo(tm) 5.2. Table 2 presents the spatial coordinates of the 8 spaces combined. The overall coordinate system has 8 real roots, 3 complex roots. The first two real and the largest imaginary dimension of the spatial coordinates of the entire data set are present in Figure 1.[6] Together they account for 76.8% of the total (real & imaginary) variance in the overall coordinate system. If traditional methods for determining the underlying dimensionality of the configuration, such as the scree test were applied, these three dimensions would represent the "best" estimate of the dimensionality. But since these procedures are arbitrary, they will only be used here to compare the structures of the individual spaces (Barnett & Woelfel, 1979). All further analysis will use all 11 dimensions.

These three dimensions on the average, account for 66.2% of the variance in the 8 conditions. They range from 57.6%

TABLE 1

MEAN DISTANCES OF THE 8 DATA SETS COMBINED

	I	2	3	4	5	6	7	8	9	10	11	12
Bad	0.0											
Myself	99.73	0.0										
Cow	114.62	108.51	0.0									
Beneficial	141.28	39.12	40.92	0.0								
Dog	94.74	100.78	65.84	54.36	0.0							
Horse	112.81	118.26	41.28	57.20	60.44	0.0						
Cat	77.08	92.73	77.00	82.39	75.05	87.04	0.0					
Good	155.59	35.16	56.32	22.71	56.34	56.08	74.17	0.0				
Sheep	99.12	109.83	46.74	59.06	54.78	58.25	71.47	60.38	0.0			
Attractive	109.50	41.51	93.46	48.15	58.33	57.81	52.98	38.87	77.77	0.0		
Goat	90.56	119.54	55.24	72.20	57.41	57.04	81.00	74.42	41.88	86.20	0.0	
Synonym	86.05	123.84	52.95	74.20	61.78	71.28	77.49	50.55	52.12	121.06	45.50	0.0

MEAN DISTANCE OF INDIVIDUAL SYNONYM FROM EACH OTHER CONCEPTS

		1	2	3	4	5	6	7	8	9	10	11	N
SWINE	X	48.50	118.17	45.81	57.87	59.10	54.65	64.97	49.26	60.93	83.40	45.52	30
	C	78.23	213.40	72.50	100.35	66.25	67.32	85.18	56.55	47.24	180.44	51.72	28
BOAR	X	94.10	98.70	45.52	100.17	55.75	66.97	64.66	41.72	48.69	133.21	43.62	28
	C	69.72	100.82	50.69	84.66	66.72	71.10	71.72	56.03	57.35	107.86	45.59	29
HOG	X	109.13	117.85	61.03	72.52	54.37	75.77	73.03	45.10	54.36	104.54	47.30	29
	C	112.00	144.68	41.09	53.66	54.47	71.53	74.26	40.26	41.48	136.93	37.84	30
PIG	X	89.28	95.89	57.32	72.14	58.97	88.28	72.00	63.62	59.04	100.14	49.93	28
	C	86.45	108.89	50.28	55.45	79.13	75.33	114.20	52.62	48.38	134.76	45.21	29

TABLE 2

GALILEO COORDINATES OF ALL CONDITIONS COMBINED

	1	2	3	4	5	6	7	8
1	77.31	59.55	3.69	-11.84	-4.53	-3.42	-0.53	2.42
2	-46.64	62.66	26.61	-14.17	-4.60	0.86	-3.42	1.48
3	3.85	-34.74	6.56	-1.70	-28.78	-2.91	11.69	-4.79
4	-44.88	-12.68	9.37	-12.00	-7.11	4.40	8.81	-5.43
5	5.90	-6.90	-12.42	-9.94	30.32	-9.65	18.16	-2.95
6	0.31	-28.95	-34.09	-8.39	-13.26	-16.74	-9.22	6.99
7	13.93	26.39	-4.13	44.53	-4.38	-0.51	3.50	-5.12
8	-52.92	-20.17	15.21	12.11	11.09	-4.17	-10.05	3.55
9	14.60	-22.14	-4.03	2.43	1.49	26.09	6.34	13.49
10	-36.08	35.20	-35.51	3.69	3.89	1.84	-3.41	0.18
11	28.84	-24.50	-7.24	-10.36	6.80	14.86	-16.27	-13.30
12	35.71	-33.74	35.97	5.61	9.06	-10.66	-5.59	3.47
EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--								
	16842.62	14296.09	5041.40	2943.75	2303.58	1449.56	1101.97	527.68
PERCENTAGE OF VARIANCE ACCOUNTED FOR BY INDIVIDUAL FACTORS-								
	49.02	41.61	14.67	8.57	6.70	4.22	3.21	1.54
PERCENTAGE OF VARIANCE ACCOUNTED FOR BY INDIVIDUAL FACTORS IN THEIR OWN SPACES-								
	37.84	32.12	11.32	6.61	5.17	3.26	2.48	1.19

GALILEO COORDINATES OF 12 VARIABLES IN A METRIC MULTIDIMENSIONAL SPACE FOR DATA SET

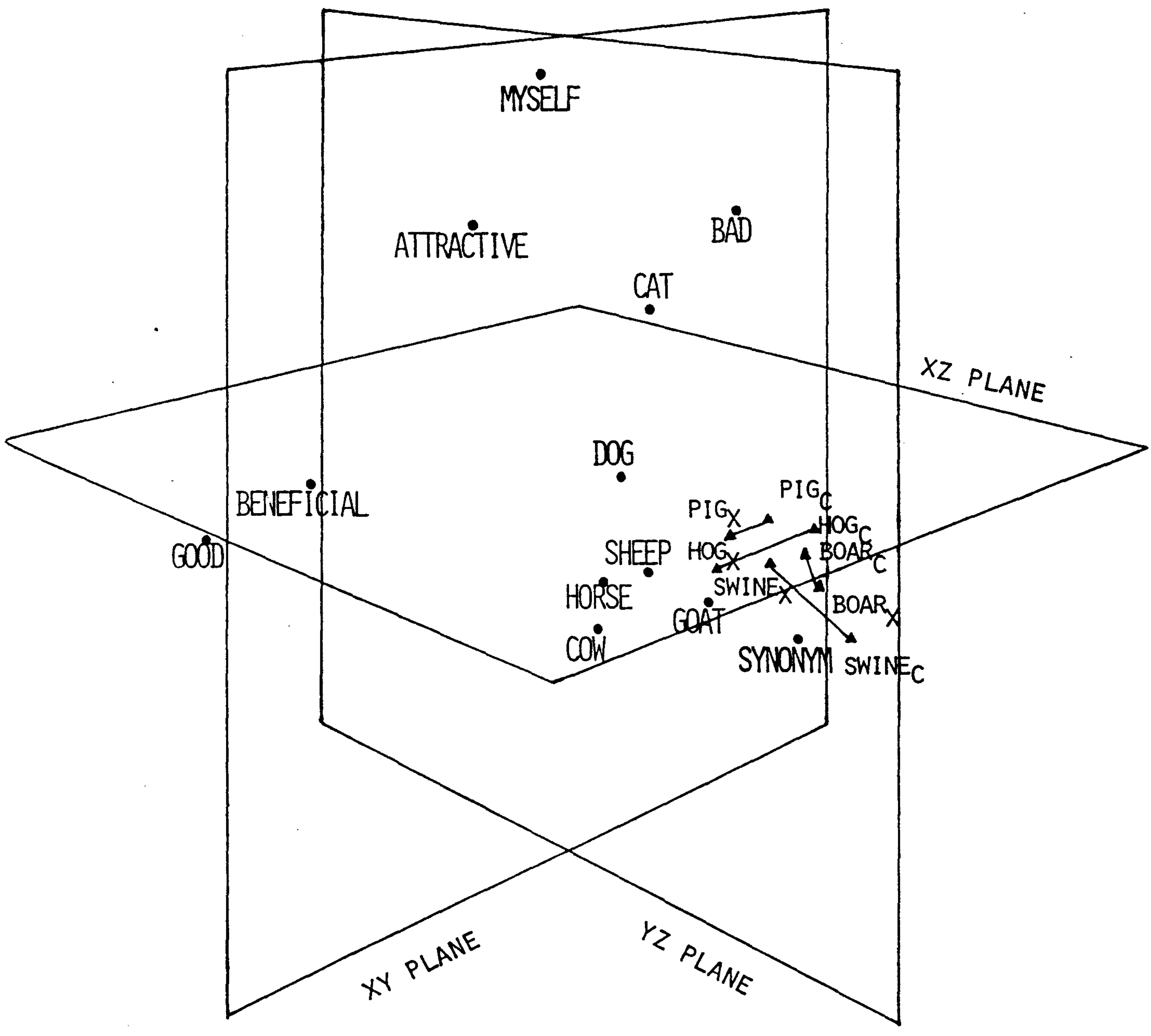
NORMAL SOLUTION

	9	10	11	12
1	0.21	0.57	-2.23	-39.45
2	-0.13	2.68	14.32	36.20
3	0.01	12.64	-8.85	3.79
4	-0.13	-16.57	-3.07	-26.98
5	0.02	3.69	10.04	8.31
6	0.00	-5.00	17.67	9.60
7	0.04	-4.44	14.03	7.59
8	-0.15	8.73	5.60	-45.59
9	0.04	0.19	4.43	6.19
10	-0.10	1.53	-36.35	7.49
11	0.08	1.85	6.90	7.59
12	0.10	-5.80	-22.49	25.30
EIGENVALUES (ROOTS) OF EIGENVECTOR MATRIX--				
	0.13	-615.80	-2832.60	-6697.72
PERCENTAGE OF VARIANCE ACCOUNTED FOR BY INDIVIDUAL FACTORS-				
	0.00	1.79	8.24	19.49
PERCENTAGE OF VARIANCE ACCOUNTED FOR BY INDIVIDUAL FACTORS IN THEIR OWN SPACES-				
	0.00	6.07	27.92	66.01

SUM OF ROOTS 34360.66 WARP FACTOR = 1.30

FIGURE 1

3 DIMENSIONAL PLOT OF BARNYARD ANIMAL DOMAIN



to 76.% (18.6%) and have a standard deviation of 5.5%. This suggests that these spaces have a comparable eigen structure. Further the synonyms are all located in the same region of the space. This can be verified by a visual examination of Figure 1. Additional evidence for the similarity among the spaces can be seen in the number of real and imaginary roots. All spaces had either 7 or 8 real and 4 or 5 complex roots. Thus, the semantic structures among the groups seem to be approximately equivalent.

In order to compare the groups, the 8 spaces were rotated to a least-square best fit congruence on the combined data set using all n-1 (11) dimensions (Barnett & Woelfel, 1979). However, only the unmanipulated words were used, so that the change in the words in the message could be assessed (Woelfel, et al., 1979 [Chapter 11]). The mean difference among the groups for the 8 unmanipulated stimuli was 13.52 units, or only 27% of the criterion metric. There is little difference among the groups. But it does suggest that semantic structure generated with words considered to be synonyms are not equivalent.

When the differences on the four concepts included in the experimental manipulation are examined, one received a different impression. For the four experimental groups, the root mean square (RMS) motion for these words was 59.28 units or slightly greater than the criterion pair, and 4.44 times larger than the eight stable words. This value was 32.21 for the control groups, or 2.35 times larger than the stable concepts. When the synonym alone is examined, there is substantial differences between the groups. For all groups, the RMS was 52.64 or 8.91 imes larger than for the other 11 words. For the experimental groups, it was 65.19 and it was 40.09 for the control groups, or 4.89 and 2.92 times larger than the stable words. These results indicated that there are differences among the spaces that are greater for those groups given a message to alter the structure. For the control groups, the differences are attributable to the differences among the synonyms. This suggests support for H_1.

Hypothesis 1

In order to determine if the variance among the groups could be attributed to the synonym rather than the other words, the spaces were again rotated to congruence. This time the other 11 words were included. This rotation attempted to minimize the discrepancies among the words which were manipulated in the design. The synonym was not included in the rotation. Since the experimental message was designed to alter the relations among the synonym and the other words, only the four control groups were used to test hypothesis 1. In this way, the manipulation would not effect the results.

The discrepancies among the synonyms and the other words are presented in Table 3. The mean difference among the pig concept was 42.39 and only 20.40 for the remaining words. This difference is 2.08 times larger and it significant beyond the .01 level ($t = 4.22$), suggesting that the null hypothesis of no difference among the semantic structures can be rejected. These differences may be attributed to the difference in meaning among the four "synonyms".

TABLE 3
DISCREPANCIES AMONG SYNONYMS

CONDITION	SWINE	BOAR	HOG	PIG
SWINE	0.00			
BOAR	50.34	0.00		
HOG	32.07	38.91	0.00	
PIG	46.39	26.89	60.05	0.00

MEAN = 32.39

MEAN DISCREPANCIES AMONG REMAINING CONCEPTS

	SWINE	BOAR	HOG	PIG
SWINE	0.00			
BOAR	16.20	0.00		
HOG	23.85	25.04	0.00	
PIG	21.50	19.02	16.80	0.00

GRAND MEAN = 20.40

Hypothesis 2

The medians for the estimated frequency of use for the four synonyms were: "pig", 20.0; "hog", 9.5; "swine", 4.7 and "boar", .3. Medians were used rather than means to control for the extreme values that some subjects reported.

The reported distances of the synonyms from myself are reported in Table 1 (see column 2). They are 118.17 and 213.40 for "swine" (experimental and control); 98.70 and 100.82 for "boar"; 117.85 and 144.68 for "hog and 95.89 and 108.89 for "pig".

An examination of all 12 hypothesized relations with swine, boar, hog and pig, for both the experimental and control conditions, reveals that 9 are in .10 level. The t-tests among the conditions are presented in Table 4. Because all of the unpredicted results concern boar, it may be useful to examine these results excluding boar. Under this condition all the relations are as hypothesized and 5 of 6 are statistically significant beyond the .10 level. Although the hypothesis is generally supported, it may be rejected because boar's values are not consistent with the hypothesized order.

Because boar's values are not consistent with the hypothesized order and the other reported relations it was dropped from the following analysis. The correlations for the control groups with the encoding estimates is r = .87, F = 3.15. For the control groups with thordike and Lorge's estimates, r = .94, F = 7.36. For the experimental groups the coefficients are r = .98, F = 24.01 and r = .91, F = 4.87 respectively. Due to the uncertainty of these coefficients, this analysis was also performed with the rank order of the frequency of occurrence or use. These coefficients are $r = .98$, $F = 24.01$, for the control groups and $r = .87$, $F = 3.15$, for the experimental groups. Since direction was specified by the hypothesis, the F-value necessary to reject the null hypothesis at the .05 level with degrees of freedom 1, n-2 was 80.70. When considering only the 3 synonyms the hypothesis seems supported. However, when statistical tests are applied none of the relations is significant. Thus, the null of hypothesis 2 cannot be rejected.

TABLE 4
T-TESTS AMONG CONDITIONS

	PIG		HOG		BOAR		SWINE	
	C	X	C	X	C	X	C	X
PIG	-----							
HOG	1.61 .10	1.40 .10	-----					
BOAR	wrong direction	.20 <.10	wrong direction		-----			
SWINE	3.64 .001	1.40 .10	2.17 .025	.02 <.10	3.11 .005	1.07 <.10	-----	

t-value
probability

Hypothesis 3

The third hypothesis suggests that the rank order of the differences between the control and experimental groups given a common message would be swine, boar, hog, and pig. This is because these words' frequency of occurrence is ordered pig, hog, boar and swine. The experimental manipulation was designed to reduce the distance between these synonyms and myself. As shown in Table 5 the differences in the synonym-myself distances did not behave as predicted. The attitude change resulting from the common message was much less than predicted for this symbol.

Again, if boar is removed from the analysis, the results are as predicted. The correlations of the differences with the frequency of occurrence as reported by Thorndike and Lorge was 1.0 and the correlation of these differences with the use estimates was $r = .94$, $F = 7.36$. This suggests that hypothesis 3 may be supported if "boar" is removed from the analysis.

TABLE 5
CHANGE AMONG CONDITIONS

	SWINE	BOAR	HOG	PIG
CONTROL	213.40	98.70	144.68	108.89
EXPERIMENTAL	118.17	100.82	117.85	95.89
CHANGE	95.23	-2.12	26.83	13.00

Discussion and Conclusions

The reported results suggest that semantic structures generated from "synonyms" are not equivalent. Despite the fact the synonyms refer to the same referent, their structures have systematic differences in meaning rendered by the individual word's unique relation to other words. Further, these variations seem to be behaviorally based, such that the more frequently a word is used, the closer it will be to the self. As a result, meaning cannot be determined by a small group of wise men composing lexicographies but must be determined by measuring the actual users of that language. Thus, the results support for a consensual behaviorally based theory of meaning (Barnett, 1976), which could be derived from the Galileo_{TM} paradigm.

This study further demonstrates the utility of the Galileo_{TM} System to cognitive process such as semantics and attitude change. The results suggest that frequency of occurrence is related to a concept's inertial mass. While the exact relation is unclear, frequency of occurrence does appear to be positively related to inertial mass and therefore inversely related to attitude change. The exact function appears to be an inverse power curve ($y = 1/x^k$) which becomes asymptotic with zero (attitude change) as frequency of occurrence approaches infinity. Although these conclusions are tentative, they do suggest that a word's frequency of occurrence in language may serve as an estimate for its inertial mass.

These results have important implications for attitude theory and research. They suggest that it is easier to change attitudes towards a symbol which occur less frequently in language than its synonym which occurs more frequently. The greater a symbol's frequency of occurrence in language, the more difficult it will be to change attitudes toward the referent of the symbol.

There are three reasons why these conclusions are tentative. One is the lack of variance in the synonym's frequency of occurrence. Two, the sample sizes for each condition were perhaps too small to produce sufficiently stable coefficients to test the hypotheses. And, three is the problem of domain specification.

In this research, subjects scaled only 4 different synonyms and regression analysis was performed on only 3 to infer the conclusions. Clearly, the number of synonyms was less than desired and the stability of the reported coefficients are uncertain. This problem could be somewhat ameliorated by including additional "synonyms" to the analysis thereby increasing the variance in frequency of occurrence in language. In this case one obvious synonym would have been "sow". While the addition of certain symbols would increase the variance in frequency of occurrence, it runs the risk of having a profoundly different semantic structure. This was the case with boar. It also increases the problem of domain specification. If "sow" had been added, it would have added a sex component to the analysis, because a sow is a female pig and boar a male. Pig, swine and hog refer to either sex.

A domain may be defined as a semantic field or a structurally related coherent set sharing some meaning properties or having some common class reference (Woelfel, et al., 1979; Fillenbaum & Rapoport, 1971). In this case, the domain is barnyard animals or across conditions, the synonym. While the procedures to measure meaning are straight-forward, the decision as to which words to measure is somewhat arbitrary. How does one define in advance the boundaries of the domain to be measured? One must rely on theory (Sharpere, 1977) because the structural organization of a particular domain and the set of underlying dimensions on which words may be arrayed are not known in advance. As shown here even dictionary synonyms produce signficantly different associational structures. Thus, the specification of the pig domain within the context of barnyard animals was uncertain adding unanticipated problems to the design. This resulted in ambiguous conclusions.

One implication of this study is that the researcher should take special care in the selection of the concepts when using Galileo_{TM}. The concepts should come directly from the same people who will be asked to perform the pair-comparisons. This is especially important if the reason for the research is to alter a population's attitude toward a given object. It has become standard practice in Galileo_{TM} research to perform a series of open-ended interviews to generate the actual words people use to evaluate a political campaign or commerical product (Barnett, et al., 1976; Woelfel, et al., 1980; Woelfel & Fink, 1980). The unacceptable alternative is for the researcher to impose a set of concepts on subjects to use when evaluating an object, even when a well-developed theory is used to guide the selection process. This may result in a misleading solution and an unsuccessful message campaign, even if the choice of words is only among a set of synonyms.

When the choice of words is among two or more synonyms, the researcher should choose that one which occurs least frequently if its position is to be altered and the one which occurs most frequently if the concept is to be a stable reference point. This is because frequency of occurrence seems to be inversely related to attitude change. Those which occur less frequently have less inertial mass and are therefore easiest to change. On the other hand, those which occur most frequently have more inertial mass and are thus more stable.

This suggests that one should always pretest words for their frequency of use of the population under study or check their frequency of occurrence in one of the standard references when using samples from the entire population. This will provide some estimates of the concept's inertial mass prior to performing the actual research.

Future research is planned to more precisely determine the relations among a symbol's frequency of occurrence, its distance from a self concept and attitude change, and to develop methods to determine a concept's inertial mass through a variety of experimental procedures. Regarding the former, regression analysis may be performed to predict the reported distance from self from the symbol's frequency of use in language, controlling for the criterion metric. This may be easily accomplished be secondary analysis of the many studies which have employed this methodology (Barnett, 1980).

Summary

In summary, this chapter has investigated the nature of synonyms and found that they are not equivalent in meaning despite having the same referent. Systematic distortations from equivalence resulted due to their variance in frequency of occurrence in language, such that, the more frequent a symbol is used, the closer it is to one's self concept. Further, frequency of occurrence appears to be related to what Woelfel and Saltiel (1978, Chapter 3) call inertial mass, that property which makes cognitive objects resistant to attitude change. In this study, the more frequently a word occurred the less attitude change resulted when given equivalent messages.

NOTES

1. An earlier version of this paper as presented to the third annual workshop on Metric Multidimensional Scaling at the International Communication Association, Acapulco, Mexico, May 18-23, 1980. The author would like to thank Joseph Woelfel, D.R. Brandt, N.J. Stoyanoff, James W. Dinkelacker, James Gillham and my Spring, 1979, class in communication research without whom this chapter would not have been possible. A special note of thanks is due Jim Henson and Miss Piggie.

2. This paper assumed a strict definition of synonyms, i.e., words which express identical or equivalent meaning and may be equally interchanged. They may be defined wholly, or almost wholly, in the same terms. Historically, there has been considerable debate over the definition of the term synonym. For a complete historical review and statement of the current status of the issue of synonyms, see the introduction of Webster's New Dictionary of Synonyms, Philip B. Gove, editor (1973).

3. The use of significance tests and inferential statistics runs against the spirit of MMDS. MMDS uses a series of continuous ratio scaled distance estimates. It seems absurd to reduce these estimates to a dichotomous decision of acceptance or rejection of the null hypothesis. These data should be used as a description of the semantic structure of groups. Thus, one could say they describe a certain relationship without attempting to infer beyond the sample of subjects or concepts. Additionally, these data are based on a large number of independent observations of the relationship between a particular pair of concepts. This notion is not taken into account by this

significant test where the unit of analysis is the number of words or spaces and thus the degrees of freedom are some small numbers rather than the number of independent observations.

4. A computer program, Galileo$_{TM}$ 5.2 (Woelfel, et al., 1976) contains all the necessary algorthims to perform the analysis described in this paper. Galileo$_{TM}$ is an integrated computer package for metric multidimensional scaling utilizing paired distance judgement data.

5. An alternative procedure would be a pre-test post-test experiment with individuals as the unit of analysis with their individual estimates of the frequency of use. However, since MMDS is designed to study cultural aggregates rather than individuals and language is a property of entire social systems, this procedure was rejected in favor of the post-test only design.

6. The displayed locus for the individual synonyms were generated as follows. For each group a set of spatial coordinates was produced. Then, each of the spaces were rotated to congruence with the overall space using only the unmanipulated words, those not included in the experimental message. Thus the synonym, the self, beneficial and attractive were allowed to vary, yielding the coordinate values plotted in Figure 1. This analytic procedure is explained in greater depth by Woelfel, et al. (1979).

7. Imaginary variance results because the multidimensional spaces are non-Euclidean. That is, the mean distance matrices are non-postive semi-definite. This problem is explained further by Woelfel and Barnett (1982).

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