

Benchmarking Technique in E-Business Using the Galileo Method

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Abstract

We propose a benchmarking technique that is combined with customer's cognitive structures. Customer's cognitive structures are determined using a multi-dimensional scaling tool that has been often used in marketing to analyze customer's behaviors. In this paper, a unique multi-dimensional scaling method is used, not only to analyze customer's behaviors, but also to perform the proposing benchmarking analysis. To do this, a survey was conducted to obtain customer's cognitive data and the Galileo method was applied to this data to obtain customer's cognitive map. A benchmarking method was then proposed based on this cognitive map. The efficacy of the proposed benchmarking method is also discussed with another data set.

1. Introduction

Successful e-business is dependent on a deep understanding of customer's cognitive structures [1-4]. The cognitive structure of customers gives entrepreneurs or practitioners a solid foundation in decision-making and that's why e-companies have invested significant resources in gaining insight into customer's cognitive domain [5]. Indeed many information systems success models include users' cognitive domain as a primary element of business success. It has been assumed that benchmarking is an effective way to enhance productivity and performance in e-business [6]. However, imitating the most successful e-companies does not necessarily guarantee a successful outcome. Further, imprudent imitation might lead to worse results if it has not been for a deep understanding of customers.

The Galileo method may assist both in enhancing understanding of customers and in applying the insight into practice. The Galileo method is a form of multi-dimensional scaling (MDS) that has been used in a variety of settings including marketing research. One of the important features of Galileo is that it

provides a visual cognitive map, using a concept called Galileo space. In addition it has an important feature that sets it apart from other approaches because it also identifies strategies that might be useful in decision and policy-making.

This study will investigate and illustrate the potential of the Galileo method as a decision support tool and benchmarking tool.

2. Background

2.1 MDS (Multi-dimensional Scaling) Methods

MDS methods are widely-used tools in marketing research [7, 8]. The ability to visualize the pattern of proximities among a set of objects makes this a powerful method for studying competitive market structures, product/service positioning, market segmentation, pricing, branding and image, and advertising. Regarding product/market positioning, for example, empirical data from brand-by-brand proximity judgments, brand-by-attributes ratings, consumer-by-brand preferences, or relevant consumer characteristics are collected and visualized such that practitioners can use the visual output to assist in decision-making [9].

MDS methods are distinct from other empirical methods in that the overall associations among objects are established by observing proximities rather than the relations between variables. Figure 1 shows the differences between conventional statistical methods and MDS methods. While the main purpose of conventional statistical methods is to figure out the causalities or functions between variables, the purpose of MDS methods is to provide a visual representation of the pattern of similarities among objects in multi-dimensional space. While data in conventional statistical methods show each variable, data in MDS methods show proximities

among objects. In the area of behavioral research, for example, each item in a questionnaire for the conventional statistical methods represents each variable, X and Y as in Figure 1. In the MDS method, however, each question asks the subjects how they would rate the proximities among objects. Thus, the MDS method is appropriate when the aim of a study is to establish customer preferences rather than finding the answer to a question.

Methods	Description	Supporting Decision Making by
Empirical	X → Y (Data)	Conducting X Predicting Y
MDS	A ← (Data) → B A ← (Data) → C B ← (Data) → D C ← (Data) → D	Observing whole network

Figure 1. Conventional statistical methods versus MDS methods

2.2 Galileo Method

The Galileo method is a specific, very powerful, variant of the MDS method. The assumption of the Galileo method that differentiates it from other MDS methods is the existence of “Galileo space.” Events in this Galileo space correspond to events of interest in experience. The meaning of any set of objects may be represented by an $N \times N$ dissimilarity (distance) matrix [10].

In order to measure individuals’ perceptions of similarities (hereafter, mental distance) among objects, a pair-wise comparison is employed[11]. The pair-wise comparison is known for its efficacy at measuring patterns of proximities and is similar to “the metric system” because both measure lengths in units[12]. For example, we can say “concept A and concept B are 20 Galileo units (GAL) apart” as we say “the length between point C and point D is 5 inches[5].”

Once Galileo data derived from the measurement of the mental distance is transformed to a dissimilarity matrix, the matrix is projected onto coordinates so as to visualize and facilitate the analysis. Please refer to Figure 2 for an example of output in the form of 3-d coordinates.

2.3 Exploring Customer Cognitive Structure in Relation to a Website Using the Galileo Method

In a neural network, a neuron is activated when it is stimulated and it sends signals to other neurons to which it is connected [13]. When an individual perceives an object, neurons concerned with that type of perceptual information are activated with weight. The network consisting of the weighted connections and nodes can be easily found in our everyday lives. For example, once “pizza” pops up in one’s mind, associated words or images of objects such as “coke,” “lunch,” “cheese,” “delicious,” “hot,” and “tomato” might also pop up in one’s mind, either strongly or weakly. Once the network is formed, it is referred to as a perceptual map, and a cognitive structure can be figured out through the perceptual mapping process.

Similarly, when a customer faces a commercial site, associated images such as price reasonability, information appropriateness, secured privacy, and interface clarity will be activated, together with strong or weak ties. If Galileo space is assumed for this network, and if the nodes and connections are expressed as a vector, such images (objects) can be positioned in the Galileo space with visually depicted distances. That is, a short distance means a strong connection to each other and a long distance means a weak one.

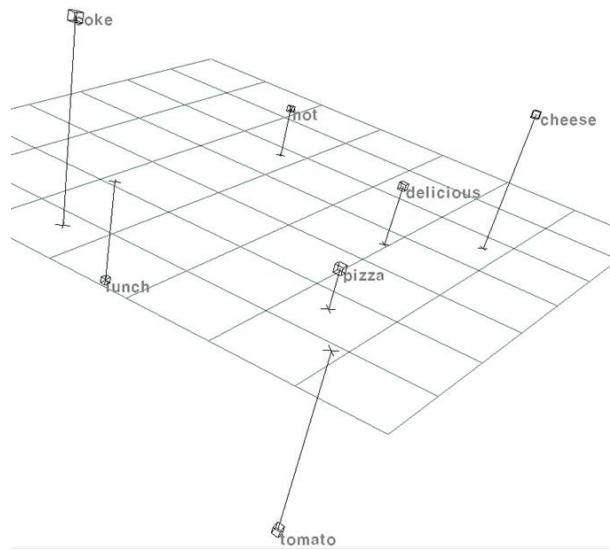


Figure 2. Chris' perceptual map about pizza

The Galileo method is a useful means of visually depicting the cognitive structure. Figure 2 shows an example of a perceptual map containing “pizza,” “coke,” “lunch,” “cheese,” “delicious,” “hot,” and “tomato.” From Figure 2, we can easily see that

Chris thinks of “delicious” the most when he perceives “pizza” by observing the shortest distance between them. In the map, the distance between two small cubes labeled by object names is the mental distance within an individual’s perceptual map.

3. Research Methods

3.1 Object, attributes, and their perceptual distances

A cognitive structure about a commercial website and its attributes is represented in a network of associations between the website and its attributes. Figure 3a shows an example of simple associations consisting of one object and two attributes. For example, assume that the object corresponds to a “commercial website,” attribute 1 corresponds to “delicious,” and attribute 2 corresponds to “sale.”

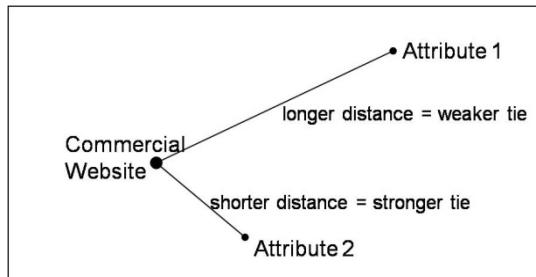


Figure 3a. Commercial website and its attributes

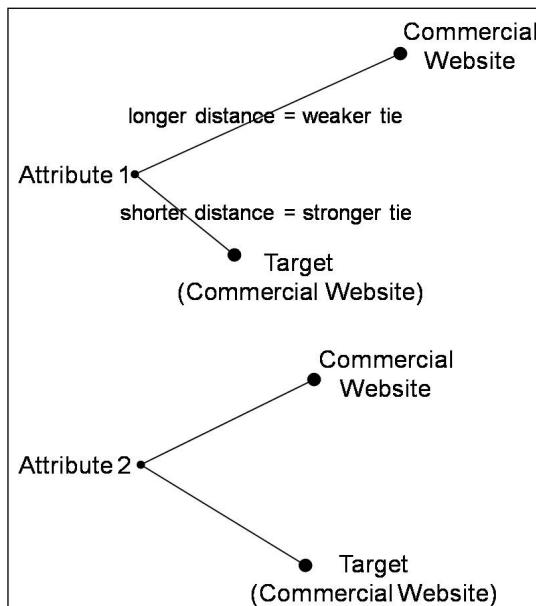


Figure 3b. Comparing distances between an attribute and two different commercial sites

Then, the lengths of the lines tell us that there is a stronger association between the “commercial website” and “attribute 1”, and the “commercial website” and “attribute 2.” Attributes can be any concept that practitioners want to research e.g. interface clarity, trust, and information quality.

Figure 3b shows the concept applied to more than one object where the second object is the target commercial website.

3.2 Data split in the Galileo method

Group differences such as gender and age within subjects can result in different patterns of dissimilarity among a set of objects in a cognitive network structure. For example, while a male group may prefer blue shirts to pink shirts, a female group may prefer pink shirts to blue shirts. As a more complex example, a group preferring site A to site B may think the fast loading speed of a commercial website is a more plausible reason to revisit it than the security of the site.

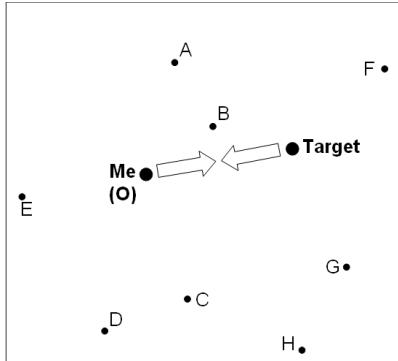
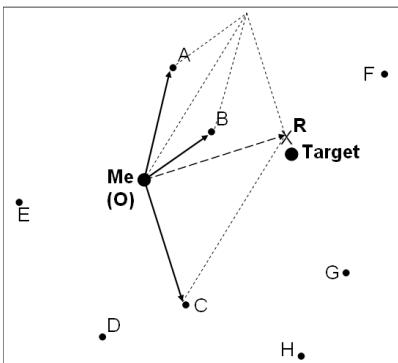
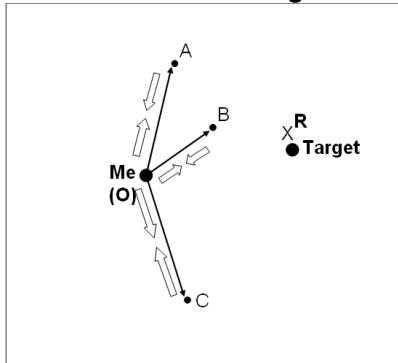
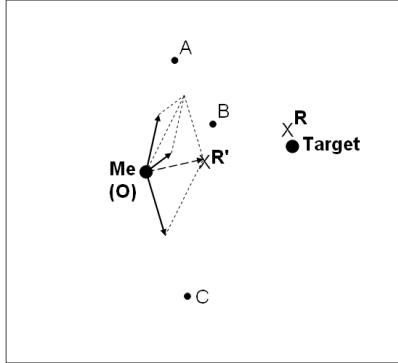
Data split is enabled by a categorical variable. In addition to the mental distance measurement in the Galileo method, a conventional rating scale such as Likert might also be useful if needed. If data in a column is categorical, Galileo data can be divided by the categories. Data split implies that the Galileo method and conventional statistical method can be combined.

3.3 Strategy generation

The purpose of benchmarking is to shorten customer’s mental distance from the target commercial websites in a perceptual map. Shortening the mental distance can sometimes be achieved by marketing strategies such as appropriate advertisements and benchmarking. This section will discuss how such strategies can be generated.

The basic concept of strategy generation is to show how a point associated with other points can be repositioned in a method of vector analysis in a Galileo space [14, 15]. Concepts represented as points in a Galileo space are interrelated to each other and any changes in their connections (distances) will affect associated connections [15]. Figure 4 shows the process of generating strategies to shorten the mental distance between two objects. For clarity, the vectors/points in Figure 4 are depicted on a 2-dimensional plane, instead of multi-dimensional space.

Points from “A” through “H” refer to each concept, and distances among those points represent

**Figure 4a. Current state and a goal****Figure 4b. Finding the vector resultant closest to the target****Figure 4c. Generating strategies****Figure 4d. Expectant result**

the mental distances drawn from measurements. Note that the two big dots and small dots represent objects (websites in this case) and attributes respectively and also that there are "Me (O)" to be repositioned and "Target." Figure 4a represents the current state and a goal. Including "O (Me)" and "Target," each point is positioned with a certain amount of distance from other points.

As in Figure 4a, the first step of strategy generation is to set a target. The goal is to shorten the distance between "Me" and "Target," represented with block arrows. The next step is to find the vector resultant closest to the target point. The vector sum of two or more vectors will be compared to find the closest point. Point "R" is set to the most appropriate vector resultant in this example, as in Figure 4b.

Once the resultant, magnitude of \overrightarrow{OR} is found, it can be reduced by division. Block arrows in Figure 4c

show the strategies. In Figure 4d, $\overrightarrow{OR'}$ represents the reduced magnitude. In decision-making with respect to marketing strategy, persuasive messages dealing with the distances between "Me" and "A," "B" and "C" can shorten customer's mental distance between "Me" and "Target." For example, it would be a good strategy for a company ("Me") to advertise that "Me" is good at "A," "B" and "C" or simply show "A," "B" and "C" a lot. Barnett et al. [15] showed that voters' attitudes were changed by persuasive messages using this algorithm.

4. Benchmarking Design, Results and Analysis

In this study, customer's cognitive structures regarding "site K" and "site N" are compared in various ways using the Galileo method. This is followed by a discussion of how this method can be used as a benchmarking technique.

"Site K" and "site N" are two leading farm product e-commerce sites in South Korea. Both sites opened for business in the same year, 2001, and deal with similar products on a similar scale and scope. "Site K" and "site N" are to be objects in the cognitive structure network.

As a possible benchmarking analysis, e-business success factors were selected. It should be noted that the following is just an example that was applied using the proposed benchmarking method.

Table 1. E-commerce success factors in this study and the literature

<i>This study</i>	<i>McKinney et al. [18]</i>	<i>Garrity et al. [19]</i>	<i>Wang et al. [20]</i>	<i>Liu & Amett[21]</i>
Ease of use	Usability	Interface satisfaction	Ease of use	System design
Structured interface	Navigation			
Fast loading speed	Access			
Timely information			Innovation	information and service quality
Accurate information	Reliability	Understandability	Information Contents	
Assists in purchase decision	Usefulness	Decision Support Satisfaction		
Adequate customer service		Task Support Satisfaction	Customer Support	
Information assurance			Security	System use
			Transaction & Payment	

Like other MDS methods, the Galileo method doesn't take functionality into account. Thus, the independent and dependent variables are not distinguished, instead only the proximities among objects are considered. Eight attributes (attributive objects) and two objects were measured using paired answers; that is, out of ten, subjects were required to choose two. In addition to the 45 paired question items, questions asking for demographic information and preferences for two commercial websites on e-business success indices such as trust, intent to revisit, and intent to purchase, were added to the questionnaire.

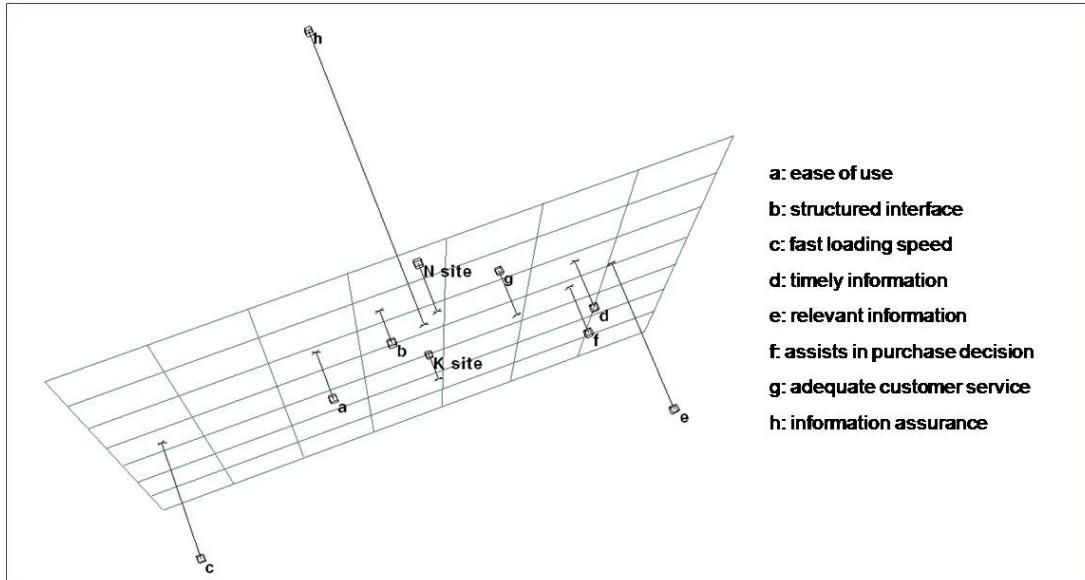
Data was collected from 70 participants. For 10 objects, more than 30 samples are necessary [16]. As the sample size increases, the standard error measure will decrease and the reliability coefficients will increase positively because of the shrinkage in the variance about the mean in the population [17]. 70 samples were enough to produce reliable results. Subjects had no purchase experience from either commercial website and thus there was no prior preference through familiarity.

4.1 The first step: choosing attributes to consider in the analysis

In order to perform a benchmarking analysis using the MDS method, attributes needed to be chosen. In this study, eight elements were used as success factors. These were ease of use, structured interface, fast loading speed, timely information, accurate information, assists in purchase decision, adequate customer service, and information assurance. These factors were derived from literature on success factors; each factor is mutually exclusive. The eight success factors used are shown in Table 1.

4.2 The second step: creating a perceptual map

A graphical perceptual map helps the practitioner to understand how customers perceive the attributes of the designated the target e-commerce websites attributes at a glance. Data split was performed to achieve effective identification, the first stage of benchmarking. Several strategies to lessen the distance from the target will be suggested using the

**Figure 5. A perceptual map – “K site”/ “N site” and attributes (success factors)**

Galileo algorithm. In this study, the superior website in each comparison was assumed to be the target.

The most fundamental output of the Galileo method is a mean distance matrix [22]. In the matrix, the means of distances are computed for every pair of objects based on responses. This matrix is projected onto coordinates to provide a visualized perceptual map. Figure 5 is a screen shot of the perceptual map depicting the “K site,” the “N site,” and the eight attributes representing e-commerce success factors. Note that the perceptual distances between concepts are distances between small cubes.

The perceptual map projected onto the coordinates in Figure 5 was rotated from its initial state so as to be more easily viewed. Contrary to other MDS methods, it is possible to manipulate the map to achieve the best visual angle to work with when the Galileo method is used [23].

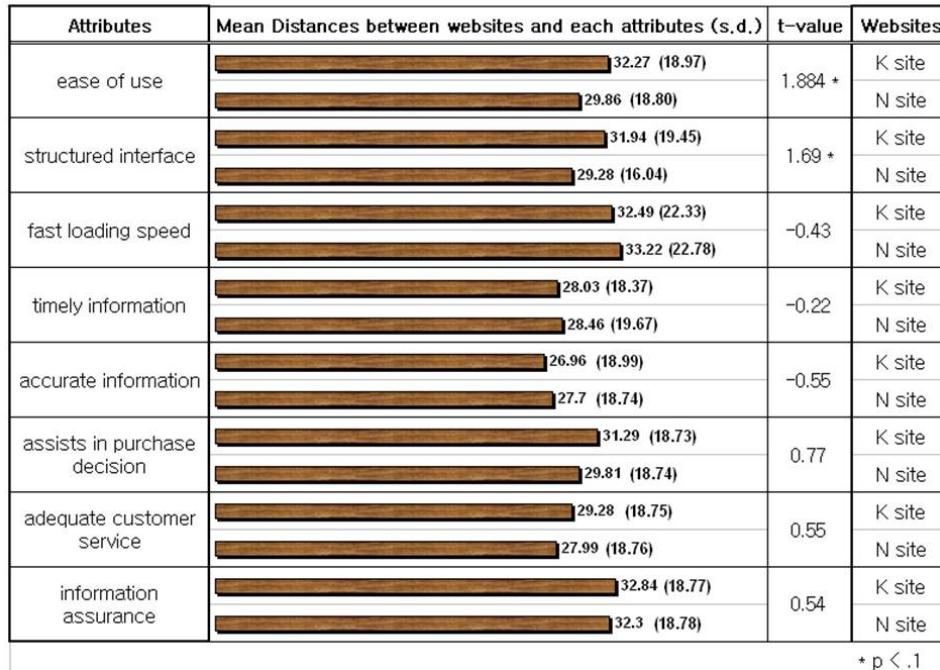
According to the perceptual map depicted in Figure 5, customers perceive timely information and assists in purchase decision to be closely related. Another notable finding is the close association between ease of use and structured interface; therefore, it appears that customers believe that, if the interface of an e-commerce website is well-structured, the website will be easy to use. Timely information and assists in purchase decision are clustered in one group, and ease of use and structured interface are clustered in another group. These groups can be used as criteria for decision-making. Structured interface and adequate customer service are close to both the

“K site” and the “N site” whereas fast loading speed and information assurance are far from both sites. This means that both e-commercial websites have well-structured interfaces and provide adequate customer service but have weaknesses in loading speed and in security and protection of customer’s privacy.

4.3 The third step: comparing mental distances

4.3.1. Each success factor versus both e-commerce websites. The first step in benchmarking is to identify one's own strengths or weaknesses against others [24]. The mental distances observed from customers provide information about the gap between one e-commerce website and another for each success factor. Table 2 shows the mean distances between each attribute and both the “K site” and the “N site”. A t-test was applied to compare the mean distances. Each bar refers to a distance; the shorter the bar, the stronger the association. The numbers next to each bar are the means of distances, and the numbers in parentheses are the standard deviations. In the t-test, the two sites showed significant difference for two attributes, ease of use and structured interface at $\alpha = 0.1$. Thus, customers perceive that the “N site” is more usable and has better structure than the “K site”. The websites were not significantly different in the other attributes i.e.

Table 2. Distances between each attribute and “K site”/“N site”



* p < .1

fast loading speed, timely information, relevant information, assists in purchase decision, adequate customer service, and information assurance. Thus, the weaknesses of the “N site” against the “K site” can be said to be usability and interface structure.

4.3.2. Comparing various perceptual maps discerned by data split. A perceptual map is a visual representation of the mean matrix. Thus, it is possible for two different groups, such as male and female to have different cognitive structures when two mean matrices are different. Suppose that “N site” is more successful in revenues and all success factors (attributes) are closer to the “N site” than to “K site”. Then, practitioners of the “K site” may decide to benchmark the “N site.” After the data split, however, if it is revealed that most customers of the “K site” are women and those female customers perceive the “K site” as better in success factors; it might not be the best solution for the “K site” to benchmark the “N site.” In this case, if the “K site” follows the “N site,” then the “K site” might lose its female customers.

Splitting data by individual characteristics can help to find very different perceptual maps that otherwise cannot be found. In addition to the example of gender, moderating factors such as hours of internet usage, experience of TV home shopping, and experience of e-commerce shopping were used as criteria to split the Galileo data in this study.

Table 3 shows the results from the data split. Only significantly different pairs are presented. Table 3 is attached at the end of this paper.

By splitting the Galileo data, two groups for each criterion were determined. Then, two distances, one between an attribute and an object (“K site” and “N site” respectively) by one split group and the other between the same attribute and the same object by another split group were compared using a t-test. This data split and t-test comparison was performed for all eight attributes. The attribute-object pairs showing significant differences between two split groups are listed in Table 3.

For the gender difference, female respondents showed a more favorable perception of the speed of both sites than male respondents. This implies that women care less about the loading speed of a commercial website than men do.

When the Galileo data is split by TV home shopping experience, customers with no experience perceived the security of both sites more favorably. When the Galileo data was split by e-commerce shopping experience, customers with no experience perceived the ease of use of both sites more favorably. Also, customers without e-commerce shopping experience perceived the information timeliness of

“K site” more favorably than customers with experience.

Practitioners may not know why an e-commerce website is preferred by customers. In this study, for Cartesian pairs – “K site”/“N site” versus attributes -, the Galileo data was split into two on the basis of the responses to the evaluative questions, such as usability, trust, purchase intent, and revisit intent. For example, in order to know customer’s preferences about trust, we asked, “Which site do you trust more, the “K site” or the “N site”?” Then, we divided the respondents into two groups; K group and N group, according to their stated preference. Table 4 shows the results of the comparisons between the K group and N group. (Table 4 is also attached at the end of this paper). For each pair - attribute and “K site”/“N site”, the mental distances of the K group and N group were compared using a t-test. Also, for each of K group and N group, two distances, an attribute versus “K site” and “N site” were compared using a t-test. No significant differences were found in the latter t-test. Thus, we can conclude that participants don’t perceive a difference between the two sites in terms of the eight attributive characteristics when they are split based on usability.

Pairs, structured interface and “K site,” timely information and “K site,” relevant information and “K site,” assists in purchase decision and “K site,” assists in purchase decision and “N site,” adequate customer service and “K site,” and adequate customer service and “N site” showed statistically significant differences by both K group and N group at the at $\alpha = 0.05$ or 0.01.

For the first pair, structural interface and “K site” in Table 4, the K group and N group showed significantly different cognitive structure. That is, customers who think that the usability of the “K site” is better than that of the “N site” and customers who think that the usability of the “N site” is better than that of the “K site” have quite different feelings about the interfaces of the two sites.

On the other hand, the K group and N groups showed no statistically significant difference for the pair, structural interface versus “N site.” Therefore, both groups perceive the interface of the “N site” in the same way.

The other pairs can be interpreted similarly. In usability, it was found that the two groups perceive the information timeliness, information relevancy, the degree of assist for purchase decision and the adequacy of customer service differently. Information relevancy in particular, was very differently perceived by the two groups. Therefore, we can conclude that information relevancy is a key factor influencing customer’s evaluations of usability.

A further interesting finding was that feelings about the “K site” for both the K and N groups varied more for all the attributes. Thus, there is a possibility that a certain amount of customers are locked in the “K site.”

4.4 The fourth step: persuasive strategy generation

The purpose of benchmarking is to shorten customer’s mental distance from the target commercial website in a perceptual map. As mentioned earlier, shortening the mental distance can sometimes be achieved by marketing strategies such as appropriate advertisements and benchmarking.

In this study, the result of the vector analysis is as follows,

Start concept: K site

Target concept: N site

INITIAL = 34.460

MINIMUM = 16.100

25.583 fast loading speed

38.333 relevant information

36.083 information assurance

The initial mental distance between the two sites was 34.46, and the distance can be shortened to 16.10 using a strategy of generating messages about fast loading speed, relevant information, and information assurance. In practice, the practitioners of the “K site” need to focus on enhancing customer’s perceived loading speed, information relevancy, and information assurance.

5. Discussion

A benchmarking technique is not a panacea. The proposed benchmarking technique shows a very helpful guideline of not only how and what to benchmark but also whether to benchmark or not.

In order to intuitively verify the efficacy of the proposed benchmarking technique, we collected another data set for Google.com and Yahoo.com with the attributes of EQ model [25]. The attributable concepts are “accurate information,” “relevant information,” “complete information,” “structured layout,” “packaged layout,” “accessible layout,” “history of information,” “sequential delivery of information,” and “current information.”

Figure 6 shows very close distance of Google and Yahoo even though characteristics of them are very different. This apparently tells us that neither of them needs to benchmark the other.

Besides the above implication, we can also imply that there should be very small lock-in effect. In other words, internet users’ use of search engine is versatile.

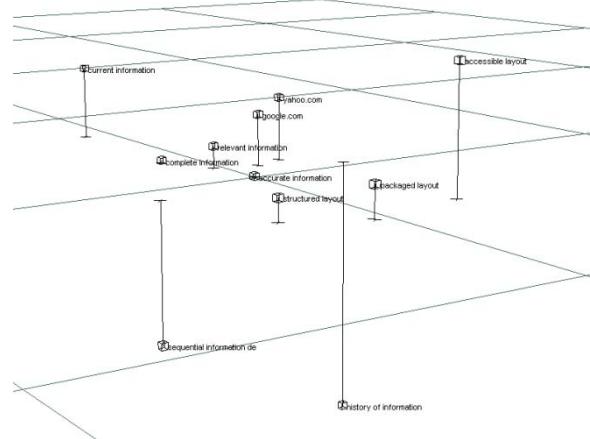


Figure 6. Perceptual map on Google / Yahoo

6. Conclusion

This paper has explored customer’s cognitive structure by generating a perceptual map using the Galileo method. The applicability of the Galileo method to benchmarking technique was demonstrated by identifying strengths and weakness against other commercial websites and generating strategic messages on the basis of customer’s cognitive structure. Two leading farm product e-commerce sites were used. A survey was conducted to obtain customer’s perceptions. Several practical implications were found.

Firstly, the Galileo method provides a visual representation that helps decision-makers to identify the current state at the first site. The Galileo method was applied to the “K site,” “N site,” and e-business success factors to explore how customers perceive them. The generated customer perceptual map illustrates the mental distances for how well a company is managing the e-commerce website in terms of attributes that customers think important. When we want to know the physical distances between cities, we use a map. Likewise, customer’s perceptual relationships among objects/concepts can be observed much more efficiently with a visual representation.

Secondly, the Galileo method can be used as a tool for detailed benchmarking planning. Benchmarking can be very costly. Thus, selective benchmarking is critical to a firm. The data splits

shown in this paper offer guidelines for selective decision-making.

The Galileo method is one type of MDS tool. The functions and features of the Galileo are straightforward: visual representation of customer's cognitive structure. However, the applicable potential of the tool is infinite. Benchmarking techniques suggested by this paper are the first step in analyzing customer's small but never-trivial perceptions and feelings towards an e-business and in helping practitioners to make sound marketing decisions.

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<Appendix> Table 3 and Table 4

Table 3. Differences in two split groups' cognitive structures depending on the split criteria

Groups Split By Moderating Factors (Individual Characteristics)		Pairs	Dist.	S.D.
Gender	Male (n=43)	Fast Loading Speed <-> K site**	37.09	20.80
	Female (n=26)		24.88	23.08
Presence of Experience of Purchase from TV Home Shopping	Male (n=43)	Fast Loading Speed <-> N site*	37.85	22.82
	Female (n=26)		26.38	22.33
Presence of Experience of Purchase from E-commerce Shopping	Yes (n=33)	Information Assurance <-> K site*	37.64	20.66
	No (n=36)		28.44	23.36
	Yes (n=33)	Information Assurance <-> N site*	37.48	21.65
	No (n=36)		27.56	22.59
	Yes (n=64)	Ease of Use <-> K site**	34.16	18.58
	No (n=6)		12.17	9.28
	Yes (n=64)	Ease of Use <-> N site**	31.55	19.61
	No (n=6)		11.83	9.41
	Yes (n=64)	Timely Information <-> K site**	29.36	18.52
	No (n=6)		13.83	8.61

* p < .1, ** p < .05

Table 4. Differences in two split groups' cognitive structures depending on customers' website preference (usability)

Groups Divided By Evaluative Items (Performance Criteria)		Pairs	Dist.	S.D.
Usability Preference	K group (n=24)	Structured Interface <-> K site*	23.88	13.28
	N group (n=45)		36.24	20.92
	K group (n=24)	Structured Interface <-> N site	25.63	14.68
	N group (n=45)		31.22	16.55
	K group (n=24)	Timely Information <-> K site*	22.04	10.18
	N group (n=46)		31.15	20.87
	K group (n=24)	Timely Information <-> N site	23.67	17.23
	N group (n=46)		30.96	20.57
	K group (n=24)	Relevant Information <-> K site**	18.75	15.15
	N group (n=46)		31.24	19.51
	K group (n=24)	Relevant Information <-> N site	25.29	16.60
	N group (n=46)		28.96	19.83
	K group (n=24)	Assists in Purchase Decision <-> K site**	21.17	14.94
	N group (n=46)		36.57	18.46
	K group (n=24)	Assists in Purchase Decision <-> N site*	24.21	13.84
	N group (n=46)		32.74	17.51
	K group (n=24)	Adequate Customer Service <-> K site**	21.67	13.30
	N group (n=45)		33.33	21.61
	K group (n=24)	Adequate Customer Service <-> N site	24.42	20.30
	N group (n=45)		29.89	20.77

* p < .05, ** p < .01