The Galileo System: a Rational Alternative to the Dominant Paradigm for Social Science Research[1]

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A measurement is a comparison to a standard. -- William Shockley

By number we understand not so much a multitude of Unities, as the abstracted Ratio of any Quantity to another Quantity of the same kind, which we take for Unity -- Sir Isaac Newton (1728)

There shall be one measure of wine throughout Our kingdom, and one of ale, and one measure of corn, to wit, the London quarter, and one breadth of cloth, to wit, two ells within the selvages. As with measures so shall it be with weights. (Runnymede, 1215)

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Introduction

All businesses operate in a world defined by communication. We need to know what our product or service is, and how to make or provide it. We need to know how to buy the supplies and services needed, and we need to know how much to pay for them. We need to know who our customers are and how to reach them, how to find, hire and support employees, and much, much more. Through communication, we are able to reach agreement about these things with our suppliers, customers, investors, employees and others in the environment where our business exists.

Communication is a process in which we encode our experiences into symbols and share them with others, who must relate those symbols to their experience. We attempt to ensure that the same symbols represent the same experiences by adopting *standards of comparison* which all our communication partners share. We know how large our products are by comparing them to the standard meter. We know how long it takes to make a product by comparison to a standard hour. We know how much our product is worth by comparing it to the standard euro, dollar or yen. In fact, this is the formal definition of measurement: *comparison to some standard.*

Our ability to communicate clearly and precisely about our experiences is not fixed in nature, but is an evolutionary, developing process. Out of communication emerges an increasing communality of shared experiences and symbols for representing those experiences. People meet in conferences to establish shared references and standards of comparison, as in the Magna Carta and the Treaty of the Meter. Over time, we grow increasingly able to compare an increasing range of experiences with increasing precision, and our corresponding agreed upon reality becomes more extensive and more clearly and precisely detailed. As simple as it sounds, *the development of shared standards of comparison is the foundation of all communication and all scientific progress.*

Social Science: The Hundred Year Detour

Human progress, however – even scientific progress – is never certain and steady. Science can and does make wrong turns, such as our journey to absolute space and the luminiferous aether, the Eugenics movement, Lysenkoism, phlogiston, Lamarckism and other widely believed mistakes that often last decades or centuries before being recognized as the errors that they are. Consider, for example, the case of the social sciences:

Often we need to communicate about human attitudes and beliefs. We need to know what potential customers think of our product or service; we need to know how they might react to alternative advertising promotions or product changes. But when we communicate about attitudes and beliefs, we no longer make reference to commonly shared comparative standards: instead, we ask how strongly we agree with certain statements, or rate things on a scale of one to ten, or place our products and our competitors' products in rank order from most to least preferred, or most to least cheerful, or the like. Although it's easy to determine the monetary value of defects in cars, for example, this is not done, and the primary measure of quality in the auto industry is a simple counts of TGW (things gone wrong per 1000 vehicles built). The difference between the very best car and the middle of the pack is less than 1 event per 1000. That one event could be a tire falling off, or loose radio knob.

Why is this?

Traditionally, many social philosophers and social scientists have believed that there is a fundamental difference between "physical" phenomena and "human", psychological and sociological phenomena, and that this difference renders them unmeasureable in the normal way. Physical phenomena, the argument says, are amenable to direct physical "operations" on which measurements can be based. Distance, for example, is measured by the concatenation of rigid rods laid end to end. This is not possible with such human variables as emotion or opinion and the like.

One of the most influential examples of this dichotomy between physical and social science came about as the result of a 1932 committee chaired by physicist Norman Campbell. Campbell's conclusion about psychological measurement presented a serious challenge to Harvard Psychologist S.S. Stevens:

> Stevens formulated his classification and discussion as a rejoinder to the British committee who, in 1932, investigated the possibility of "quantitative estimates of sensory events" (p.22). Physicist Norman Campbell's verdict was: *Why do not psychologists accept the natural and obvious conclusion that subjective measurements of loudness in numerical terms (like those of length) are mutually inconsistent and cannot be the basis of measurement?* Stevens comment on this is: *Why, he might have asked, does the psychologist not give up and go quietly off to limbo?* (p.23) www.rasch.org/rmt/rmt111n.htm

As a result, Stevens formulated the now widely accepted four-way classification system; nominal, ordinal, interval and ratio, to describe four different kinds of measurement. Within Stevens' taxonomy, there exists a core "reality", such as a trait, belief, attitude, or other phenomenon, and measurement is an effort to map that underlying reality onto a set of symbols. The level at which this can be accomplished depends on the nature of the phenomenon: some can only be mapped onto unranked categories, some can only be placed in order, some can be assigned to numerals separated by equal intervals, and some can be measured as ratios to some standard. If a measurement device can do this repeatedly and get the same result, it is considered *reliable*, and, if it corresponds accurately to the underlying reality, it is considered *valid*[2].

The notion of validity specifically assumes the existence of a phenomenon independent of our measurements. Social scientists believe they can ascertain the correspondence of measurements with the thing itself, as the notion of validity implies, whereas physical scientists understand that they can only assess the correspondence of measurements to other measurements. The understanding that science searches for correlations among observations rather than correspondences between our ideas and physical was expressed strongly by Karl Pearson in his 1892 book, *The Grammar of Science.* In fact, the young Einstein was strongly influenced by Pearson's philosophy of science. (http://en.wikipedia.org/wiki/Karl_Pearson).

In order to search for these correlations among observations, Pearson developed what is now known as the Pearson Product Moment Correlation, *r*, to calculate the extent to which values of pairs of variables covaried. In many ways, Pearson's method is clever:

By expressing variables as deviations from their means, one could write pairs of variable vectors next to each other and multiply corresponding values by each other. If the variables co-varied positively, one variable would likely be higher than its mean when the other was also higher than its mean; when a variable was lower than its mean, so, most likely, would be the other variable, and the two negatives would make a positive number. Thus, if two variables co-varied positively, the result of summing the cross products would be a large positive number. Similarly, if the variables co-varied inversely, positive values of one variable would most likely be paired with negative values of the other, and the sum of the cross products would be large and negative. This sum would, of course, depend on how many pairs of scores were added, so it would be divided by N, the number of such pairs.

Because there were no common standards of measure, however, the sum would also depend on the size of the scales on which the variables were measured. If a variable were measured in meters, for example, the sum would be a thousand times smaller than if it were measured in millimeters. If one variable were measured on a Likert-type scale from one to five, and the other on a Thurstone scale ranging from 0 to 100, the difficulties would be compounded.

In order to try to overcome this difficulty, Pearson developed the concept of the *standard deviation* to serve as a common standard against which all biological phenomena should be compared. Each variable is to be measured as a ratio to its own standard deviation, which is a measure of statistical dispersion around the mean value of the variable. This has the effect of making every scale exactly one unit long.

Mathematically, the correlation coefficient *r* as defined by Pearson is the cosine of the angle between the two variables. In the world created by Pearson's methods, all variables are the same length – 1 unit – and all relationships among variables are expressed solely as angles (or cosines of angles). This produces a world in which every experience is constrained to the surface of a hypersphere with a radius of one, which, it turns out, is not a particularly convenient choice for visualization[3].

This model -- Stevens' non-comparative measurement system combined with Pearson's correlation analysis -- is virtually universally accepted in all the social sciences, but curiously, nowhere else. Within the world defined by these procedures, comparative standards do not exist, different observations are measured on different and incompatible scales, experiences are unique to each observer, and collective experience is muddled and incoherent. While many, and perhaps most social philosophers and social scientists believe this is the nature of social phenomena, we should at least consider the possibility that it is rather the result of a particularly inauspicious choice of measurement and analysis rules[4].

The Galileo System: A Rational Alternative to the Dominant Paradigm

The Galileo System is a theory and method that specifically considers the current paradigm of research on human attitudes and beliefs to be an aberration from proper scientific method, and specifies an alternative based on the core principles of science. It begins with the assumption that Norman Campbell was wrong, and that human attitudes and beliefs are no more nor less measurable than any other attribute. Secondly, it assumes S.S. Stevens was wrong, and that there is only one kind of measurement: comparison to some standard. Third, it believes that Karl Pearson was wrong, and that the root mean square deviation of a variable is not a universally useful standard for comparison.

Specifically, the Galileo model is founded on three principle:

- We have no access to the world apart from our observations;
- All measurement consists of comparison to some standard, and
- These principles apply with equal force to all aspects of human experience, including human attitudes and beliefs.

The Galileo Space

[3] The late John Tukey once said to me at a Conference on Multivariate Analysis at Asilomar in 1980, "The correlation coefficient: I hope to be rid of that noxious pests in my lifetime!"

[4] To make the level of confusion resulting from the adoption of this system of measurement and analysis clear, recall the example above where we use the standard meter to measure the size of our product, the standard hour to determine how long it takes to make, and the standard euro, dollar or yen to measure its value. Consider what would happen to commerce as we know it if we measured size on a five point scale from "very large" to "very small," time on a similar scale ranging from "very brief" to "very lengthy", and value on a scale ranging from "worthless" to "very valuable" in seven steps. Notice also that only the first variable, size, can make any claim to being a "physical" phenomenon; both time and value are as abstract as variables can be. Yet they clearly can be – and are – measured by comparison to a standard.

The metaphor underlying the Galileo model is a space within which are arrayed a set of “objects.” Based on the work of Mead, Durkheim, Haller, Sewell and others, the Galileo model defines an “object” as “anything that can be designated or referred to” (Woelfel, 1967). Objects are not assumed to exist in nature, but are rather socially designated subsets of the continuum of ongoing experience that a culture considers as a unitary entity. These can be solid objects, such as rocks, houses or cats, imaginary objects such as griffons, force and mass, or anything else, such as behaviors, actions, feelings, emotions, products, political candidates, attributes like “good”, “bad” and “evil” – that is, anything that can be designated or referred to.

Each of these objects is defined in relation to the others, based on their similarity or dissimilarity. In the Galileo model, dissimilarities are measured as distances compared to a standard distance. The result of these measurements is a square matrix of interpoint distances which defines a space. Within this space, objects that are similar are near each other, while objects which are different are far apart.

The Self as Object

An object which is always present in every neighborhood in the space is the self, that is, a person’s conception of who he or she is. The self, too, is defined in terms of its relationships to the other objects in the space. People’s selves are close to the attributes that describe them, and far from those attributes that they don’t exhibit. Behaviors that are close to people’s selves are performed more frequently than those that are far from them; products and services that are close to people are more frequently bought by those people. Political candidates that are close to the average voter’s self point receive more votes than those who are farther away. Media that are closer to people’s selves are more attended than media farther away.

Beliefs and Attitudes.

In the Galileo model, a “belief” is defined as the conceived distance between any two objects, and an “attitude” is a belief about the self – that is, the conceived distance between the self and another object. To define a person or group’s beliefs and attitudes about any object, one must first determine what objects lie in the neighborhood of the object in question. Next, one must measure the pair wise distances among these object (one of which will always be the self) by comparing each distance to a standard distance. Usually, since no international agreements about standards have been set yet, the standard distance is chosen as one of the distances between a pair of concepts in the neighborhood. This pair is usually called “the criterion pair.” The resulting square matrix of interpoint distances, expressed as ratios to the distance between the criterion pair, is then projected onto coordinates to define the Galileo space in that neighborhood.

Constructing a Galileo Space

Galileo is not the only methodology that results in a space of sorts. Procedures such as factor analysis, discriminant analysis, multidimensional scaling, perceptual mapping, correspondence analysis and the like all produce space-like results that bear a superficial resemblance to Galileo space, but the differences are profound. Perhaps the easiest way to understand the difference is to understand the different procedures by which they are constructed.

Based on the underlying assumption that human variables cannot be measured precisely, conventional methodologies make observations on crude likert-type, quasi ordinal, or other non-comparative scaling device. They then convert the resulting numbers into spatial coordinates.

But, based on the assumption that we can know something about human beliefs and attitudes independent of any measurement, these procedures generally have a preconceived idea of what the resulting space ought to look like. Almost universally the goal of analysis is a two or three-dimensional Euclidean space which gives a rough and ready picture of the most general features of the data. Since the data are considered to be untrustworthy anyway, or perhaps reliable only in their ordinal properties, conventional analysis techniques *transform the observed values* in ways that make the space come out two or three dimensional and Euclidean. In general, the raw data cannot be reproduced from the map to even a crude approximation.

In the Galileo model, such precedence of preconceived hypotheses over observation is the antithesis of science. Galileo analysis is based on the assumption that precise, comparative measurement is possible, and, indeed, essential to science. Accordingly, Galileo spaces are measured very carefully and precisely, and mathematical analysis is restricted entirely to distance-preserving or "rigid body" operations.

First, the objects in the neighborhood are carefully identified using variants of classic Thurstone scaling procedures[5]. Second, the distances among the objects are measured using the method of ratio pair comparisons, where each distance is estimated as a ratio to a standard distance (the ciriterion pair). Since international standards do not yet exist for Galileo distances, a distance between a pair of objects in the neighborhood is typically chosen as a standard[6]. The result of these measurements is a square matrix of interpoint distances which is typically sufficiently precise for analysis even of individual respondents. When averaged over large numbers of respondents, the level of precision can be increased without limit.

Examples of simple Galileo neighborhoods:

[5] Typically, either documents or human respondents are surveyed about the topic to be studied, and the underlying "objects" are identified by cluster analysis utilizing Catpac, (qv) an artificial neural network.
[6] Online examples can be found at The Galileo Matrix, http://www.thegalileomatrix.com.

Figures 1 through 4 show four typical Galileo spaces. The first is a picture of one person's perceptions of several persons and attributes. The directions (up, down, left, right, back and forth) have no significance, nor does the grid, which is only provided to help visualize how far apart the objects are, like the lines of longitude and latitude on the globe. The same is true for the stems, which serve only to show where the objects lie relative to the grid.

The closer the person is to an attribute, the more the respondent believes it describes that person. Figure 1 shows that the respondent believes Sally to be more friendly and honest than Rita, Bob and Jeff, but believes Jeff to be much richer than the others.

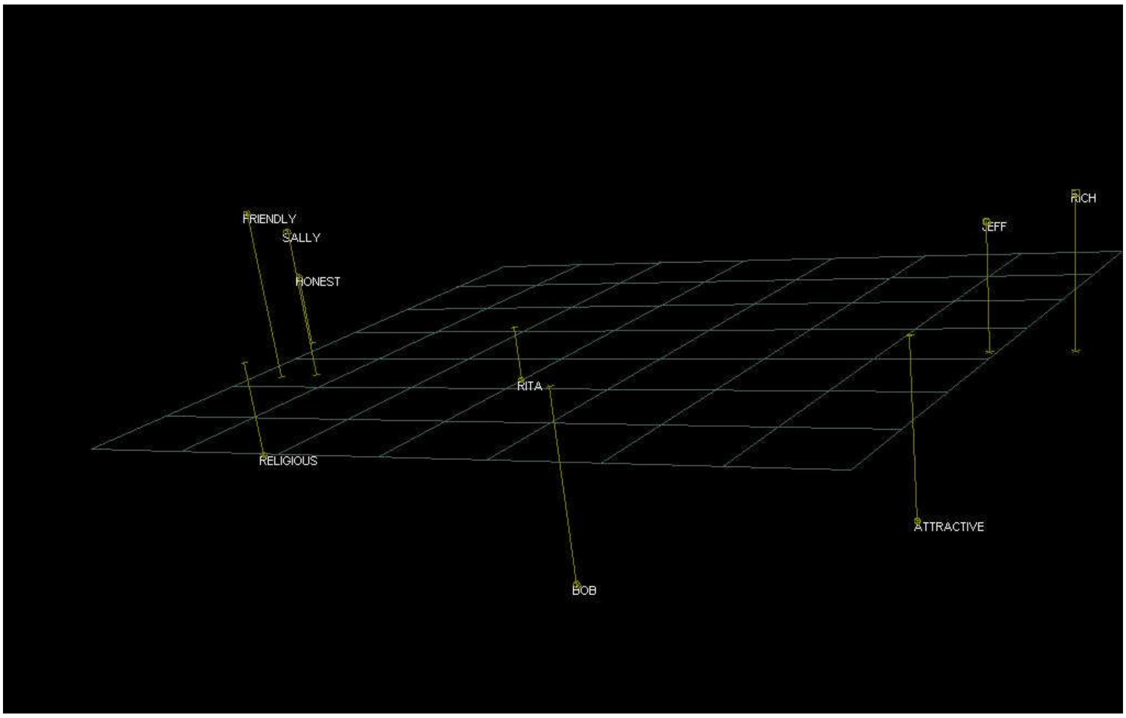

Figure 1: Galileo space of an individual's perception of several persons and some of their attributes (N=1).

Figure 2 represents the neighborhood of selected cigarette brands, their attributes and an ideal point, referred to here as "ideal cig." The notion of an ideal point in a Galileo space is based on the theory that people are most likely to buy the product they believe best. This theory is not always true, but works best when all other factors, such as price, are equal, as is the case with cigarettes, where there are fewer barriers to buying the brand you consider best.

In most other cases, however, the ideal point fails, as Figure 3 shows.

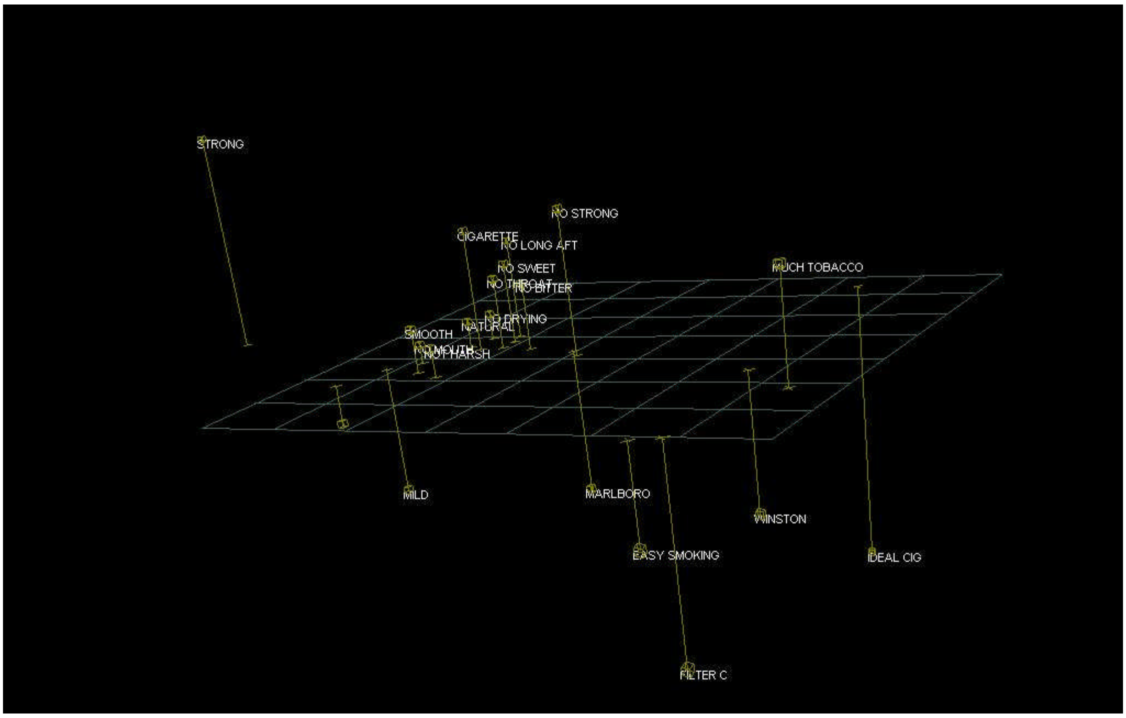

Figure 2: Galileo neighborhood of selected cigarettes, attributes and an ideal point.

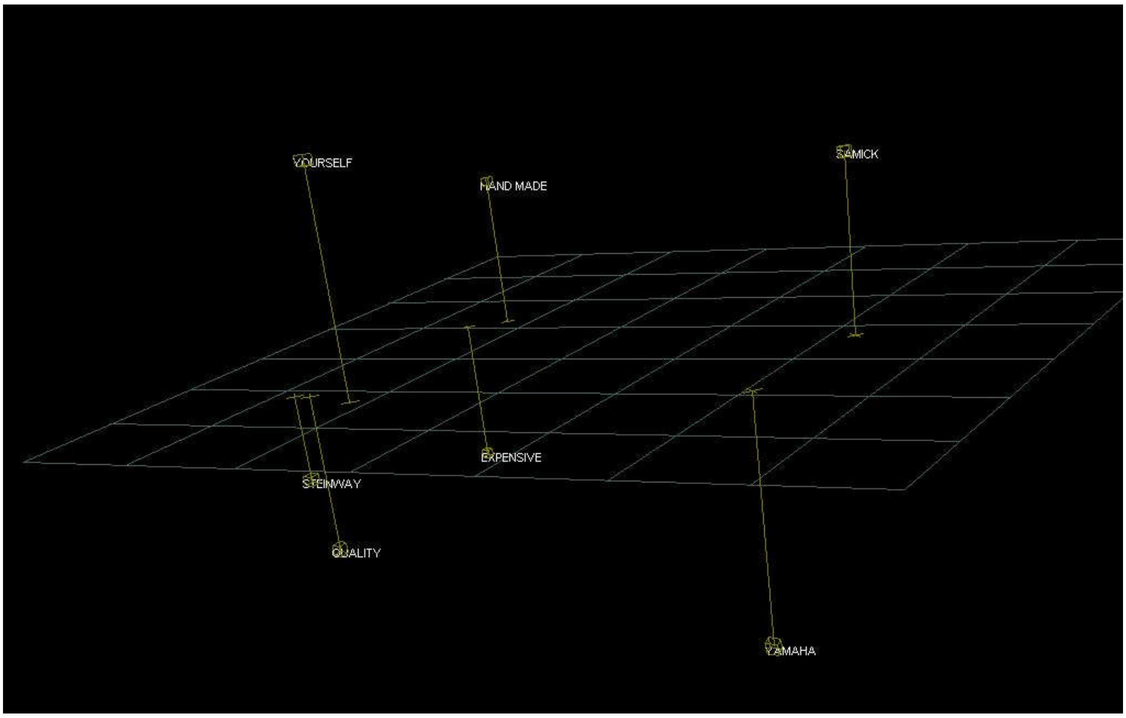

Figure 3: Galileo Neighborhood of Steinway, two of its competitors, and selected attributes.

Figure 3 is a typical Galileo picture of a product (Steinway), two of its competitors (Yamaha, Samick) and several attributes that describe them. It shows Steinway closer than the other brands to the attributes quality, handmade, and expensive. It also shows the object “yourself”, which is the location of the average customer. The typical customer for a Steinway piano is either wealthy, professional, or willing to make extreme financial sacrifices in order to own a Steinway. Yamaha, however, sells as many pianos in a year as Steinway has sold in the past 130 years, so, for a typical piano buying segment, the self-point will lie much closer to Yamaha than Steinway, even though Steinway lies closer to the ideal point. This means that the piano purchaser believes the Steinway to be a much closer to an ideal piano, but the Yamaha to be much closer to the kind of piano a person like him/herself would buy.

This is a classic case in which the ideal point fails, since many potential piano buyers acknowledge Steinway as the ideal, but the extraordinary price rules out purchasing one. Another area in which the ideal point fails is the auto market (see Figure 4), where the ideal vehicles (Porsche, Ferrari, Mercedes, Lexus) sell the lowest market share. In part, ideal vehicles have lower market shares because they have smaller production runs – i.e., there are fewer of them to sell. In some cases, it is because the companies making these vehicles simply expect to sell fewer. But in other cases, it is because the company lacks the means to produce more of them. In most cases, however, luxury vehicle manufacturers rarely “sell out” the entire production run of any make or model.

In general, the best indicator or market share known in Galileo space is the distance from a product to the average self point. In a large private commercial study done on a US national sample, the correlation between market share and distance from self for five major brands was -.998 (Woelfel, 2006). By comparison, the correlation between sales and favorability (how much the car is liked) is only .82. In a most recent study by Cheong, et. al., the correlation between distance of communication media from the self point predicts and number of hours of use of each medium per day very accurately. For each unit closer to the self in Galileo space a medium was located, the rate of use went up by about 12 minutes per day. The zero order correlation was -,90, with N about 400 cases (Cheong, et. al., in process).

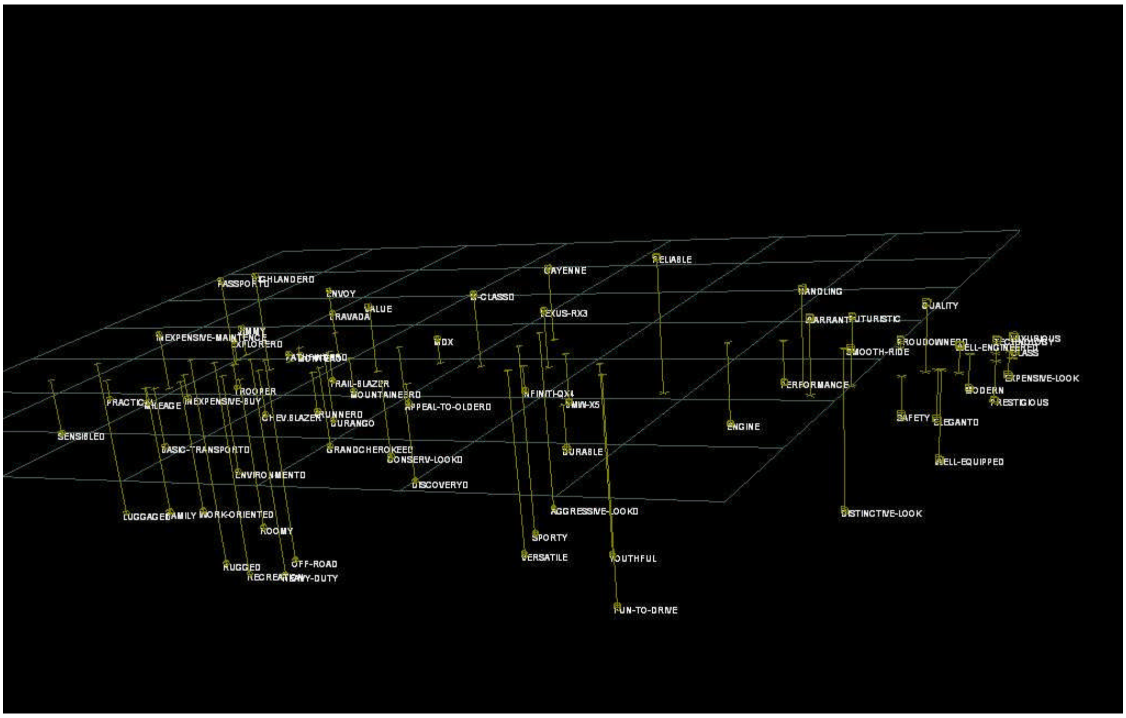

Figure 4: Galileo neighborhood of selected SUV's and attributes (made from Catpac II)

These findings strongly support the underlying theory, which holds that behavior is motivated not by needs or desires, but rather by the self concept. Galileo theory, following the interactionist perspective of Mead (1934) and others, holds that people perform behaviors they believe are consistent with their self conception. People buy products that are appropriate for them, that is, they buy products that people like themselves buy. No matter how much a person may prefer the red convertible, she will not buy it if she believes herself to be a station-wagon person (Woelfel, 1993a).

Galileo as a Computational[7] Theory:

[7] Many of the mathematical and statistical operations described here are standard procedures which can be accomplished with existing software packages, although often with considerable tedium. Packages specifically intended for use by social scientists, such as SAS and SPSS, tend to be optimized for correlational and non-metric operations. Some operations, such as determining means, standard deviations, standard errors and the like are straightforward, and it is possible to make Galileo coordinates using unstandardized factor analysis or multiple discriminant analysis. Rotation of high dimensional non-euclidean spaces, however, cannot be accomplished with these packages, nor can Automatic Message Generation.

In 1973, 11 of the scientists originally working on the Galileo project founded what is today The Galileo Company, which holds the rights to the legacy code which performs all these operations. The Galileo Company can be found at www.galileoco.com.

Although the previous examples are useful in explaining how Galileo works, Galileo spaces are not simple two or three-dimensional visual maps intended to give a visual display of the main features of the data. On the contrary, Galileo spaces are typically high-dimensional non Euclidean spaces which cannot be visualized in any holistic way, but which rather serve as the basis for mathematical analysis[8]. Because the data in a Galileo space are defined at the ratio level, the range of mathematical operations that are defined for Galileo space is without limit, but there are two specific operations we will discuss here: comparison of spaces and message generation.

Comparison of spaces

The foundation of all measurement is comparison. In business, one may wish to compare segments of a market (males, females, age groups, countries, treatment groups to control groups, etc.) to each other. Or, equally important, one may wish to compare the same group to itself over time, before and after intervention, or over continuous time to establish trends.

As important as these operations are, conventional spatial models are fundamentally unable to make such comparisons. Although one might always make a non-metric MDS map of males and another of females and look at them side by side, the results will be ambiguous, since each map is a based on a different non-linear (and unknown) transformation of the raw data.

When data are based on correlations it is impossible to detect differences in size of two spaces, since they are constrained to unit radius by the standardization (Woelfel, et. al., 1980). Woelfel and Barnett (1992) showed that non-metric MDS techniques were unable to represent the simple two-dimensional motion of clock hands over time, a problem which the Galileo system solves easily and exactly (Woelfel, et. al., 1988, 1989; Hao, 2004; Hsieh, 2005).

Appendix 1 shows Galileo maps of selected vehicles for national US samples across an 8 year period from 1992-1999 (Woelfel, 2006). All have the same orientation, and can show true changes over time unaffected by artifacts of orientation or changes in scale.

Because of its ability to maintain a common metric across samples and over time, Galileo can easily project multiple samples and multiple time periods *onto the same spatial coordinates*, a procedure which no conventional social science method can do. Figure 5 shows the set of 11 common emotions as perceived by three different people, one an English speaker, on a Hindi speaker and another a Korean speaker, all projected onto the same coordinates:

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[8] Although the first three dimensions of Galileo space are often plotted visually, they are only useful for illustrative purposes, and all meaningful analysis of Galileo space must rest on mathematical computations based on all the spatial coordinates.

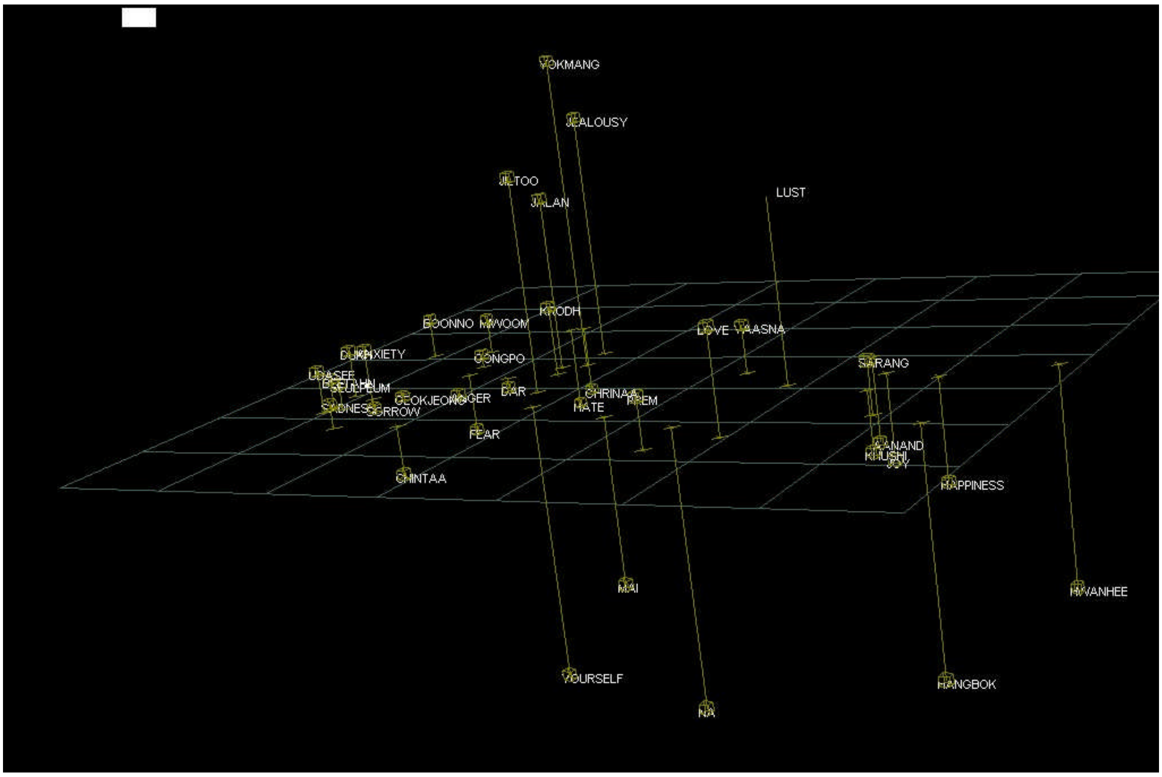


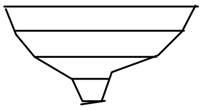
Figure 5: English, Hindi and Korean emotion terms projected on common Galileo coordinates.

Within this space, differences among the locations of the terms across languages indicate the difference in meanings of the terms attributable to language. At the bottom center, for example are the hindi, Korean and English words representing "yourself"; if they had identical meanings in the three languages, they would be located at a common point. To the far right, the corresponding terms "hangbok", "hwanhee," and "happiness" exhibit more difference than the three terms "joy", "khusi", "aanand," (Woelfel, 2003.).

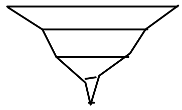
Other Comparisons

Because the Galileo method keeps a standard unit size, it's possible to compare theoretical ideas that are otherwise unrelated to each other. For example, one of the foundational concepts of advertising research is the sales funnel. Several variations of the concept exist, but, in general, all describe a narrowing path to the purchase of a product or service. The "mouth" of the funnel is considered to represent awareness of a product: a fairly large number of potential customers are "aware of" or "familiar" with it. Of these, a smaller number will have a favorable opinion of it, and, of these, even a smaller number will consider it, then a smaller number will actually shop for it, while a still smaller number will end up preferring or purchasing it. The seller, of course, must try to get potential customers into the funnel.

Unlike real funnels, however, in which almost everything that gets in falls through, many, usually most, of the potential customers who fall into the sales funnel somehow climb back out and fall into somebody else's funnel. To some extent, this can be accounted for by the "shape" of the funnel. There is some evidence (see figure 6) that the funnels for high quality products are wider and steeper than those of products perceived to be of lower quality.



Toyota Funnel



Dodge Funnel

Figure 6: Toyota and Dodge Funnels from 1999 data

Even so, unless a product sells more than 50% of its potential market, most potential customers climb out of even the best of funnels. This can be hard to explain when the sales funnel is considered in isolation, as it almost always is. In the actual marketplace, however, there are many funnels, one for each competing product or service, and the funnels actually overlap. Figure 7 shows an example of two nearby funnels:

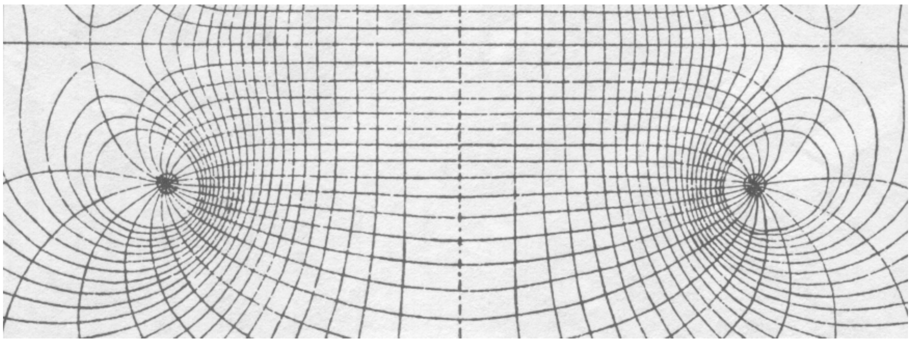


Figure 7: Two Hypothetical Sales Funnels

Customers who stand on the cusp at the center of the picture are equally likely to fall into either funnel. If the customers are moving (that is, if their attitudes are changing) they may skip around the outer edge of a funnel and roll over the cusp into the other funnel as a marble rolling over the surface might.

To get a proper understanding of the function of the sales funnel, it's necessary to consider not only the size and shape of the funnel, but also its position relative to the funnels of the competition. With conventional social science measurement and analysis technology, this is not possible. Since Galileo keeps a standard metric, it is possible to overlay the sales funnels on the Galileo space.

Figure 8 shows the Dodge and Toyota sales funnels superimposed on a Galileo perceptual map made from 1999 data. (In this map, the funnels are viewed from the top.)

Note that the outer rim of the funnel very large, since 77% of the people in the market report being familiar with Dodge. The innermost circle represents the output of the funnel. It's quite small, because only 4.4 percent of the sample ends up preferring Dodge.

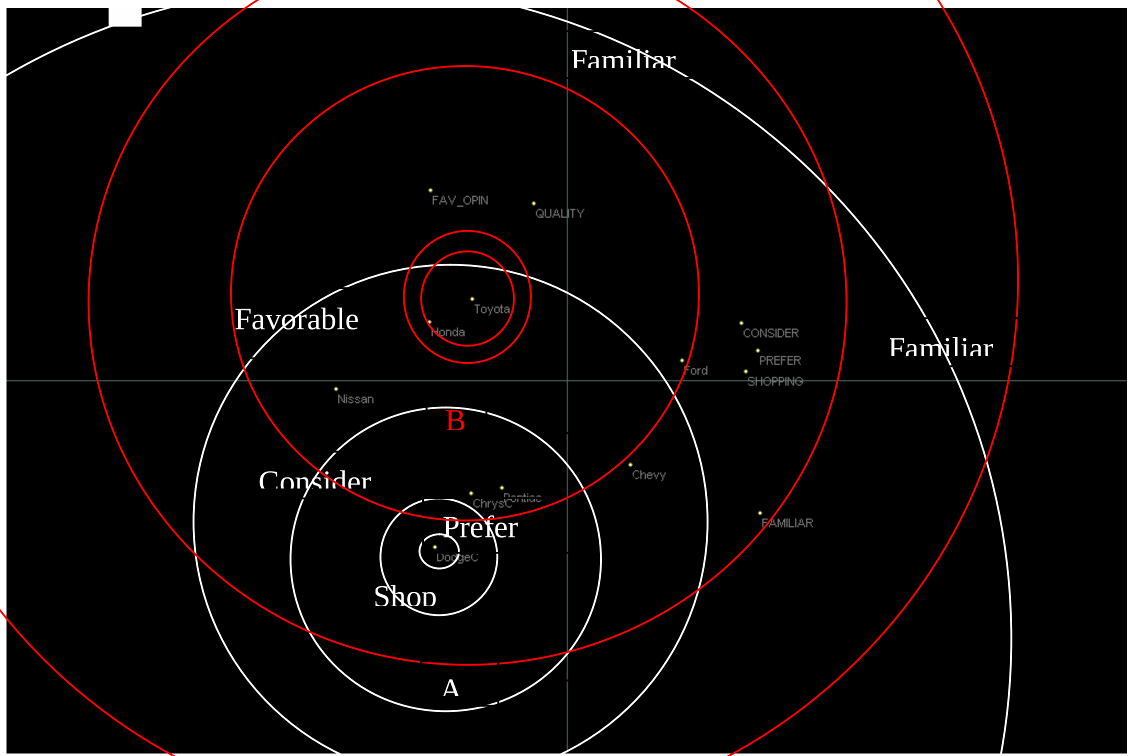


Figure 8: Dodge(white) and Toyota (red) sales funnels superimposed on Galileo perceptual map (1999 data).

None of the other funnels have been included to prevent confusion, but it's clear that, for example, Toyota's even larger funnel almost completely overlaps the Dodge funnel, as will the funnels for other makes. The resulting picture is one of potential customers inhabiting a bumpy surface covered with funnels into which one might fall. The direction and grade of the slope any customer experiences at any given moment depends on where he/she is on the perceptual map. Potential customers located near the "A" at the bottom center of the picture are in the Dodge funnel and the Toyota funnel, but they are much deeper into the Dodge funnel. They are probably more likely to fall into the Dodge funnel. Potential customers at "B", however, while also in both the Dodge and Toyota funnel, are much further into the Toyota funnel. (Although not drawn on the map, they are probably even further into the Honda funnel, and could probably be expected to fall there.)

Although there is always a tendency to slide down the slope toward the funnel, other market forces can also redirect the customer's trajectory, leading to a fairly complicated picture.

Message Strategies

While a simple two dimensional perceptual map may give the illusion that a simple visual inspection could reveal useful insights into the market it represents, the very precise, high dimensional non Euclidean representations resulting from Galileo's rational measurement make it clear that more complex mathematical analyses are needed to gain true insight.

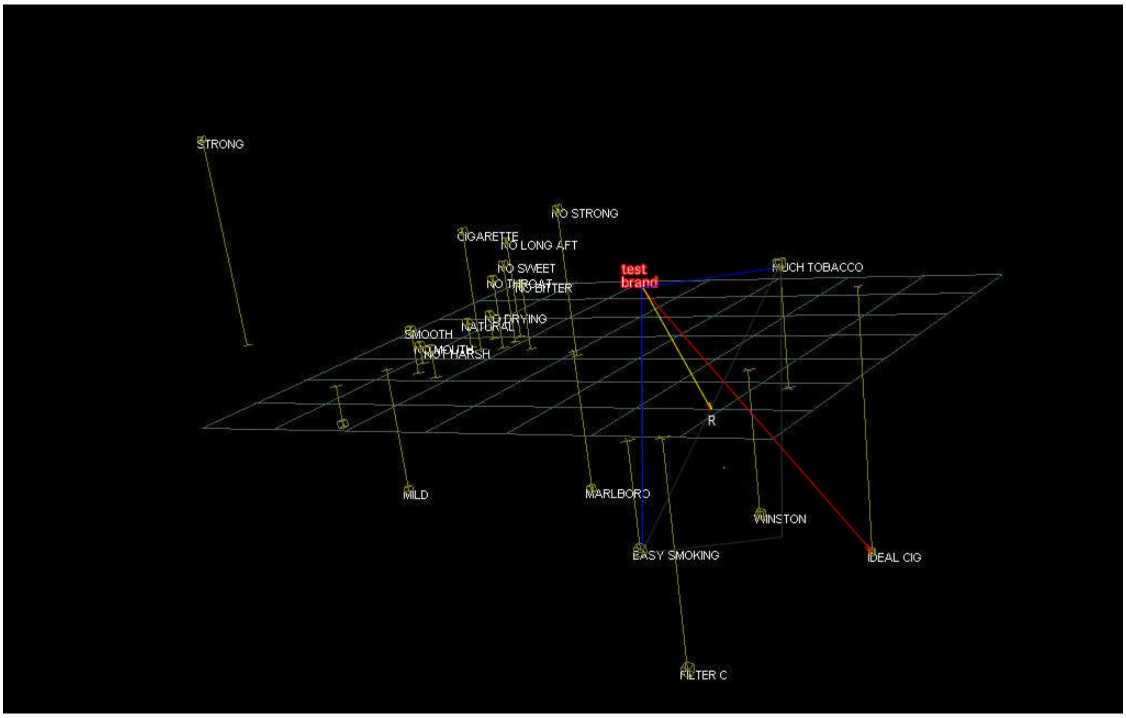


Figure 9: Parallelogram of Forces Representing the Effect of Messages in Galileo Space

Figure 9 illustrates one of the most important mathematical procedures in Galileo space: *automatic message generation.* In Galileo Space, a message is defined as information about the relationships between two or more objects. A simple message contains information about only one pair of objects, while a compound message includes information about three or more objects. Technically, each simple message is a vector in Galileo Space, so that the assertion in that the Test Brand in Figure 9 has "much tobacco (taste)" is a vector (blue arrow), and the assertion that the Test Brand is "easy smoking" is a vector (blue arrow). The first message alone would cause the Test Brand to move toward "much tobacco (taste)", and the second message alone would cause the Test Brand to move toward "easy smoking." In Galileo Space, messages average as vectors, however, so the compound message "Test Brand has much tobacco taste and is easy smoking" produces the resultant vector represented by the yellow vector in Figure 9. This can be compared to the optimal message, which is that the Test Brand is the ideal cigarette, represented by the red vector.

Once a Galileo Space has been constructed, it's a very straightforward matter to calculate the likely effects of every possible message combination and list the most effective possible messages.

Recent Advances: Neural Networks and Galileo Space

The last several decades have seen great advancements in understanding the underlying physical mechanism of Galileo space. Most important is the growing understanding of the neurological basis of cognitive processes. The stimuli which underly perception activate cells called "neurons" which form the internal representation of the stimuli. When neurons are simultaneously activated, they tend to form interconnections, which are strengthened when repeatedly coactive, and weakened when not used. These sets of interconnected neurons are the substrate for the "objects" of Galileo theory.

This new understanding has led to a whole new basis for developing Galileo spaces. Catpac[tm] is a computer program which reads ASCIItext, and it's artificial neural network engine finds clusters of meaning underlying the text (Woelfel, 1993; Yom, 2003) These underlying clusters can be represented graphically in dendograms, or as Galileo spaces. The SUV space shown in Figure 4 above was constructed by Catpac after reading a text describing the various vehicles and their attributes. Even newer technologies, such as Wölfpak (Woelfel, et. al., 2005, 2006) can operate in any language supported by Unicode. Figure 10 shows a Wölfpak analysis of a page of the Galileo website written in both English and Korean. (http://informatics.buffalo.edu/faculty/woelfel/history_kr.htm)

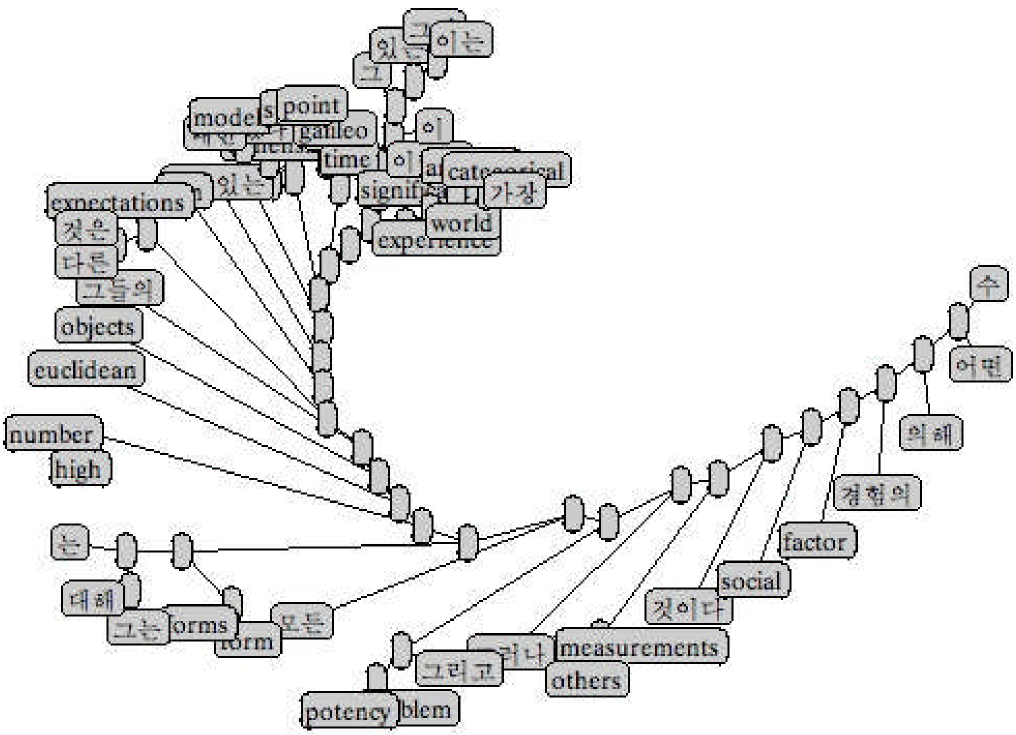


Figure 10: Wölfpak Cluster analysis of text in English and Korean

Applications

Galileo methods have found increasing application in business and have been used successfully in almost every kind of marketing and advertising research, including Measurement of Attitudes and Beliefs, Strategy Development , Customer Satisfaction, Corporate Image, Corporate Culture, Segmentation, Forecasting, Pricing, New Product Development, Media Research, Political Research, Archetype retrieval, and Tracking. Galileo is particularly well suited for experiments, including copy tests, new product evaluations and the like.

The development of the artificial neural network engines has opened up many new areas of Galileo research involving analysis of text, online questionnaires, analysis of internet content, focus groups, depth interviews and CAPI/CATI projects.

Conclusions

This essay has argued that the dominant paradigm of contemporary social science and business research is misdirected, based on the false assumption that human attitudes and beliefs cannot be measured in the same way as we measure all other aspects of our experience. The "detour" resulting from this false assumption has had a grave effect on social science in general and business in particular.

The failure to utilize rational measures eventually leads to the commoditization of markets. When people lack the tools to find differences in public opinion, it leads to an inability to effectively position (or communicate information about) products within a market space... As a result, the only differentiating factor becomes price.

As with business, this unfortunate detour had exacted a huge cost on the social sciences. Namely, nobody takes them seriously. Apart from the Galileo model, there isn't one good predictive model of human behavior, and there is even less understanding how attitudes change over time because there are no effective means in widespread use to study these phenomena.

The Galileo System is not so much a set of techniques and procedures as it is a philosophy of science. That philosophy holds that there is only one science – not physical science, social science, biological science and the like – and that science adheres to certain fixed principles. First, there is no access to the world except through measurement. Second, measurement is always and only comparison to some standard.

The techniques that have been described here are direct consequences of the application of the founding principles set forth above. The continuing application of the same principles should lead to the development of many more, much more powerful and effective techniques in the future.

References

Barnett, G., and J. Woelfel, "On the dimensionality of psychological processes," Quality and Quantity, 13, 1979. (pp. 215-232)

Barnett, G., R. Wigand, R. Harrison, J. Woelfel, A. Cohen, "Communication and cultural development: a multidimensional approach," Human Organization, 40(4), 330-337, 1981.

Chen Hao, A Method to Measure the Intercultural Communication Difference: The Application of Multidimensional Scaling system in intercultural communication researches. Unpublished MA Thesis, University at Buffalo, State University of New York, 2004.

Cheong, Pauline Hope, Jennie Hwang, Benjamin Elbirt and Joseph Woelfel, Media Use as a Function of Identity: The Role of the Self Concept in Media Usage, in preparation, 2006.

Danes, J., J. Hunter and J. Woelfel, "Belief change and accumulated information," in J. Hunter, J. Danes and S. Cohen, Mathematical Models of Attitude Change, Academic Press, Orlando, FL 1984. (pp. 204 - 230)

Danes, J., J. Hunter and J. Woelfel, "Belief change as a function of accumulated information," Human Communication Research, Spring, 1978. (pp. 241-252)

Foldy, J., and J. Woelfel, (1992). "Cognitive Processes as Damped Harmonic Oscillators, Quality and Quantity, 26,

Hsieh, Raymond Jui Chun, Comparison across the reference frame: Rotation of Galileo spaces with inconsistent objects. An example of comparison of use's perceptions and online legal policies, Ph.D. Dissertation, University at Buffalo, State University of New York, 2005.

http://en.wikipedia.org/wiki/Karl_Pearson

Kincaid, D.L., J.O. Yum, J. Woelfel and G. Barnett, "The Cultural convergence of Korean immigrants in Hawaii: an empirical test of a mathematical theory," Quality and Quantity, 18, 1983. (pp. 59-78)

Mead, G. H., Mind, self and society from the standpoint of a social behaviorist, C. Morris (Ed.). Chicago: The University of Chicago Press, 1934.

Newton, B., E. Buck and J. Woelfel, "Metric multidimensional scaling of viewer's perceptions of TV in five countries," Human Organization, 1984. (18 pp.)

Rosen, D., J. Woelfel, D. Krikorian & G.A. Barnett, “Precise Procedures for the Analysis of Online Communities.” Journal of Computer Mediated Communication, 2003.

Stoyanoff, N.J., J. Woelfel & S. Danielsen, Datorer som harmer hjarnan hjalper chefer att fatta ratt besult, Quid Novi, 1995, pp. 126-131.

Woelfel, J., "Comment on the Blumer-Bales dialogue concerning the interpretation of Mead's thought," Commentary and Debate, *The American Journal of Sociology*, Vol. 72, No. 4, January, 1967, p. 409.

Woelfel, J. and E. Fink, The Measurement of Communication Processes: Galileo Theory and Method, N.Y., Academic Press, 1980. (278 pp.)

Woelfel, J., "A Dynamic theory of cognitive processes," Proceedings of the XII Annual Meeting of the World Organization of General Systems Conference, Paris, 1984. (17 pp.)

Woelfel, J., "An East-West model of Communication" in Tsujimura, Akira, Communication Theory from Eastern and Western Perspectives, Nippon Hyoron Sha Co.., Ltd, Tokyo, Japan, 1987. (15pp)

Woelfel, J., "An East-West model of communication," Korean Journal of Communication, 14, 1981. (pp. 164-195)

Woelfel, J., "Artificial neural networks in policy research: A current assessment," Journal of Communication, 43(1), 63-80. 1993.

Woelfel, J., "Engineering Cultural Beliefs and Attitudes in the Developing Nations," Informatologia Yugoslavia, 18 (3-4), 171-172, 1986.

Woelfel, J., "Foundations of cognitive theory," in D. Cushman and R. McPhee, (Eds) Explorations in the Message Attitude Behavior Relationship, Academic Press, 1980, (pp. 89 - 116)

Woelfel, J., "Galileo as a cognitive system," Informatolgia Jugoslavia, 17 (1-2) 83-88, 1985. (11 pp.)

Woelfel, J., "The Galileo System: a theory and method for analysing cognitive processes," in J. C. Mancuso and M. L. Shaw, Cognition and Personal Structure: Computer Access and Analysis, Praeger Press, 1987

Woelfel, J., "Variational principles of communication," in G. A. Barnett and J. Woelfel, Readings in the Galileo System: Theory, Methods and Applications, Dubuque, IA, Kendall-Hunt, 1988. (pp. 147-168)

Woelfel, J., (1996) Attitudes as Non Hierarchical Clusters in Neural Networks, In, Boster, F. J. and G. A. Barnett (Eds.) Progress in Communication Sciences: Attitude Change and Persuasion, vol. 13, NJ: Ablex.

Woelfel, J., “Cognitive processes and communication networks: a general theory,” in G. A. Barnett and W. Richards. (Eds), Recent Advances in the Study of Communication Networks, Norwood, NJ Ablex, 1993a.

Woelfel, J., “Conversational neural networks,” in G. A. Barnett and W. Richards. (Eds), Recent Advances in the Study of Communication Networks, Norwood, NJ Ablex, 1993b.

Woelfel, J., and G. A. Barnett (1992) "Procedures for controlling reference frame effects in the measurement of multidimensional processes," Quality and Quantity 26: 367-381.

Woelfel, J., and G. A.. Barnett, (1992)."Procedures for the precise measurement of cognitive processes: Rotation to theoretical criteria," Quality and Quantity, 26,

Woelfel, J., and G. Barnett, "Multidimensional scaling in Riemann space," Quality and Quantity, 16, 1982. (pp. 461-491)

Woelfel, J., and J. Saltiel, "Cognitive processes as motions in a multidimensional space," in G. A. Barnett and J. Woelfel, Readings in the Galileo System: Theory, Methods and Applications, Dubuque, IA, Kendall-Hunt, 1988 (pp. 35-54)
.
Woelfel, J., Artificial Neural networks, in Woelfel, J., and N. J. Stoyanoff, (1995). Artificial Neural Networks for Advertising and Marketing Research, Amherst, NY, RAH Press, pp. 7-32.

Woelfel, J., D.L. Kincaid, B. Newton and J. Lee, "The effect of compound messages on the global characteristics of Galileo spaces," Quality and Quantity, 20: 133-145 (1986).

Woelfel, J., G.A. Barnett and R. Pruzek, "Rotation to simple processes: The effect of alternative rotation rules on observed patterns in time-ordered measurements," Quality and Quantity, 23:3-20 (1989).

Woelfel, J., J. Danes, "Multidimensional scaling models for communication research,' in P. Monge and J. Capella (Eds), Multivariate Techniques in Communication Research, Academic Press, New York, 1980. (pp. 333 - 364)

Woelfel, J., M. Cody, J. Gillham, and R. Holmes, "Basic premises of multidimensional attitude change theory," Human Communication Research, Winter, 1980. (pp. 153-167)

Woelfel, J., R. Holmes and D. L. Kincaid, "Rotation to congruence for general riemann surfaces under theoretical constraints," in G. A. Barnett and J. Woelfel, Readings in the Galileo System: Theory, Methods and Applications, Dubuque, IA, Kendall-Hunt, 1988. (pp. 219-234)

Woelfel, J., R. Holmes, M. Cody and E. Fink, "A multidimensional scaling based procedure for designing persuasive messages and measuring their effects," in G. A.

Barnett and J. Woelfel, Readings in the Galileo System: Theory, Methods and Applications, Dubuque, IA, Kendall-Hunt, 1988. (pp. 235-242)

Woelfel, J., R.A. Holmes, B. Newton and D. L. Kincaid, "An experimental measure of the mass of occupation names," in G. A. Barnett and J. Woelfel, Readings in the Galileo System: Theory, Methods and Applications, Dubuque, IA, Kendall-Hunt, 1988. (pp. 313-332)

Woelfel, J., Social Science Applications of Non-equilibrium Thermodynamics: Science or Poetry? Procedures for the Precise Measurement of Energy in Social Systems, In, Boster, F. J. and G. A. Barnett (Eds.) Progress in Communication Sciences: Attitude Change and Persuasion, vol. 13, NJ: Ablex.

Woelfel, Joe K., Hao Chen, Pauline Hope Cheong, Raymond Hsieh, Jennie Hwang, Devon Rosen, Joseph Woelfel, Wölfpaktm: A Neural Network for Multilingual Text Analysis, Paper presented at the 25th annual meetings of the International Society for Network Analysis, Los Angeles, CA,, February, 2005

Woelfel, Joseph, J.C. Woelfel, and M.L. Woelfel, "Standardized vs. unstandardized data matrices: which type is best for factor analysis?", Quality and Quantity, 14, 1980, (pp.1-13)

Yom, Miriam, Web Usability von Online-Shops, Göttingen, Verlag, 2003.

Appendix: Galileo maps from 1992 through 1999

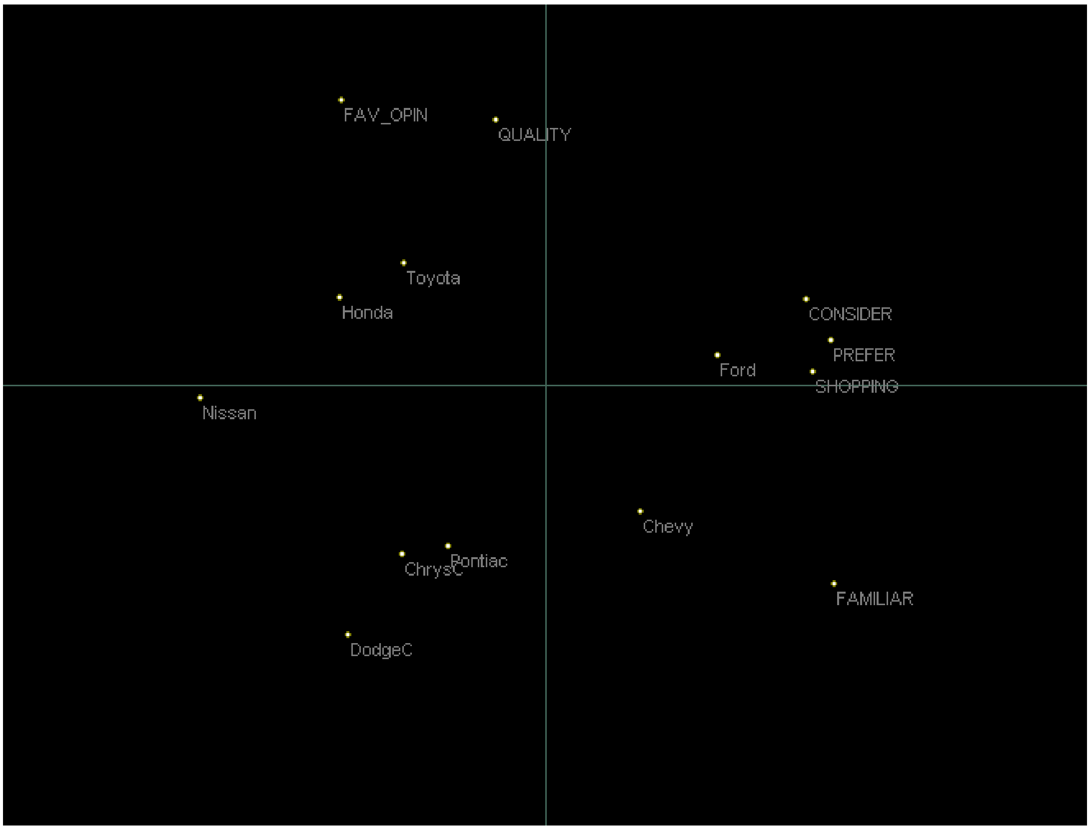


Figure 11: Galileo Map 1992

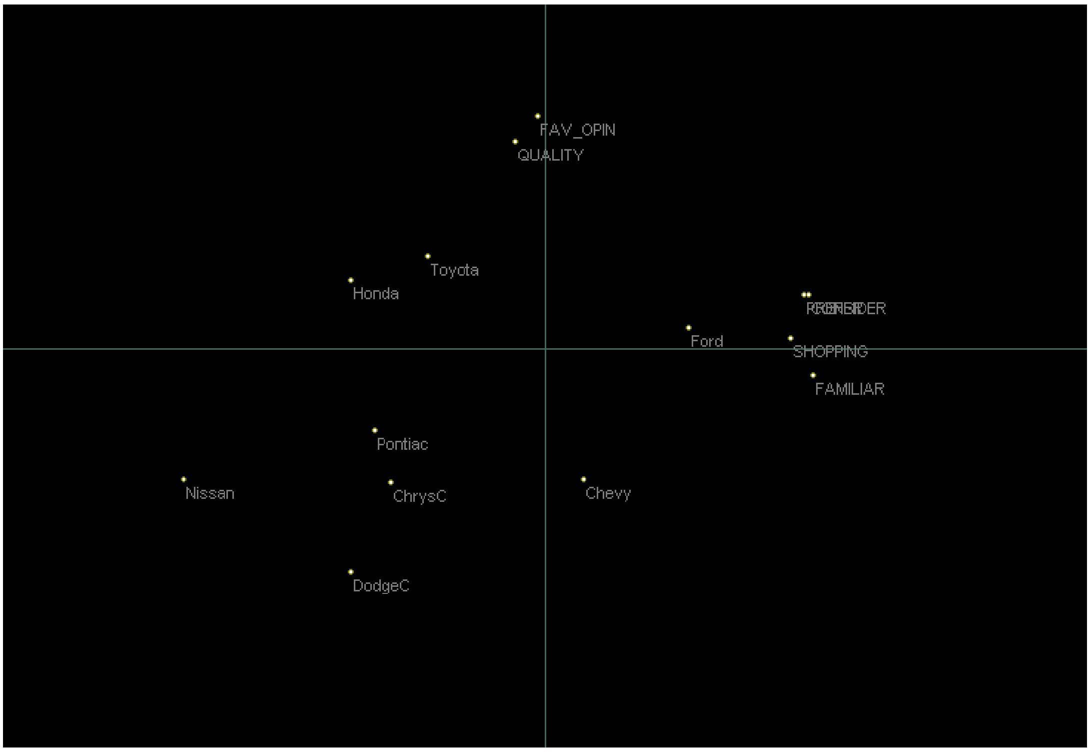


Figure 12: Galileo Map 1993

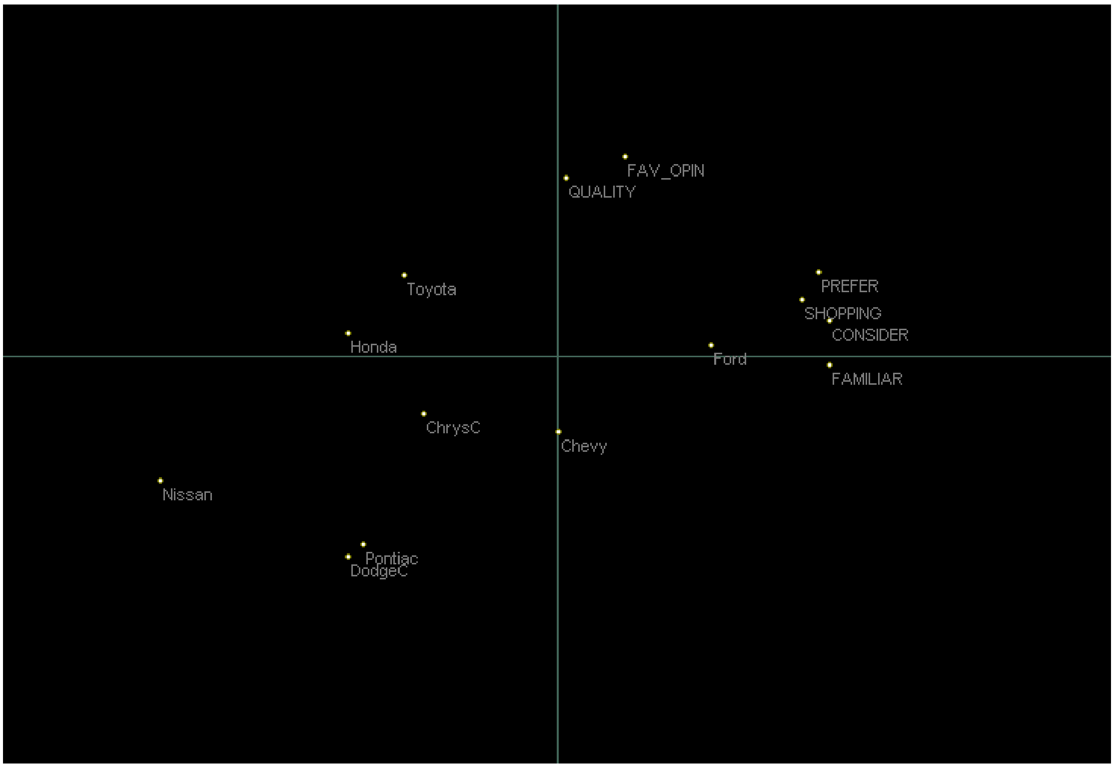


Figure 13: Galileo map 1994

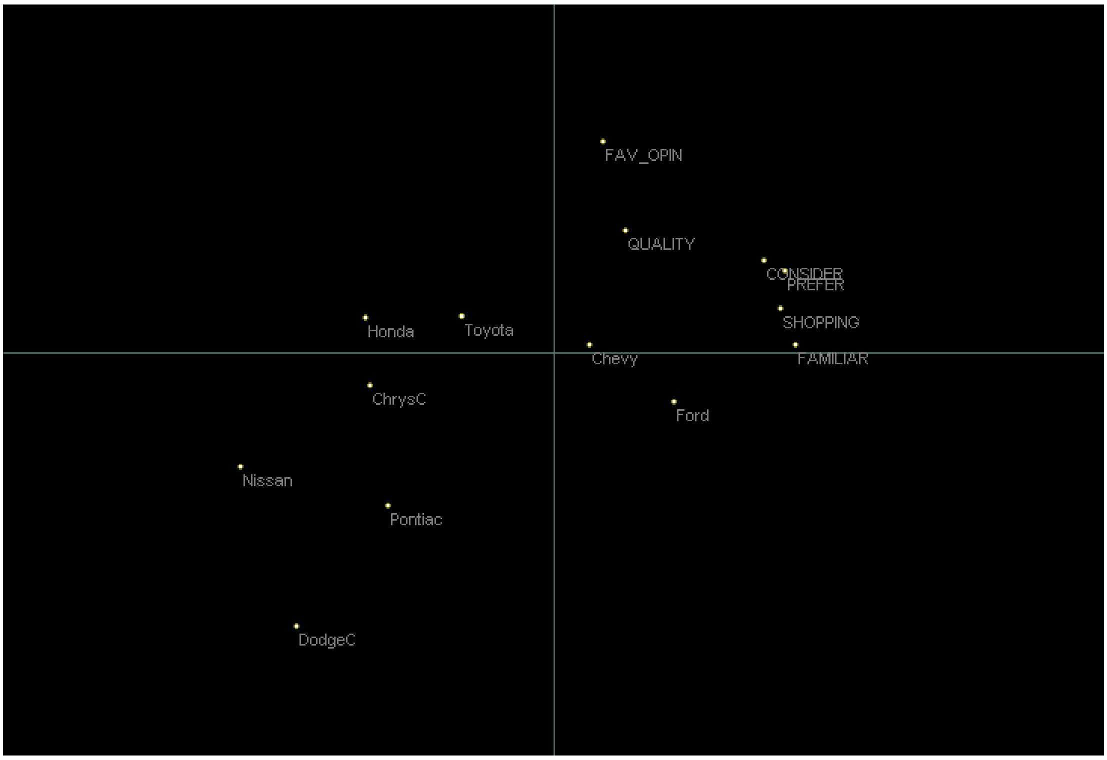


Figure 14: Galileo map 1995.

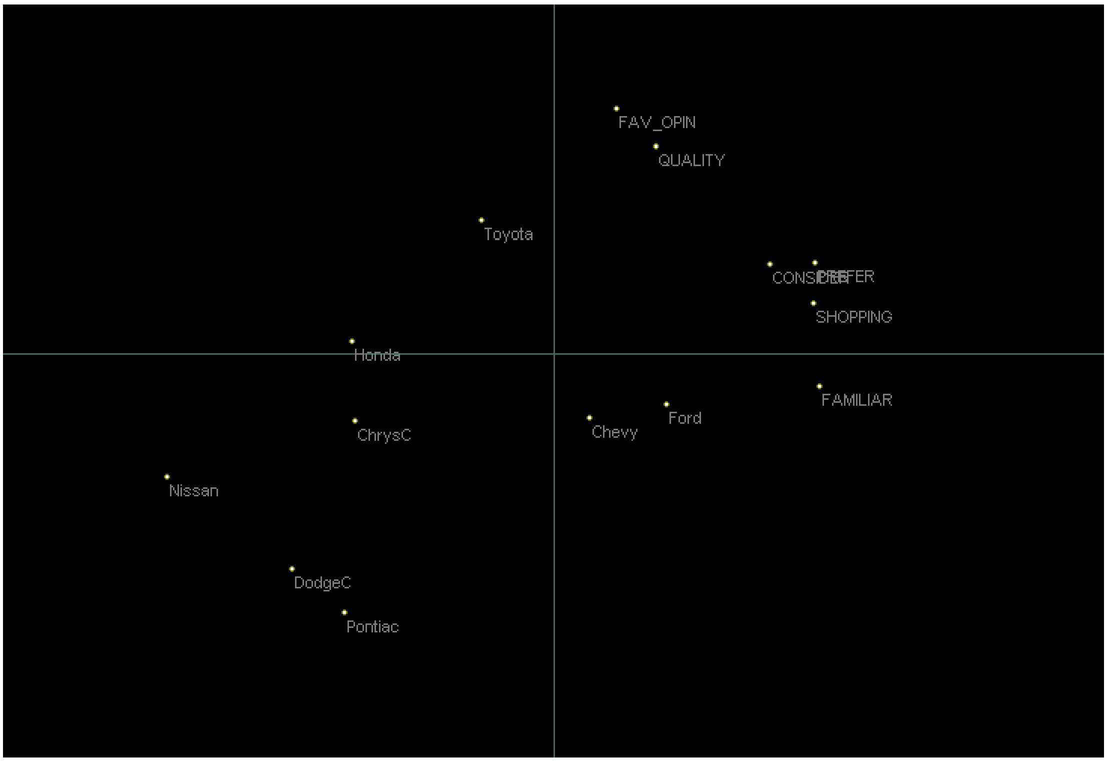


Figure 15: Galileo map 1996

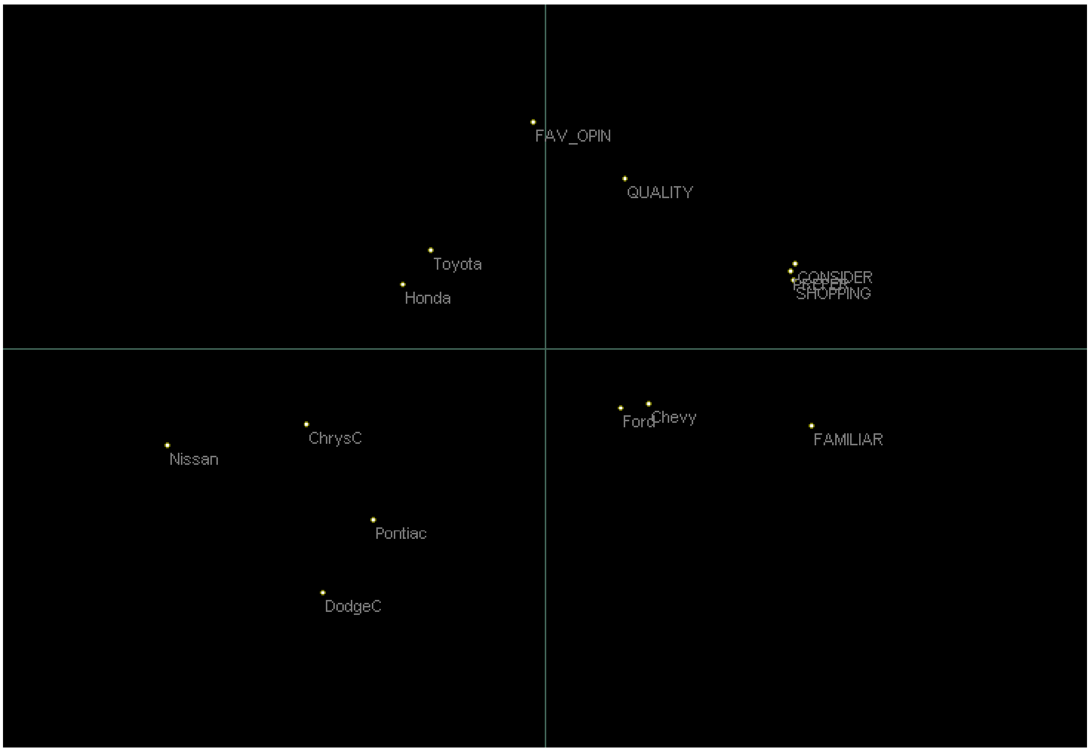


Figure 16: Galileo map 1997

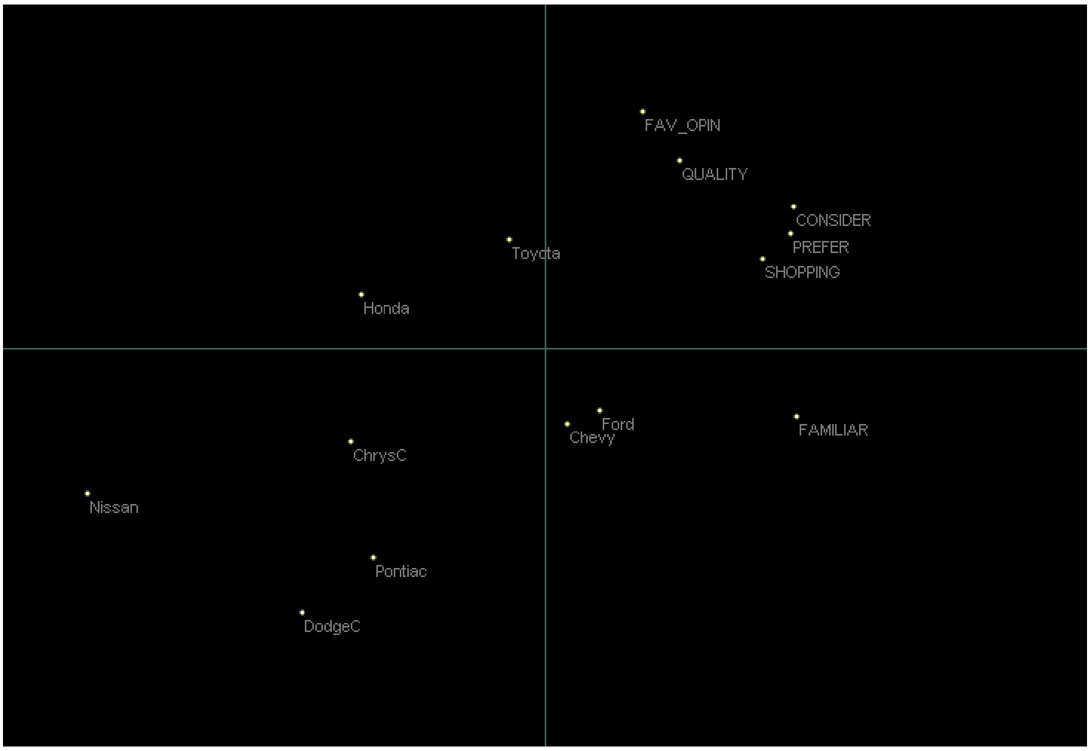


Figure 17: Galileo map 1998

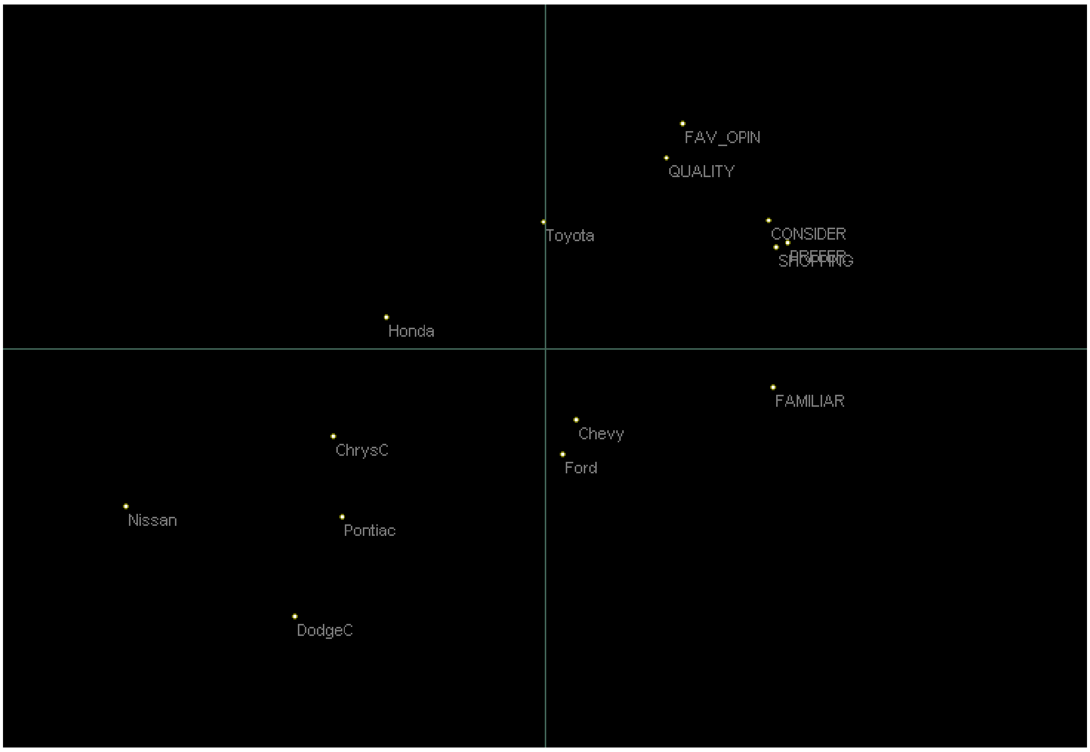


Figure 18: Galileo map 1999