The Impact of Galileo Theory as a Mass Persuasion Technique: Experience with the Adoption of an Agricultural Technology

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ABSTRACT Galileo theory is a theory of cognitive change operationalised by multidimensional scaling representations of relevant cognitive concepts or objects, such as the relevant concepts and attributes of a new technology. A mathematical vector addition procedure is used for analysing the dimensional relationships between concepts to assess the effects of persuasive messages to bring about attitude change. The content of the most efficient messages for this purpose can thus be established. Samples of Wisconsin dairyfarmers in three experimental and two control groups were used to assess the impact of Galileo derived messages on changing attitudes towards, and adoption of, a new technological service. The results provide tentative support for the theory.

Introduction

There has been a long interest in rural sociology in the processes of adoption and diffusion, largely reflecting instrumental objectives of planned social intervention. Strategies of persuasion to influence attitudes and, in turn, the behaviour of farmers and others are both explicit and implicit in most programs which seek to influence rates of adoption. Developments in the modelling and analysis of social "cognitive structures" have meant the effects of communication processes can be measured and the impact of persuausive communication can be predicted.

Woelfel and his colleagues have developed a series of techniques, known as the Galileo system, for analysing group cognitive structures in which spatial structural relationships are derived by multidimensional scaling (Woelfel and Fink, 1980; Woelfel, 1980; and Serota, Cody, Barnett and Taylor, 1978). The set of procedures identifies the main concepts any group of people use to understand and define a topic. The beliefs and attitudes a group hold about the relevant concepts can be measured accurately. Quantitative procedures can then be used to establish the most effective persuasive messages for the audience about the topic. The relative efficiency of all possible message strategies relevant to the problem of interest can be systematically established. This measurement based system thus identifies the most efficient communication strategies of the range of possible messages for mass communication.

Persuasive messages based on Galileo analysis have been used in areas such as the marketing of automobiles, the advertising strategies for a political candidate (Barnett, Serota and Taylor, 1976), the tourism industry (Korzenny, Ruiz and Ben David 1978), setting the advertising foundation for a statewide referendum, and attempts to increase the use of a dairy herd testing service offered by the Dairy Herd Improvement Association (Wallace 1979). In each of these studies, a small sample was taken from the target population, their attitudes and beliefs were measured using the Galileo procedures, optimal messages generated and

distributed through various media to the target population and the behavioural changes in the population subsequently noted. In each of studies behavioural changes in the predicted directions were noted, however there was no attempt to determine if cognitive changes in the multidimensional representation corresponded to the changes in observed behaviour and no analysis was undertaken to determine if the behavioural changes in the target populations were causally linked to the persuasive broadcast messages. Lastly, although some studies have shown cognitive changes (see Cody 1980), these studies suffered from the lack of measures of behavioural change or pretest control groups for the baseline measurement of change.

Galileo theory

The Galileo system employs metric multidimensional scaling (MMDS) to provide a dimensional representation of distance, or dissimilarity, measures, amongst the concepts which are relevant to the communication problem of interest. The MMDS projection onto N coordinate axes can be thought of as an N-dimensional map, in a space-time continuum, of cognitions relevant to the communication problem. The continuum is multidimensional because a separate vector will locate each attribute or object in the cognitive space. MMDS[1], unlike nonmetric scaling, employs transformations which preserve the distance or metric characteristic of the raw data. The Galileo theory of mass communication is based upon using this cognitive representation to predict movements of concepts through space due to the introduction of informational or persuasive messages. Galileo theory represents a definition of attitude as a response locating an object of thought on multiple dimensions of judgement (McGuire, 1985). The concept "self" is one of the objects that can be positioned in the multidimensional space. Changes in beliefs about concepts (such as might be induced as a result of a communication) are conceptualised in terms of changes in the positions of these concepts relative to others in the same knowledge or cognitive domain. Changes in attitude are are interpreted in terms of changes in the position of self in relation to these concepts. The essence of the theory is that the direction of these changes may be predicted on the basis of the initial positions of the concepts involved. In this conceptualisation of attitude and belief the dimensions of the cognitive space reflect the subjects' personal judgemental criteria rather than those imposed by a researcher.

In the typical conventional use of a multidimensional scaling solution visual analysis and intuitive judgement of the configuration of the concepts in the first two dimensions are used to design a message strategy to bring about attitude change. In the Galileo approach a simple vector addition procedure is used to establish a theoretically optimum message set based on the concepts being used. Using the coordinates of the N-dimensional space as a reference frame, concepts are located as position vectors from an arbritrary origin and attitudes are defined as vectors from the self point to the remaining concepts. A vector is constructed between the concepts one wishes to move, then the surrounding concept vectors are analysed to determine which, when associated with the initial vector, will cause the greatest movement in the desired direction. The amount and direction of change in the N-dimensional space can be calculated from the Galileian Transformation equation for the

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[1]Metric multidimensional scaling is essentially an unstandardised principal components factor analysis.

acceleration of associated masses (Einstein, 1962). The accelerated concepts, with unit inertial mass, are hypothesised to move along a resultant vector, which is obtained by the summation of the vectors from the concept to be moved to each of the concepts with which it is paired in the message. The cognitive representation is thus used to identify optimally persuasive messages[2] with which to move the concept of interest towards a designated 'target' concept according to vector theory.

Galileo theory reflects the development of an accumulated information model of persuasive communication and belief change: belief change is proportional to the discrepancy between the original belief and the belief communicated in the message, and inversely proportional to the amount of information which the receiver has about the topic at the time the message is received (Danes, Hunter and Woelfel, 1978). Informational messages are seen as analogous to forces acting on the concept objects which have the properties of inertial masses.

Research design and approach

Objectives

The communication objective of this study was to persuade dairy farmers in north western Wisconsin to subscribe to the Wisconsin Dairy Herd Improvement Cooperative's Somatic Cell Testing program (the DHIC SCT). This program is designed to quantitatively identify subclinical, or hidden, mastitis which is a mammary gland infection of dairy cattle. The Wisconsin DHIC has in the past attempted to persuade farmers to subscribe to the program through agents of the association, but the expected response level did not materialize.

The experimental objective was to compare the predicted and actual attitude and behavioural change associated with Galileo determined communication messages.

Experimental design

The experimental design incorporated two experimental groups of farmers not currently using the SCT program. One group received an optimal message based on Galileo theory (the MAX group); the other group received a relatively less efficient message which Galileo theory indicated would have a smaller positive effect (the MIN group). The two sets of messages, designed to persuade farmers to subscribe to the DHI SCT service, were administered between pre and posttest interviews (time T1 and T2) in which attitudes were measured.

Two control groups were utilized, one group (CON1) was interviewed at both T1 and T2, but received no persuasive message. The second control group (CON2) was interviewed at T2 and received no message. The CON1 group served as the baseline group against which any change in the experimental groups was measured, while the CON2 group was used to detect any effects due to sensitization caused by the pre-testing at TI. An additional group of users of the SCT (USERS) were utilised to establish the differences in attitude and belief between user and non-user groups.

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[2] Messages are defined as assertions about the interrelations among the concept objects in the domain or cognitive space.

Sample selection

The membership list for Wisconsin DHIC, indicating users and non-users of the SCT for six counties in northwestern Wisconsin, provided a population of 541 non-users (those never having participated in the SCT program), 601 users (those currently in the SCT) and 327 former users who had withdrawn from the SCT. The experimental and control samples were drawn by random selection from the non-user population: two experimental groups MIN and MAX, a control group CON1 (each n=35), control group CON2 (n=30), and a concept elicitation group (n=73). A USERS sample (n=31) was randomly selected from the user population.

Galileo procedures

The first step in a Galileo study is to elicit the salient concepts in the area to be investigated. Next, similarity scores for all possible pair-wise comparisons of these concepts are recorded on a common ratio scale. This is accomplished by choosing a pair of criterion concepts related to the concepts under investigation and assigning a value to represent the difference between the two criterion concepts. Each of the exhaustive pair-wise concept comparisons is then compared to the criterion pair. This comparison is the ratio of the perceived difference of the comparison pair to the criterion pair and has the properties of a ratio scale. A metric multidimensional representation is derived for the mean distance scores for respondents in a designated group.

Methodology

Interviews of all subjects were undertaken by the Wisconsin Survey Research Laboratory using a computer assisted telephone interview procedure. Focus interviews of subjects in the concept elicitation group identified those concepts or ideas most frequently used by farmers to structure their thinking about the problem of subclinical mastitis and the place of the SCT. The interviews were tabulated and a frequency count was made of the words and concept labels used by the respondents in order to establish the most commonly used descriptors. From this list, the seven most frequently mentioned concepts were included in the questionnaire together with the concepts 'yourself' and 'DHI somatic cell test'.

A survey instrument incorporating the 36 possible pair-wise comparisons of the nine concepts was administered to subjects in each of the experimental and control groups. For the pairwise distances between the concepts the primary cognitive dependent variable was the mean distance between the concept 'DHI SCT' and the concept 'yourself', representing the attitude toward the DHI SCT. The smaller the distance, the more favourable the attitude toward the DHI SCT.

Using the pooled data analysis (all non-user groups at time T1), the relative persuasion efficiency of all possible concept combinations was calculated. The minimum effect message was constructed from the concepts 'high somatic cell count', 'hidden mastitis', 'expensive', and 'monitoring'. The message read "Monitoring high somatic cell counts can reduce expensive hidden mastitis". The maximum effect message was composed of the concepts 'creamery', 'milk quality', 'profit', and 'monitoring'; it read "Monitoring milk quality increases your profit at the creamery". Both messages contained the statement "Sign up for DHI's sommatic cell test program now".

Flyers with the respective persuasive messages were mailed to both the maximum and minimum experimental groups, followed by another identical flyer five days later. All flyers were mailed in envelopes containing the return address of the Dairy Science Department at the UW-Madison. None of the flyers were returned, so it is assumed that all of the flyers were delivered to the experimental subjects.

Four days after the second set of flyers were mailed, the second wave of interviews commenced, with the same pairwise comparison instrument being used. Of the 35 subjects interviewed in each of the three groups at time T1, in the MIN group 29 were reinterviewed ,in the MAX group 30 were reinterviewed , and in the CON1 group 34 were reinterviewed. The post-experimental control group CON2 consisted of 30 completed interviews, of which 28 were usable. Once the second wave of interviews was completed, the DHIC was instructed to identify all the subjects who subsequently subscribed to, or sought information about, the SCT.

Results

(1) Unidimensional analyses of distance data

Analyses of distance data are based on comparisons of the distance between the concept "DHI SCT" and the concept "self" which were predicted to change as a result of the persuasive messages. Comparison of the sample of those farmers using the SCT program and the group samples of the non users indicates a significantly smaller distance between the program and the self position and hence a more favourable attitude towards the program (Table 1).

Table 1. Mean distance "DHI SCT' and "self": Users and nonusers

Users (n=31)		All Non Users (n=104)				
Mean distance	Stnd. error	Mean distance	Stnd. error	Mean Diff.	t	Signif.
36.8	7.5	51.7	5.4	14.9	1.61	.05

The theoretical efficacy of the content of the two persuasive messages is presented in Table 2. The two message sets were derived from the 9 dimensional coordinates of the aggregated non user samples. A separate analysis of the relative efficiency of the message sets for the individual MIN and MAX groups indicated the same message sets would be selected.

Table 2. Theoretical predicted attitude change for MIN and MAX messages[a]

Message	T2 Distance: DHI SCT-Self[b]	T2 Dist vs T1 Dist %
MIN	45.3	88
MAX	23.1	45

a Based on all non users sample (n=104).
b Predicted by resultant vector of relevant message set.

The substantive univariate tests of the effectiveness of the message sets derived by Galileo theory are presented in Tables 3, 4, and 5. The change in attitude brought about by the MIN message was as predicted by the theory, the change in attitude being marginally significant (Table 3). Comparison of the attitude position for the MAX message group at time T1 and T2 indicates only a small change in the predicted direction. When the change of attitude for the experimental groups is compared with that

Table 3. Within group differences: Mean distance "DHI SCT" and "self" at time T1 and T2 (paired samples)

Group	Time T1		Time T2		T1-T2		
	Mean	S.E.	Mean	S.E.	Diff.	t	Signif.[a]
MIN (n=29)	60.7	11.3	46.3	9.0	14.4	1.41	0.08
MAX (n=27)	45.2	11.4	43.9	6.9	1.3	0.13	0.45
CON1 (n=29)	45.3	6.4	54.8	8.6	-9.5	-1.10	0.14

a one tailed tests

of the control group CON1, the large difference for the MIN message group is significantly different from that for the control (Table 4). Comparisons of the time T2 position of the MIN and MAX groups with the CON1 control group (Table 5) indicate a similar positive, but statistically not significant, effect of the two message sets on attitudes towards the SCC program.

Table 4. Change in attitude (mean distance differences between time T1 and T2): Experimental groups vs control group

Group	Experimental Mean	Experimental SE	Control Mean	Control SE	Diff	t	Signif.[a]
MINT1-MINT2 vs CON1T1-CON1T2	14.4	10.2	-9.5	8.6	23.9	1.80	0.04
MAXT1-MAXT2 vs CON1T1-CON1T2	1.3	10.2	-9.5	8.6	10.8	0.81	0.20

a one tailed tests

Table 5. Between group differences: Mean distance "DHI SCT" and "self" at time T2

Group	Experimental Mean	Experimental SE	Control Mean	Control SE	Diff	t	Signif.[a]
MIN vs CON1 (n=29) (n=30)	46.3	9.0	55.7	8.4	-9.4	-0.76	0.23
MAX vs CON1 (n=28) (n=30)	45.9	7.0	55.7	8.4	-9.8	-0.89	0.18
CON1[c] vs CON2 (n=30) (n=28)	45.3	6.4	33.3	6.3	12.0	1.34	0.19[b]

a one tailed tests
b two tailed test
c CON1 measured at time T1

Consideration of the control groups suggests that there were interviewing effects or exogenous factors which caused an increased difference, or a less favourable attitude, over time (Table 3). The group interviewed post treatment only (CON2) indicated a more favourable, but statistically not significantly different, attitude to the SSC program (Table 5). For the CON2 group, the grand mean for all between concepts distances was considerably less than for all other groups, suggesting that this group employed a different metric scale when making pair-wise

comparisons between concepts. If the difference for the CON2 group is rescaled so that the group grand mean is equivalent to the other groups there is no apparant attitude change from CON1 at time T1. While a weak inference might be drawn that that there was a generally more favourable disposition towards the program over the duration of the study, it does appear that the interview procedures themselves tended to have a sensitisation effect, making subjects less favourably disposed towards the program.

(2) Three dimensional relationships between concepts

In this section three dimensional representations of the relevant motions are presented: in the subsequent section motions in the total space will be considered. The unidimensional analysis of attitude change ignores a large amount of the information available in the pre and post treatment data matrices concerning the belief structures relevant to the concept of interest - the SCT program. Use of a spatial model, implicit in the use of multidimensional space as a representation of cognitive relationships, means that a change in attitude is a motion in the space involving a general change of position relative to other concepts which define the space. The remaining analyses involve a Procrustes rotation of the group spaces to a modified least squares best fit (see Woelfel and Danes, 1980; Schonemann and Carroll, 1970). Since the axes in a multidimensional space have an arbitrary orientation, rotation and translation is necessary to "match" the spaces as closely as possible before comparisons of them are undertaken. The transformation minimises the discrepancy between the spaces while leaving the measured distances invariant.

The contrast in spatial relationships of concepts for users and non users is shown in Figure 1. The relationships between concepts, representing the belief structures, of users and non users show differences of some magnitude. There are important contrasts for at least five concepts: non users see the SCT [7] as expensive [6] whereas users do not; but in contrast, users see hidden mastitis [5] as expensive [6] whereas non users do not. For users, SCT [7] is more closely associated with milk quality [3] and monitoring [8]; non users see themselves as closer to quality milk than users. The rotation procedure has ensured that the two configurations are centered on a rigid self point, allowing relative differences in attitude (distance of a concept from the self) to become apparant. Large differences in attitudes are evident. Users are more concerned about high sommatic cell count [1] and hidden mastitis [5] and are more favourably disposed, than non users, towards SCT [7].

Figure 1 about here

Motions in three dimensional space for the experimental treatments (Figure 2) depict a "trajectory", the points for each concept being the position of the aggregrate group of non users at time T1, and then the time T2 positions of the CON, MIN and MAX groups, respectively, each rotated to a best fit with the T1 aggregate group. A comparison of the self concept [9] and SCT [7] shows these concepts to be closest together for the MIN message group and futhest apart for the CON1 group. The MAX message produced the largest movements toward the self concept [9] for high sommatic cell count [1] and hidden mastitis [5] - both concepts which differentiated the user group from non users (see Figure 1).

Figure 2 about here

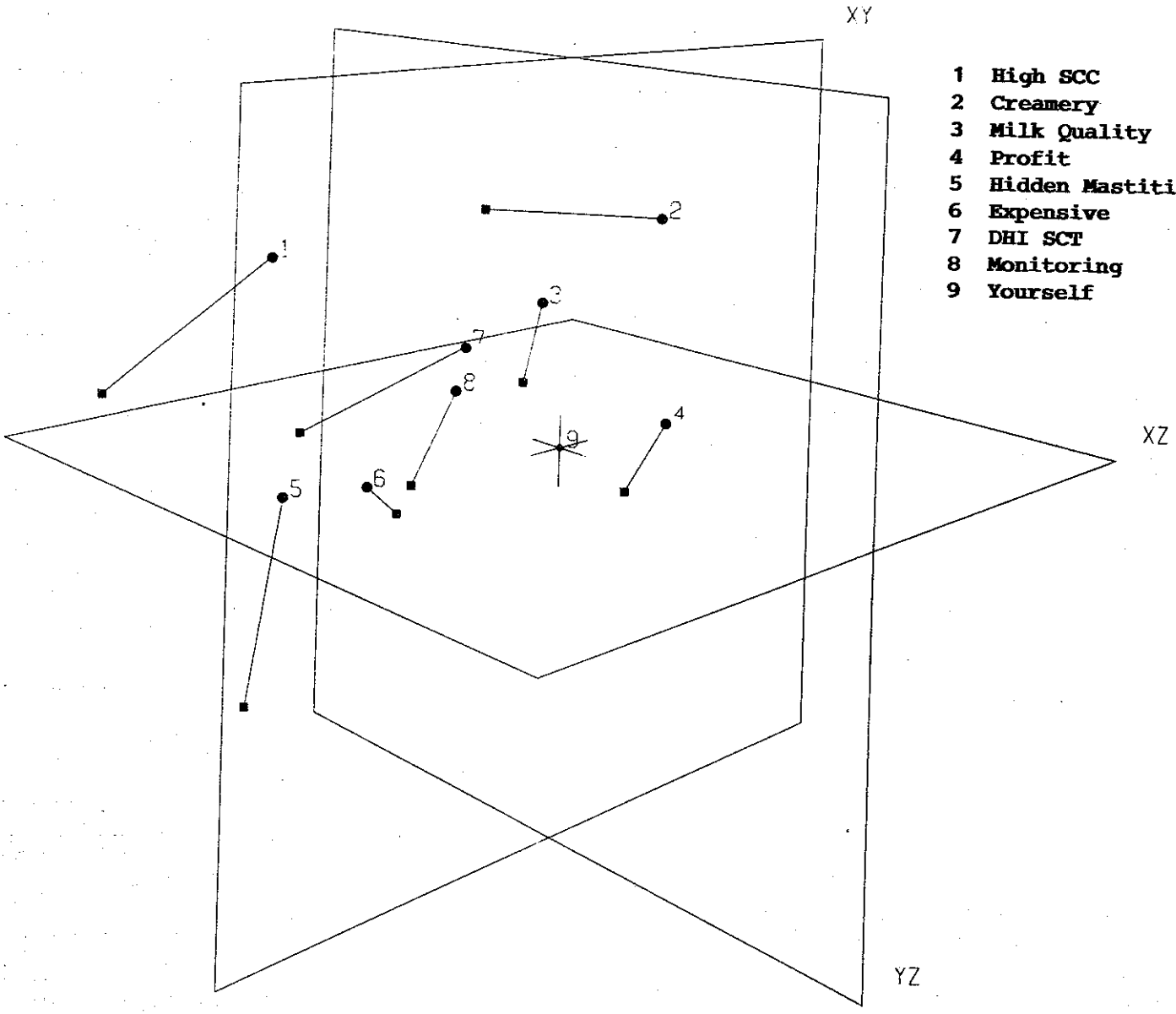

Figure 1. Comparison of SCT users (●) and non users (■).

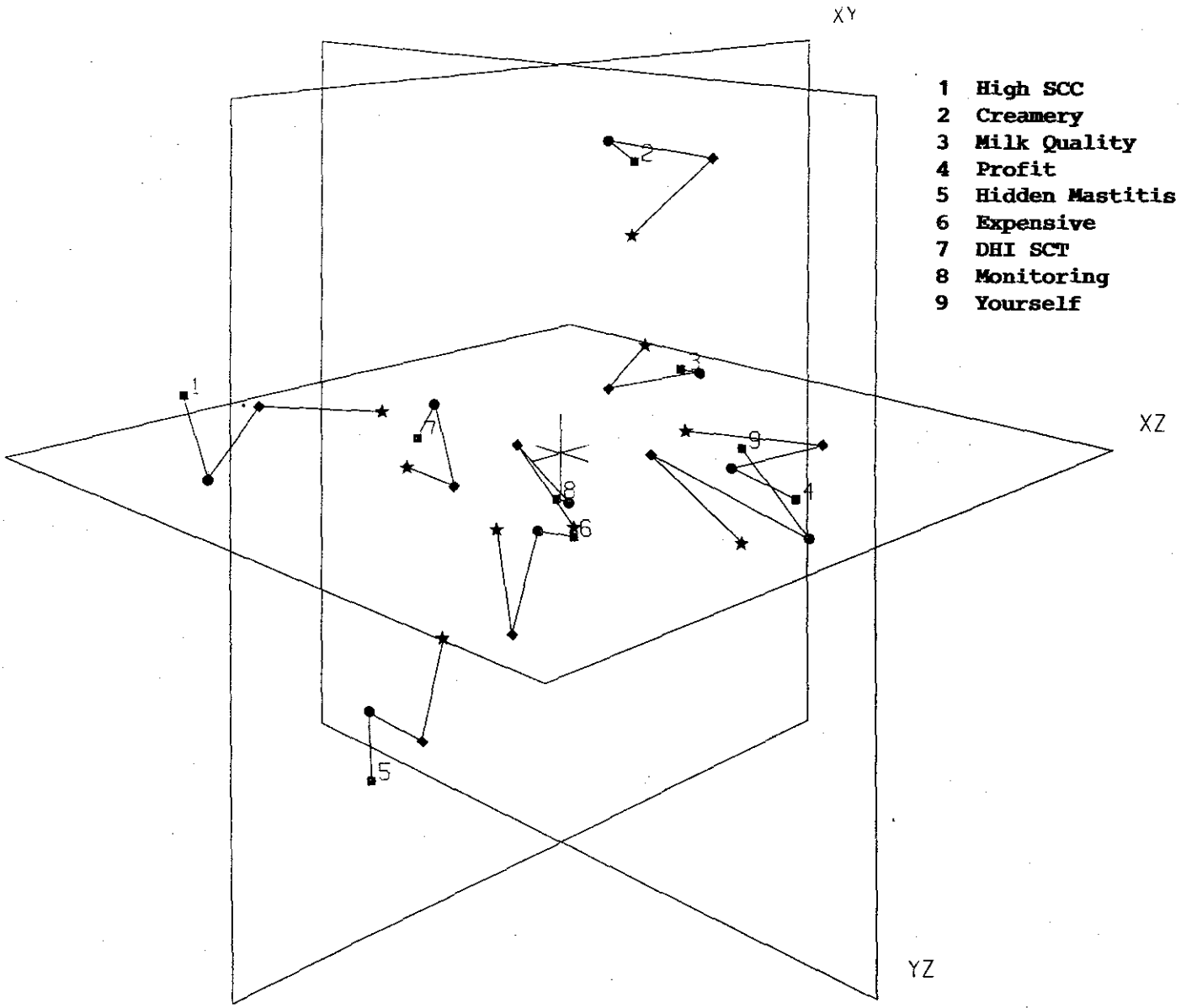

Figure 2. Comparison of treatments: time T1 - all non users (■); time T2 - CON1 (●), MIN (◆), and Max(★).

The belief structures of the T1 aggregate group and the T2 CON1 group are essentially similar for concepts 2,3,6,7, and 8. The "zig zag" motion of the self concept suggests considerable attitude variation between the four treatments or conditions.

(3) Relationships in the total space

The three dimensional analysis is inaccurate, or inefficient, to the extent that not all of the variance in the matrix of mean pairwise distances is captured in three dimensions. For the unweighted least squares rotation, used to compare the T1 and T2 conditions, the relative motions of the concepts in the total space can be calculated. The distance is given by the square root of the sum of the squared differences between coordinates of the concept at time T1 and T2 (see Woelfel and Fink, 1980). The Riemannian distance that each concept moved from its time T1 to time T2 position is shown for the MIN, MAX and CON1 groups in Table 6.

Table 6. Distances moved between time T1 and time T2 for experimental and control conditions (in nine dimensional space)

CONCEPT	Condition MIN	MAX	CON1
1 High SCC	21[a]	10i	8
2 Creamery	7i	34[a]	10
3 Milk Quality	13i	32[a]	2i
4 Profit	16i	40[a]	14
5 Hidden Mastitis	40[a]	4	5i
6 Expensive	40[a]	13i	13
7 DHI Somatic cell test	22[a]	30[a]	15
8 Monitoring	52[a]	5[a]i	7i
9 Yourself	15i	15i	14
Mean Motion	13.7	10.7	6.5

[a] Manipulated concept
i Imaginary number in riemann space

In the nine dimensional analysis the largest mean motion occured in the MIN group and the smallest in the CON1 group. The largest distance moved for DHI sommatic cell test was in the MAX message group and the least distance for the CON1 group. More importantly, the concepts for which large movements (greater than 20) occured were exclusively the manipulated concepts - those respectively used in each of the message conditions. This evidence emphasises the differential effect of the respective messages on the cognitive structures or belief systems of each of the experimental groups. No large concept movements were observed in the CON2 group.

(4) Behavioural changes

Records were kept of the members of each of the MIN, MAX and CON1 groups who made enquiries about, or enrolled for, services of the DHI SCT program. Two months after the experimental messages two members from the MIN, three members from the MAX, and two members from the CON1 groups had signed up for the DHI SCT program.

Discussion

The developments in the modeling of cognitive stuctures and the analyses of the communication effects in cognitive space which are incorporated in Galileo procedures have three main components. Firstly, the use of well established metric multidimensional scaling procedure to provide a coordinate framework in which to structure relationships between relevant concepts. Secondly, relatively new rigid motion rotation procedures which minimise the the discrepancy between multidimensional spaces while leaving the measured distances within each space invariant, allow a common frame of reference across time periods and thus allow observation of the relative movement of concepts under different experimental conditions. Thirdly, the use of vector addition procedures to determine the resultant motions as a result of impact of message sets which are hypothesised to act as "forces" in the multidimensional cognitive space. Such an analysis depends, amongst other things, upon the ratio metric nature of the multidimensional space. The research in this study was directed towards this last component: assessing the effectiveness and validity of messages generated by Galileo procedures.

Differences in the cognitive structure of users and non users of SCT were identified, particularly in relation to the expensiveness of SCT and of hidden mastitis. The magnitude of the difference in attitude toward the SCT of users and non users of the SCT provides support for the validity of the distance from an object to the self position being related to behaviour toward the object. The changes in attitude of the non user experimental groups, as a result of the two persuasive messages, were in the predicted direction; but only the MIN case was of the predicted magnitude. The movement in attitude of the MIN group was significant when tested against the time T1 position and against movements in the CON1 group from time T1 to T2. Movement brought about by the MAX message was less than that of the MIN message and not significant when compared against its time T1 position or the control group. The large standard errors associated with small sample sizes meant that large differences were required for statistical significance.

While the MAX message had a more demanding requirement of attitude movement, the message had less power than the MIN message. Explanations of the apparent failure of the MAX message are, to some extent, conjectural; but factors related to the context of the message and to the selection of the messages may be relevant. A consideration of the message sets indicates that there were rather few "degrees of freedom" in the selection of the two messages. The MIN and MAX messages each incorporated five concepts from the pool of nine concepts, with two concepts (SCT and Monitoring) being common to both messages and all of the concepts being employed in one or other of the messages. The linking of concepts, identified by Galileo procedures, to form a message also provides an additional source of variarability which may distort the experimental conditions. In order to construct a sensible message both experimental conditions contained key words which were not generated by Galileo procedures. The MAX message contains the word "increases" and the MIN message contains the word "reduces", both potential concepts for changing the influence of their respective messages. Independent evidence collected during the study suggests that the sequence of concepts in the MIN message "reduce expensive hidden mastitis" would have more credibility than the MAX message "increase your profit at the creamery". The link of logic from expensive hidden mastitis to increased profit is more extended (and more problematical) in the MAX message.

In the nine dimensional analysis the largest motion of SCT was for the MAX message, but apparently this motion was not strongly in the predicted direction towards the self point. The large distances moved by the message concepts suggest that the messages had an impact on belief structures consistent with the respective content of the messages.

The complex and tenuous nature of the link between attitudes and behaviour has been well documented in the attitude literature (see Dawes and Smith, 1985). The numbers of subjects recorded as signing up for the SCT program were small. The differences between groups could not be regarded as significant; however, nine per cent of the members of the MAX group adopted the SCT program which, if translated to a large population, would be regarded as an acceptable behavioural impact in a marketing campaign.

In this study the evidence of the persuasive power of Galileo generated messages is somewhat tentative: relevant belief structures were changed in both experimental conditions, attitudes were changed in the predicted direction, but attitude change of the predicted magnitude only occured in the MIN condition. Evidence of associated behaviour change was not conclusive. However, constraints imposed by the experiment itself and the relatively complex behaviour linked to the attitudes which were the focus of the study, suggest that it would be productive to investigate a series of situations of varying attitude and behavioural complexity with larger experimental samples and larger concept pools from which to select message sets.

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