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From the Chairman of the Editorial Board

This issue is a compendium dedicated to the instruction, experience, ideas, and theories that have evolved from using Kano's methods within CQM companies. This paper has no single author. The material in the paper was pulled together from other CQM publications, from requests for experiences of Kano users, and from theoretical ideas that have been circulating informally within the companies. I am grateful to all who contributed to this paper and to those that allowed their writings to be adapted for use in this paper.

The following individuals have refereed papers in 1993: David Boger, Dennis Buss, Ismael Dambolena, Alan Graham, Steve Graves, Paul Horwitz, Laurie Langone, Jeff Mayersohn, Joseph Posk, Ash Rao, Diane Shen, and Robert Wood. I greatly appreciate their help. I also would like to thank those who helped with the production of the journal: Lene Abel, Barney Gage, Jay Howland, Trish McKinnon, Craig Murphy, Maury Ringel, Ted Walls, and Robert Wood.

Kano's Methods for Understanding Customer-defined Quality

A compendium of ideas and experiences from Charles Berger, Robert Blauth, David Boger, Christopher Bolster, Gary Burchill, William DuMouchel, Fred Pouliot, Reinhart Richter, Allan Rubinoff, Diane Shen, Mike Timko, and David Walden

The Center for Quality Management (CQM) six-day introductory TQM course presents several concepts relating to understanding customer-defined quality based on the work of Professor Noriaki Kano of Tokyo Rika University and several of his colleagues in Japan. These concepts have become embedded in the Concept Engineering (CE) process for operationally defining customer requirements,[1] which a number of CQM companies are using as part of their product development process.

When first introduced to Kano's ideas, people are usually excited by them. Kano's ideas about types of quality are often a revelation, and his method for sorting the features of a product into various quality categories based on a questionnaire filled out by customers offers an apparently straightforward process for gaining deep understanding of customer requirements. However, as with so many tools, successful application of Kano's methods requires skill and experience.

Within the CQM companies, we now have a good bit of experience with the application of Kano's methods and some insight into how to use the methods effectively. This compendium of material provides an overview of Kano's methods, presents some experiences using the methods and some tips for use, and discusses a number of subtleties that users should be aware of. It is divided into the following major categories, most of which have more than one subsection.

Useful ideas for improving the way we use Kano's methods are scattered throughout sections II through V.

We hope that this compendium will help readers use Kano's methods more successfully—and that the experience and wisdom gained in so doing also can be shared through the CQM.

I. Introduction to Kano's Methods[2]

In planning a product or service, one makes a list of potential customer needs that the product or service should perhaps try to satisfy. Going to see current and potential customers ("voice-of-the-customer" visits) is one good way to get ideas for what should be on the list of potential customer requirements. For simplicity, throughout the rest of this paper we will call these potential customer requirements simply "customer requirements" or "CRs," with the implicit understanding that one must investigate any CR list in greater detail to understand which of the customer requirements need to be included in the final product (or service).

Many methods are available for investigating the characteristics of customer requirements.[3] For instance, one can ask customers to rank-order them. The particular method we will discuss here is based on the work of Professor Noriaki Kano of Tokyo Rika University.

Professor Kano and his colleagues developed a set of ideas[4] that we summarize as follows.

1. Invisible ideas about quality can be made visible.

Customer ideas about quality are often confused and difficult to see clearly, but they can be made

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[1] G. Burchill, D. Shen, et al., *Concept Engineering Manual*, CQM Document 7I, September, 1992.

[2] Much of the text in this section is adapted, with permission, from Shoji Shiba et al., *A New American TQM*, Portland, Oregon, 1993, Productivity Press and the CQM, pp. 221-230.

[3] Chapters 7 to 11 of *Design and Marketing of New Products* by Glen L. Urban and John R. Hauser, 2nd edition, (Englewood Cliffs, NJ, Prentice Hall, 1993) describes many other methods of inquiring about and understanding customer needs.

[4] Noriaki Kano et al., "Attractive Quality and Must-be Quality," research summary of a presentation given at Nippon QC Gakka: 12th Annual Meeting (1982), January 18, 1984. Presentations given at Japanese Society for Quality Control Annual Meetings, Noriaki Kano and Fumio Takahashi, "Himshitsu no M-H Sei Ni Tsuite" (Motivator and Hygiene Factor in Quality), October 1979; Noriaki Kano, Shimichi Tsuji, Nobuhiko Seraku, and Fumio Takahashi, "Miryokuteki Himshitsu to Atarimae Himshitsu (1), (2)" (Attractive Quality and Must-be Quality [1], [2]), October 1982, and published in *Quality*, JSQC, vol. 14, no. 2 (Tokyo: Japanese Society for Quality Control, 1984).

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clear. As the customer ideas of quality are made clear, many requirements emerge, and they fall into several groups, as represented by the tree structure of customer requirements in figure 1 (below).

Example of Customer Requirements

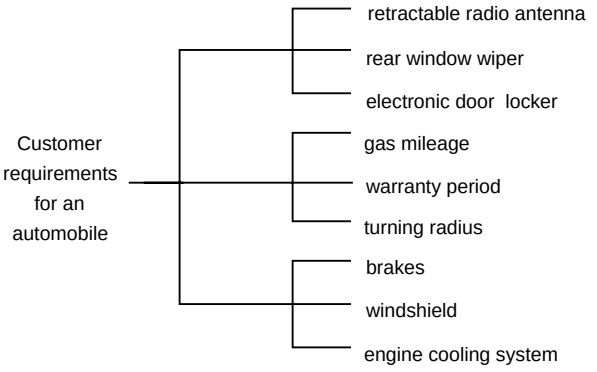

Figure 1

2. For some customer requirements, customer satisfaction is proportional to how fully functional the product is.

The horizontal axis of the Kano diagram in figure 2 (above right) indicates how fully functional some aspect of a product is, and the vertical axis indicates how satisfied the customer is. Traditional ideas about quality have sometimes assumed that customer satisfaction was simply proportional to how functional the product was– that is, the less functional the product, the less satisfied the customer, and the more functional the product, the more satisfied the customer. In the figure, the line going through the origin at 45 degrees graphs the situation in which customer satisfaction is simply proportional to how fully functional the product is: the situation in which the customer is more satisfied (up) with a more fully functional product (right) and less satisfied (down) with a less functional product (left).

Such customer requirements Kano designates as "One-dimensional" customer requirements.[5] For example, in automobiles, gas mileage (unless it is quite bad) is likely to be a One-dimensional customer requirement: Better gas mileage provides more customer satisfaction and worse gas mileage provides more customer dissatisfaction. (Study the graph for a moment and be sure you understand how the 45-degree line through the origin indicates a One-dimensional customer requirement, one where more functionality leads to more satisfaction.)

The Kano Diagram

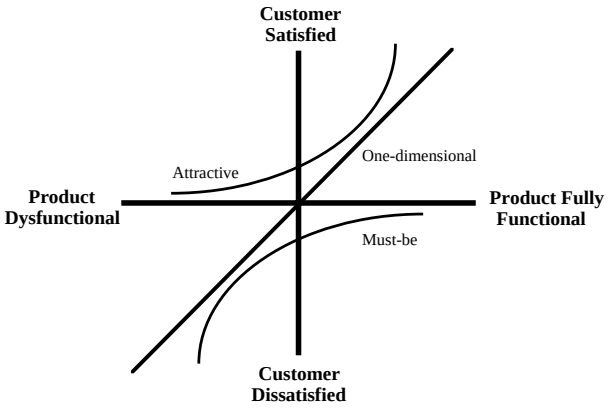

Figure 2

3. Some customer requirements are not One-dimensional—there are also "must-be" and "attractive" elements.

Figure 2 also has curves labeled "Must-be" and "Attractive."[6] The Must-be curve indicates aspects where the customer is more dissatisfied when the product is less functional, but where the customer's satisfaction never rises above neutral no matter how functional the product becomes. For instance, having poor brakes in an automobile causes a customer to be dissatisfied; having good brakes, however, does not raise the level of the customer's satisfaction. Good brakes are expected—they are a Must-be requirement.[7] (Study the Must-be curve to understand this requirement situation: A little or a lot of a given feature leaves the customer unmoved [basically neutral and certainly not satisfied]; however, any lack of that particular feature quickly dissatisfies the customer.)

The Attractive curve indicates areas in which the customer is more satisfied when the product is more functional but is not dissatisfied when the product is less functional. For instance, an automobile customer may not be unsatisfied if the radio antenna does not automatically lower itself into the car body when the radio is turned off, but the customer may be more satisfied when the car has this feature.[8] (Study the Attractive

[5] Some companies use the word "satisfiers" instead of One-dimensional customer requirement. That is, the more fulfilled this requirement is, the more satisfied the customer is.
[6] These curves are just roughly sketched. Section Vc will consider their exact shape in more detail.
[7] Some companies call these Must-be elements "dissatisfiers"; they can dissatisfy but they cannot produce a significant level of satisfaction.
[8] Some companies call these attractive elements "delighters," that is, they do not dissatisfy if absent but can delight when present.

curve to understand the kind of situation where lack of a feature leaves a customer basically neutral [certainly not dissatisfied]; however, having more of the feature quickly increases the customer's level of satisfaction.)

A customer may also be indifferent to a quality element, for instance to having a cigarette lighter in a car. Indifference would be plotted on figure 2 roughly along the horizontal axis—that is, the customer is neither satisfied nor dissatisfied whether the product is dysfunctional or fully functional.[9]

4. Customer requirements can be classified by questionnaire.

Kano and his colleagues believe that the One-dimensional, Attractive, Must-be, and Indifferent customer requirements can be classified through a customer questionnaire. On this questionnaire each question has two parts: How do you feel if that feature is present in the product, and how do you feel if that feature is not present in the product? To each part of the question, the customer can answer in one of five different ways.[10] For example, see figure 3 (below).

Based on the responses to the two parts of the question in figure 3, the product feature (how good gas mileage is, in this example) can be classified into one of six categories:

A=Attractive
M=Must-be
O=One-dimensional
I=Indifferent
R=Reversel
Q=Questionable

The first four categories have already been defined, and these are primarily what we are seeking in the Kano analysis. The other two categories indicate the following situations: There is a contradiction in the customer's answers to the questions (=Questionable); or our *a priori* judgment of functional and dysfunctional was the reverse what the customer feels (=Reverse).[12]

For each customer one determines into which category a given product feature falls by looking up the customer's answers to that feature's questions in the following Kano Evaluation Table, figure 4 (next page).[13]

For example, if the customer answers, "1. I like it that way," about "gas mileage is good," the functional form of the question, and "5. I dislike it that way," about "gas mileage is poor," the dysfunctional form of the question, we look at the intersection of the first row and the fifth column and find an O, indicating that gas mileage is a One-dimensional customer requirement from

[9] The Kano diagram showing in figure 2 is useful for illustrating Kano's concepts of quality. However, the tabulations explained in part 4 of this section are more useful for understanding the quality elements of an actual product.
[10] These are the translation of Kano's five answers as the CQM companies were taught them by Professor Shoji Shiba in 1990. Sections III and V discuss alternative formulations of the five answers.
[11] The answers to the questions are numbered in this example to help the reader follow the description of how a Kano questionnaire is processed. Subsection IIIa gives a fairly compelling argument for not numbering the answers.
[12] See part IIa.4 for a suggestion of how to handle the Reverse case in certain instances.
[13] A derivation of this table is explained in subsection Vc.

A Pair of Customer Requirement Questions in a Kano Questionnaire

functional form of the question

If the gas mileage is good, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
If the gas mileage is poor, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.

dysfunctional form of the question

Figure 3[11]

Kano Evaluation Table

Customer Requirements → / Functional ↓		Dysfunctional 1. like	2. must-be	3. neutral	4. live with	5. dislike
Functional	1. like	Q	A	A	A	O
	2. must-be	R	I	I	I	M
	3. neutral	R	I	I	I	M
	4. live with	R	I	I	I	M
	5. dislike	R	R	R	R	Q

Customer Requirement is:

A: Attractive
M: Must-be
R: Reverse
O: One-dimensional
Q: Questionable result
I: Indifferent

Figure 4

Examples of Three (Potential) Customer Requirements in a Kano Questionnaire

1a. If the gas mileage is good, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
1b. If the gas mileage is poor, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
2a. If the brakes are good, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
2b. If the brakes are poor, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
3a. If the radio antenna automatically retracts when the radio is turned off, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.
3b. If the radio antenna does not automatically retract when the radio is turned off, how do you feel?	1. I like it that way. 2. It must be that way. 3. I am neutral. 4. I can live with it that way. 5. I dislike it that way.

Figure 5

the customer's point of view.

A portion of the Kano questionnaire for a survey about an automobile is reproduced in figure 5 (facing page).[14]

Once all the Kano questionnaires for a survey have been collected, one tabulates them by looking up the classification of each customer requirement on each questionnaire in the Kano Evaluation Table and tallying it in the appropriate place in the row for that requirement on a Kano questionnaire tabulation form (figure 6, next page).

The result of the tallying of all customer's questionnaires is a matrix such as the one shown in figure 7 (next page).

For each row of the tabulation, that is, for each customer requirement, the dominant customer view (dominate classification) is indicated by the highest tally.[15] If two or more categories are tied or close to tied, it may be an indication that more information is needed: You may be dealing with two market segments, or you may need to ask questions about more detailed customer requirements.

From the tabulation of customer responses to the Kano survey for the automobile, a Kano diagram can be annotated–for example, a diagram showing the Must-be, One-dimensional, and Attractive, as in figure 8 (page 39)[16].

All customer requirements are not equal. Improving performance on a Must-be customer requirement that is already at a satisfactory level is not productive when compared to improving performance on a One-dimensional or Attractive customer requirement. Having insight into which customer requirements fall into which quality dimensions can improve focusing "on the vital few."[17]

IIa. Developing and Administering Kano Questionnaires[18]

In general, the steps to follow to develop and use a Kano questionnaire are:

1. Develop the questionnaire.
2. Test the questionnaire and revise if necessary.
3. Administer the questionnaire to customers.
4. Process the results.
5. Analyze the results.

1. Developing the Questionnaire

To construct the questionnaire formulate a pair of questions for each potential customer requirement for which you desire customer feedback. In the Concept Engineering (CE) process, these potential customer requirements come from step 6, the requirements KJ; the Kano process itself is step 7 of Concept Engineering. In Concept Engineering, the Kano questionnaire and analysis are used to confirm and categorize the customer requirements discovered through voice-of-the-customer visits and analysis of the data collected from customers. In other situations, potential customer requirements might be developed in other ways. For instance, a survey might test aspects of an existing product or service to find out if they are valid—if customers appreciate them as much as, or in the same way that, the provider of the product or service expects.

The first question in each pair of questions for a customer requirement refers to a situation in which the requirement is met, and it is worded in a format similar to the following: "If [the product] satisfied [requirement x], how would you feel?" This is the *functional* question. The second question in each pair refers to the case where the requirement is not met. This is called the *dysfunctional* question, and is worded in a format similar to the following: "If [the product] did not satisfy [requirement x], how would you feel?"

When writing the pairs of functional and dysfunctional questions for each potential customer requirement, use the following guidelines:[19]

- You may have to step down the ladder of abstraction to construct a clear question. When the potential requirements come from analysis of voice-of-the-customer data, avoid straying from the original intent of the customer requirement statement. In Concept Engineering, refer to the requirement KJ and translation worksheets if necessary.
- Beware of polar wording in the question pairs; multivalued orientation is preferred. Consider this functional question: "If line placed in the basket stayed in it until cast, how would you feel?" Instead of wording the dysfunctional question "If line placed in the basket falls out before casting, how

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[14] In this example the first question in every pair is the functional form of the question, and the second question in every pair is the dysfunctional form of the question.

[15] The mode of the distribution.

[16] This optional annotated Kano diagram may be useful in explaining the results of the survey to other people; however, it has a lot less information than a tabulation table such as that shown in figure 7.

[17] See part 5 of section II for more discussion on how to act on the Kano results.

[18] Much of the text in this section is adapted with permission from *Concept Engineering*, CQM Document 7I, G Burchill, D. Shen, et al., 1992, pp. 3.3-3.12.

[19] It is also helpful to get some advice from someone in your firm who has experience in administering surveys.

Looking Up Questionnaire Answers in Evaluation Table and Tabulating the Result

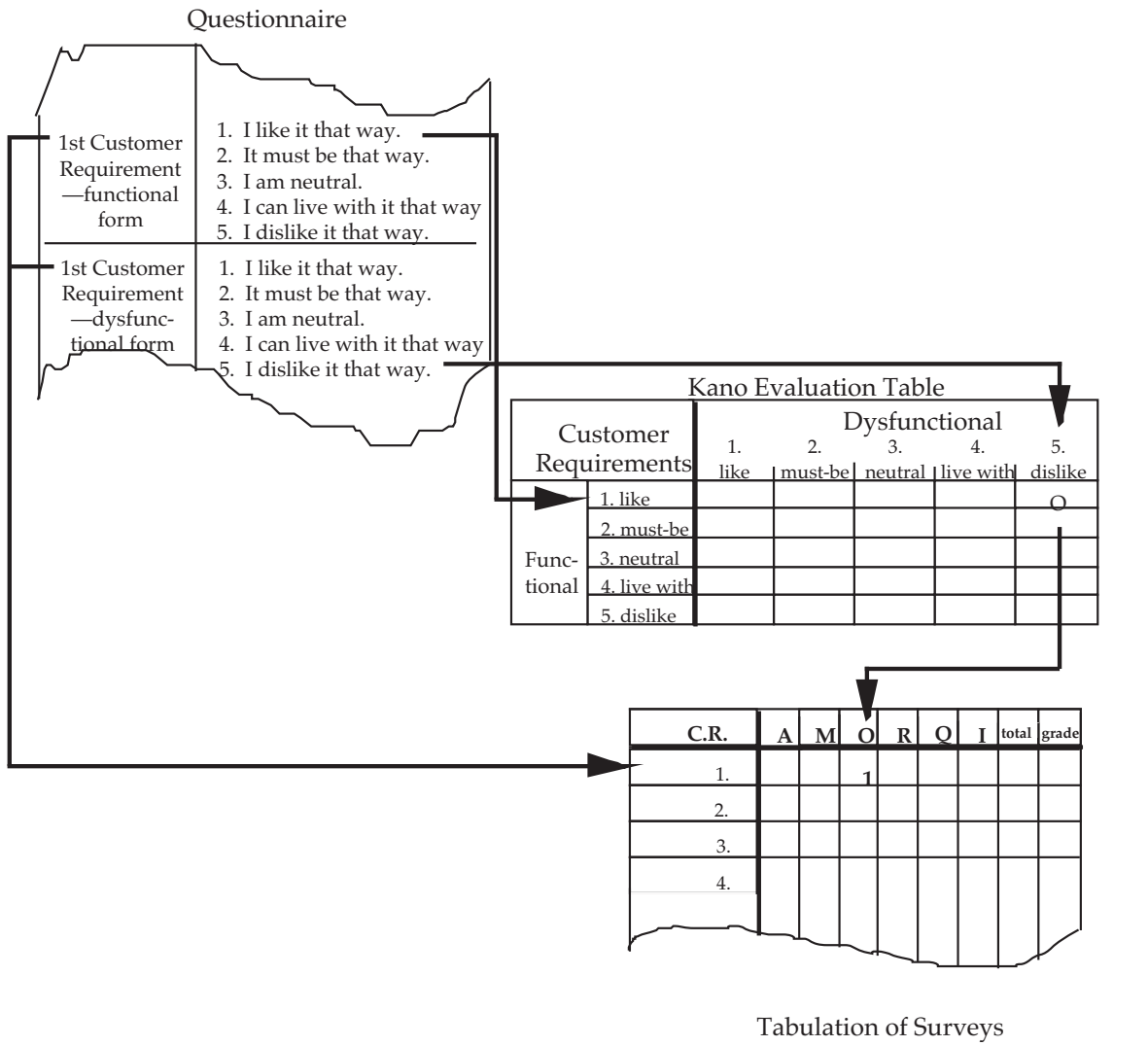


Figure 6

Tabulation of Responses for Each Customer Requirement in a Kano Questionnaire about an Automobile

C.R.	A	M	O	R	Q	I	total	grade
1.	1	1	**21**				23	O
2.		**22**			1		23	M
3.	**13**		5			5	23	A
…	6	1	4	1		**11**	23	I
…	1	**9**	6	1		6	23	M
…	7		2	3	1	**10**	23	I

Figure 7

Kano Diagram for Car Customer Requirements

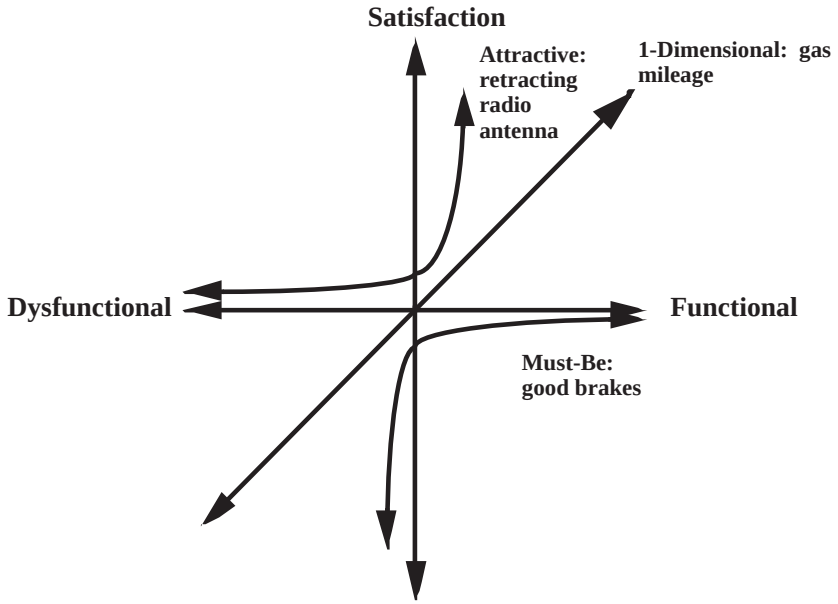


Figure 8

would you feel?," it is preferable to ask, "If some line placed in the basket falls out before casting, how would you feel?"[20]

- Don't try to cram several thoughts into one question. You want to know which question the respondent is answering. If a particular requirement contains more than one thought, use more than one Kano question, but bear in mind the need to keep the survey to a manageable length.
- Make sure questions are in customer terms, not development terms, that is, in terms of benefits, not features.
- The time you are taking to hear your customers' views contributes to the company's professional image. The format of the questionnaire should further enhance that image.

2. Testing the Questionnaire

When a questionnaire is to be sent to many customers, it's important that it be understandable. This is especially true of a Kano questionnaire, since it is unfamiliar to most people asked to fill it out. We recommend testing all of your questionnaires internally before distributing them to customers. A test run will help identify unclear wording, typographical errors, or confusing instructions.

Refining the questionnaire may require iteration. These guidelines can help you test your questionnaire effectively:

- Have members of the team preparing the Kano survey answer the questionnaire first. Each team member should think of a customer, try to predict his or her response, and note which questions the customer may not understand.
- Next select people inside your company to answer the questionnaire, and administer it to them. Select from a variety of backgrounds, for example, senior managers, development engineers, marketing personnel, and so on.
- Revise the questions and retest.
- Listen carefully and without bias to what your internal test customers say. If they find something confusing, it is quite likely that others will as well. Revise questions or add instructions as necessary.

3. Administering the questionnaire

The points below suggest some of the many details to consider in administering your questionnaire. You may be able to prepare for several of the points long before you have to prepare the Kano survey, thus shortening the time to prepare the questionnaire, send it, and wait for responses.

[20] This example is from the case study of the stripping basket for fishing, described in the Concept Engineering Manual.

- Select the customers you would like to survey. If you are using Concept Engineering, we suggest returning to the customer selection matrix to develop a target list, applying the same criteria used there. In order to ensure a statistically significant sample, most teams poll considerably more customers than were interviewed. Remember that not all customers will respond.
- Decide what medium you want to use: telephone (voice or fax), face-to-face presentation, mail, or other means. The most common method is through the mail. If you plan to use the mail, write a letter of introduction that explains the purpose of the survey and includes directions for the customer.
- Collect demographic data that will enable you to distinguish potential market segments if they exist. Categories of helpful information might include company and personal characteristics, familiarity or experience with product, use of competitor's products, and so forth.
- *Include instructions for filling out the questionnaire.* This is particularly important for the Kano questionnaire, since it is likely to be new to customers. Subsection Vb provides sample instructions.
- If you are using a Self-stated Importance questionnaire[21] in addition to the Kano questionnaire, use the same sequence of questions in both to make comparing the results of the two questionnaires easier.
- Send out the survey. Keep a log of customers to whom the survey was sent, along with the date. This will help you follow up, if necessary; and will help you avoid duplication if you choose to expand your sample later.
- Record responses as they arrive.

4. Processing the results

In part 4 of section I, we sketched how to process each completed questionnaire by looking up, in the Kano Evaluation Table, a "score" for the answers to the pair of questions for each potential customer requirement being investigated. We explained how these scores are in turn tallied into a tabulation matrix. Figure 6 illustrates this process.

In the far right column of the tabulation matrix, assign a category (grade) to each of the requirements. The simplest way to choose a category is to use whatever code appears most often in the responses for that requirement (that is, to use the statistical mode of the responses).[22]

If any requirement receives a substantial number of Questionable (Q) scores, it should probably be temporarily deleted from the analysis until the confusion with the question can be resolved or the thought processes of the respondents can be explored.

If a majority of the people who responded to the questionnaire give a Reverse (R) score to one of the customer requirements, it indicates that the marketplace's thoughts about that question are the opposite of those of the survey's creators. For instance, a company providing packaged vacation tours might construct a pair of questions such as the following:

> Functional: How do you feel about a vacation package where there are pre-planned events most of every day?
>
> Dysfunctional: How do you feel about a vacation package where there are few preplanned events each day?

If only a few people respond that they dislike having preplanned events most of every day and like having few preplanned events each day (see cell 5-1 in figure 4), this indicates that there are a few people in the marketplace who are different from most other people. (There may be a good market segmentation opportunity here.) But, if a large number of the responses say they dislike having preplanned events most of every day and like having few preplanned events each day, this large number of reverse scores indicates that the questionnaire's creators are thinking about things in the reverse of the way most customers are thinking about them.

In this case, one can rescore *all* of the questionnaires for this pair of questions, using the answers to the dysfunctional question as an index to the functional side of the Kano Evaluation Table, and the answers to the functional questions as an index to the dysfunctional side of the Kano Evaluation Table. This retroactively converts the question into the reverse form favored by most customers:

> Dysfunctional: How do you feel about a vacation package where there are preplanned events most of every day?
>
> Functional: How do you feel about a vacation package where there are few preplanned events each day?

In this way, the data already collected can be used. To repeat, to make this retroactive conver-

[21] See description in subsection IIb.

[22] See section IV for more sophisticated analysis methods.

sion work, the responses for *all* people who answered this pair of questions must be rescored, whether or not their original score for the pair of questions was Reverse.

5. Analyzing the Results

Several benefits are obtained from analyzing Kano data:

- Gaining a better understanding of requirements;
- Prioritizing requirements for development activities;
- Distinguishing market segment characteristics;
- Aiding in the design tradeoff process.

The purpose of administering a Kano questionnaire is to understand better the characteristics of customer's requirements. The responses should be seen only as a guide; they do not provide exact answers as to which features must be included in the product or which requirements need not be fully satisfied.

Establishing the method by which you will analyze the data before disseminating the questionnaires will save time. Will you use manual or automated input and analysis tools? Knowing this will enable you to marshal the necessary resources while you are waiting for replies.

There are various possible analysis approaches. As mentioned earlier, a simple way to rank the requirements is to score each according to the mode (the most frequently occurring dimension) in each row of the tabulation matrix. Thus, a requirement voted Must-be (M) by 43 percent of respondents and Attractive (A) by 38 percent of respondents would be interpreted as a Must-be requirement.

You may want to go beyond the simple mode and look at the second most frequent dimension for each requirement. For example, take a case where there are two questions and fifty responses to each. Thirty customers rate the first requirement Attractive and twenty rate it Indifferent. On the second requirement, thirty customers again rate it Attractive, but the remaining twenty rate it Must-Be. In this case, it is likely that the two requirements should be treated differently. The second requirement should receive higher priority from the team.

When two Kano codes are tied in the scoring for a given question, consider:

a. Following up with customers for additional insight,
b. Looking for market segmentation differences,
c. Selecting the classification that would have the greatest impact on the product (use the following ordering: M > O > A > I).

Another way to study the data is to construct a spreadsheet with columns for the first, second, and third most frequent responses, as in figure 9 (below).

Spreadsheet of Most Frequent Responses to Customer Requirements

Customer requirement number	Most frequent response	Second most frequent response	Third most frequent response
1	A	O	
2	A	O	
3	M		
4	O	I	I
5	O	A	
6	M	A	
7	A	O	M
8	M		
9	O	M	I

Figure 9

Then the rows can be rearranged into groups according to the following order: Must-Be's first, One-Dimensionals second, followed by Attractives, Indifferents, and Reverse requirements, as in figure 10 (below).

Spreadsheet of Customer Requirements Sorted in Order of Most Frequent Response

Customer requirement number	Most frequent response	Second most frequent response	Third most frequent response
8	M		
3	M		
6	M	A	
9	O	M	I
5	O	A	
4	O	A	
1	A	O	
7	A	O	M
2	A	O	I

Figure 10

If you used a Self-stated Importance Questionnaire[23] in parallel with the Kano survey, it can be helpful in further sorting the Kano responses. One way to order the requirements within each group is by importance ranking. For example, if there were several customer requirements whose mode was Attractive, you might use the Self-stated Importance data to rank the Attractive requirements in descending order of importance. This would help you discern which Attractive requirements the development team might want to focus on.

The Kano survey results will be only one of several factors that will dictate what should be included in a product. A general guideline is to seek to fulfill all Must-be requirements, be competitive with market leaders on the One-dimensional Requirements, and include some differentiating Attractive elements.

In general, the return you can expect from fulfilling a requirement (in terms of customer satisfaction) should guide the effort you invest to fulfill it. As stated earlier, improving performance on a Must-be customer requirement that is already at a satisfactory level is not as productive as improving performance on a One-Dimensional or Attractive requirement. Classifying customer requirements into Kano's dimensions will allow you to focus your efforts where your customer will notice their effect the most.

IIb. Self-Stated Importance Questionnaire[24]

The CQM companies using Kano's methods often use a Self-stated Importance questionnaire together with the Kano questionnaire. Therefore, we describe it here.

According to research by Professor John R. Hauser at MIT,[25] the Self-stated Importance questionnaire can help organizations understand the relative importance of each requirement for customers. An organization can use such a survey in parallel with a Kano survey to help focus attention on the most important results from the Kano survey.

Constructing the Self-Stated Importance questionnaire is straightforward:

1. For each of the potential customer requirements to be included in the Kano questionnaire, construct a question on the Self-stated Importance questionnaire in the following general format: "*How important is it or would it be if:* [requirement x]?" For example: "How important is it or would it be if the car has good gas mileage?"

2. Provide a scale on which customers can mark their responses from "Not at all important" to "Extremely important." Figure 11 (below) gives an example.

IIIa. Experience in the Use of Kano's Methods in the Specification of BBN RS/1 Release 5.0

[Editor's Note: Robert Blauth, Reinhart Richter and Allan Rubinoff of BBN Software Products

[23] See subsection IIb, on this page.

[24] The text in this section is adapted from G. Burchill, D. Shen, et. al. , *Concept Engineering*. CQM Document 71, 1992, pp. 3.3-3.4.

[25] John R. Hauser and Don Clausing, "The House of Quality," *Harvard Business Review* No. 3 (May-June 1988); John R. Hauser, "Comparison of Importance Measurement Methodologies and their Relationship to Consumer Satisfaction," MIT Marketing Center Working Paper 91-1, 1991. Chapters 7 to 11 of "Design and Marketing of New Products" by Glen L. Urban and John R. Hauser (Englewood Cliffs, NJ, Prentice Hall, 1993) describe many other methods of inquiring about and understanding customer needs. That book uses the term Self-*rated* Importance questionnaire.

Example from Self-stated Importance Questionnaire

	Not at all important		Somewhat important		Important		Very important		Extremely important
How important is it or would it be if: The car has good gas mileage?	1	2	3	4	5	6	7	8	9
How important is it or would it be if: The car has good brakes?	1	2	3	4	5	6	7	8	9
How important is it or would it be if: The car has a long warranty period?	1	2	3	4	5	6	7	8	9
How important is it or would it be if: The car has a small turning radius?	1	2	3	4	5	6	7	8	9

Figure 11

were asked to provide some informal thoughts on the use of Kano's methods in connection with specifying Release 5.0 of BBN's 10-year old RS/1 statistical data analysis product.]

Reinhart Richter says: As I understand Kano's method, it is a method of using five standard answers ("Like," "Must-be," etc.) to functional and dysfunctional questions about a product feature or function to classify (not rank) the feature or function into one of six categories:

> "Must be" meaning if the product does not have this no one will be interested in it.
>
> "One-dimensional" meaning the more you provide this function the more satisfied the customer will be
>
> "Attractive" meaning the customer is happy when it is there but will not complain if it is not there
>
> "Indifferent" meaning the customer does not care about this feature
>
> "Questionable" and "Reverse" meaning that we probably have done something wrong phrasing the question or, under certain circumstances, that this particular function has a negative interaction with other important functions and we have not really understood what we are talking about.

I personally think that this method is brilliant. It does have some intrinsic difficulties, though.

A. The person answering the questions needs to understand that the default answers shall reflect a classification, not a ranking. If the answers are misunderstood as being a ranking on a 1 to 5 scale, they may misunderstand how to interpret the answers, and then analysis with the 5x5 Kano Evaluation Table may give misleading results. In particular, *avoid numbering the default answers on the Kano questionnaire, and provide examples of how to answer.*

B. Phrasing the standard answers to the question should be done with great care, particularly in an international environment. If you do not translate the questions and answers, people with a less profound knowledge of the English language may not understand them, and the results will be meaningless.

The first time our international customer base was confronted with a Kano survey, they thought "It must be that way" was much stronger than "I like it that way." They were confused about why "It must be that way" was the second, not the first default answer. I myself understood what this was all about only after studying up on it, and I was a member of the team administering the survey. *Educate the people answering the questions.*[26]

If you do translate the questions and answers, on the other hand, you need to make sure that Kano's "spirit" — that is, classification — survives.

C. The mode statistic used to analyze the results may need to be modified. If the Kano questionnaire asks about very general functions, such as whether a car should have three or four wheels or whether a software package should have a graphical user interface or a command interface, everybody will have a specific opinion. If, however, the Kano survey asks about very specific functions, such as whether a car should have ceramic valves or a software package should support a particular printing device, then the majority of the respondents may be Indifferent.

Extremely detailed questions can increase the "noise level" to a point where all "requirements" are considered Indifferent. For example, if 18 answers classify a function as One-dimensional, 19 as Attractive, 18 as Must-be, 20 as Indifferent, 2 as Reverse, and 3 as Questionable, then the mode statistic classifies this function as Indifferent even though 57 out of 82 people answering say that they need this function in one way or the other. *Consider doing something to decrease the noise level before applying the mode statistics.*

One way to modify the mode statistic is as follows:

```
If (One-dimensional+Attractive+Must-be) > (Indifferent+Reverse+Questionable),
Then grade is maximum(One-dimensional, Attractive, Must-be),
Else grade is maximum(Indifferent, Reverse, Questionable).
```

In figure 12 (next page), for CR1, (19+18+18) > (20+2+3). Therefore, the grade is A; that is, maximum(18, 19, 18). For CR2, (7+6+9) < (36+2+2); therefore, the grade is I, or maximum(36, 2, 2).

D. It may happen that the person answering the Kano survey is already using a competitor's product in addition to your product for certain tasks presently not covered by your product. In this case the person may answer the question pairs with "Must be/Live with" for a particular feature. The customer thinks that the function is very important, but if it is not covered by your

Robert Blauth, Reinhart Richter and Allan Rubinoff are employees of BBN's Software Products Division, and have used Kano's methods in the specification of products.

[26] Subsection Vb includes an example of instructions on how to answer questions.

Example of the use of modified mode statistic.

C. R.	A	O	M	I	R	Q	total	grade
1.	19	18	18	20	2	3	90	A
2.	7	6	9	36	2	2	62	I
…								

Figure 12

product it does not cause big problems, because the customer can use the competitor's product. In this case the Kano Evaluation Table yields an Indifferent classification even though it should be a Must-be. *Consider modifying the Kano Evaluation Table element (functional=Must be,dysfunctonal=Live with) from Indifferent to Must-be.*[27]

E. The Kano method should always be combined with a Self-stated Importance ranking.

F. For existing products such as RS/1, use of Kano's method to analyze the need of new functionality may be questionable. If a certain additional function does not and cannot interfere with any other function or property of the software, then this additional function should not be able to be "Reverse" or "Questionable" unless you misphrased the question. Also, such an additional function should not cause a feeling of "Live with" or "Dislike." *Drop default answers on questions where they don't make any sense.* They probably only confuse the reader.

[Robert Blauth and Allan Rubinoff confirm some of Richter's points and make some additional points.]

The wording of the five possible answers is the most problematic part of the survey. We ran into problems with international customers' interpretation of "I like it that way" vs. "It must be that way." We also had trouble with the answer "It must be that way" to the dysfunctional version of the requirement statement—it is difficult for some people to comprehend how "It must be that way" can be a possible answer to the statement that the product doesn't have what the customer wants.

Wording the functional and dysfunctional requirement statements was difficult. Some of the features that we asked about were not clear to people answering the survey, and so the validity of some of the answers was questionable. Also, wording was difficult if the choice was really not black or white. For example, the dysfunctional version of the requirement was to provide users with support for a 24 hour clock format and the functional version of the requireent was to provide support *only* for a 12-hour format.

In formulating the questions, we did try to emphasize benefits rather than specific features, as the CQM instructions on Kano suggested. However, we were not always able to do so, and as a result a lot of the questions were fairly specific about features. Some of this may have been the result our team's unfamiliarity with Kano surveys. But it may be that in some ways the Kano survey was unsuitable for our purposes. Some of the things we were proposing required talking about specific features; just emphasizing benefits would have resulted in questions that were too vague to elicit useful feedback.

There should be a brief explanation of the Kano format included with the questionnaire. This would help the customers better understand the use of the positive and negative questions as well as the meaning of the five possible answers.

The survey seems to be well suited to defining a new product, but awkward for developing a new release of an existing mature product like RS/1. For example, if a current customer says a specific proposed feature is a Must-be, how do we interpret that? That is, if the feature is truly essential, why is that person using the product in the first place, since the product doesn't have the feature now?

The survey was not very useful for distinguishing between small features and large ones. For example, if a small feature is considered a Must-be by respondents, that's probably not equivalent to a large feature being considered a Must-be. Presumably, a small feature won't make or break a sale of the product, whereas a large feature might.

The survey helps you make decisions about what features to include in a product but is not very helpful for determining how to implement a feature. Different people will have different preferences about how a feature should work, but it is hard to use the Kano survey to determine this.

It seems that a Kano survey would be most useful for defining a new product, since it helps you determine what things a product should do without committing you to a specific approach to doing those things. In the case of RS/1 5.0, though, there were a lot of historical constraints on what the new release could do and how it could do them.

[27] See also the suggestions in subsection Vc for other changes in the Kano Evaluation Table.

It was important to look at combinations of scores before making a final determination of priorities. For example, if one requirement fell into the low end of the Attractive scores but had a large number of One-dimensional scores, we might consider keeping that requirement in the Attractive list.

IIIb. Observation of the Use of Kano's Method

[Editor's Note: As part of his PhD research, which included Concept Engineering, Gary Burchill has observed Kano's methods in use as much as or more than anyone else associated with the CQM. He has provided the following observations.]

I am absolutely convinced that characterizing the customer requirements into Kano's categories is very valuable. Design is a trade-off activity. Any credible insight the designer can develop with respect to which customer requirements can or cannot be sacrificed is invaluable for keeping development effort focused, making necessary trade-offs, and maximizing customer benefit.

Here are some situations I have observed:

- Developers insisting that a particular requirement must be satisfied in the product, since it was a Must-be
- Program managers deciding on the basis of relative priorities within the Attractive category which requirements *not* to address in the current release of the product
- A development team negotiating with its management about development schedule in order to accomodate key Attractive requirements
- Kano analysis (with relative priorities) seeming to increase the credibility and confidence of the team with respect to the design objectives, perhaps on account of increased traceability

Writing the customer requirements in the functional and dysfunctional format of the Kano questionnaire is hard, however. The writer of a pair of questions is forced down the ladder of abstraction. This can create a situation where the pair of questions is about a smaller customer requirement than was heard in the voice-of-the-customer interviews. Writing more pairs of questions to address the remaining aspects of the requirement heard from the customers is not feasible, because it would result in too long a questionnaire.

Writing multivalued pairs of functional and dysfunctional questions is also difficult. To write a 0/1 pair of questions is easy, but when you develop question pairs that are anchored on opposite ends of the scale, the responses you receive are often questionable.

Some people get distracted by the wording and order of the five standard answers. This is unfortunate, since one individual on the team preparing a Kano questionnaire with a prove-it-to-me attitude can disrupt progress of the entire team. In the larger scheme of things, I am not sure it matters that much what words you use to describe the five responses, especially when respondents presist in perceiving them to be an ordinal scale from better to worse.

Adding the Self-stated Importance information increases the designer's ability to discriminate among customer requirements. Mike Timko's extension to combine the two scales into "better-than" and "worse-than" scales is a siginficant enhancement.[28]

Engineers, in general, seem to have less trouble than marketing people in seeing the inherent usefulness of Kano's characterization of the various customer requirements and in overlooking the potential problems with the response scale. Possibly this is because marketing people have other methods for analyzing customer requirements with which they are already fully conversant.

Gary Burchill was the leading contributor in the development of CE. Gary is now continuing service in the U.S. Navy, and is based in Pennsylvania.

IIIc. A Bose Development Team's Experience With Kano Mapping

[Editor's Note: Editorial Board member David Boger also had observations on the use of Kano's methods.]

At Bose we have used Kano's methods as part of the use of Concept Engineering to plan a new product. Once the development team has sought and analyzed the voice of the customer and developed a list of key customer requirements, the team must operationalize what it has learned. This means (*a*) defining metrics against which solutions for each customer requirement can be tested, and (*b*) verifying that the team has accurately heard and understood the voice of the customer and translated it into an appropriate requirement statement.

It is this latter element of Operationalization that employs the Kano's techniques. Kano lets us categorize each requirement according to how customers define the relationship between the degree to which the requirement's functionality

David Boger is with Bose Corporation and participated in the Enchilada case study presented in the Summer 1993 issue of the CQM Journal.

[28] See subsection IIIc for a further endorsement of Timko's ideas and subsection IVb for a description of this extension.

is present in the product concept and the customer's perceived level of satisfaction. The Kano survey data gives the development team a basis for decisions with regard to leveraging resources. Essentially the team translates the Kano results into a customer requirement weighting factor.

However, how best to make this translation? Is it reasonable simply to categorize each of the requirements into one of the four Kano dimensions? The Center for Quality Management's Concept Engineering manual describes one method of taking into account the proportion of scores in each dimension. Page 5.11 of the document shows how a team should redefine Kano results in order properly to complete a Pugh-style selection matrix.

An alternative approach for deriving a weighting factor has been suggested by a development team from Analog Devices. This approach interpolates within the Kano Diagram's two dimensions of functionality and satisfaction, thereby providing more accurate weighting information.[29] The method actually arrives at two independent factors—one to be applied when the solution under evaluation provides functionality with regard to a customer requirement better than a reference solution, and the other to be applied when the solution under evaluation is worse than a reference solution.

Bose development teams have plotted these so-called "better than" versus "worse than" scores and found the graphical representation illuminating. Consider the graph in figure 13 (below).[30]

Two dimensional Representation of the Integration of the Kano Quality Categories

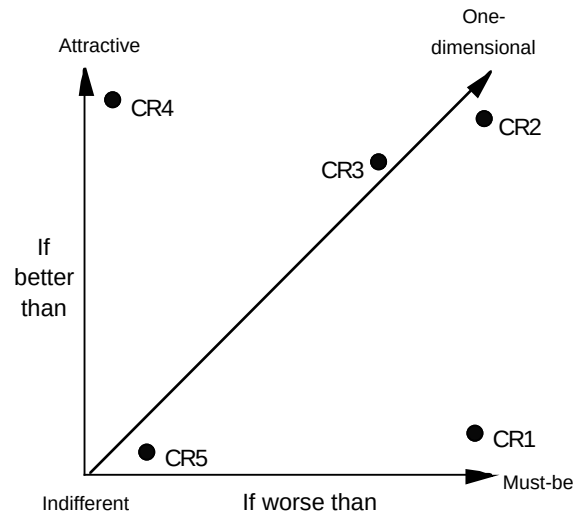


Figure 13

In this example, five Customer Requirements are plotted on the "better than" and "worse than" axes. Points that lie near the origin (CR5) show low scores on each scale and are therefore increasingly Indifferent as they approach the origin; these are the least important requirements for which function should be provided in the product concept. Points that lie farther from the origin and hug the horizontal axis (CR1) are increasingly more pure Must-be Kano requirements and therefore deserve the full attention of the development team. Points farther from the origin and close to the unity slope line are increasingly one-dimensional (CR 3, 2). Finally, those points that reside away from the origin and close to the vertical axis are more like Attractive elements (CR4).

In general, it can be seen that the priority of the Customer Requirements may be represented in a descending order on this graph by a curved line beginning on the "worse than" axis far from the origin and then sweeping in an arc in a counterclockwise direction ending on the "better than" axis near the origin. This is illustrated in figure 14 (below).

Order of Decreasing Importance

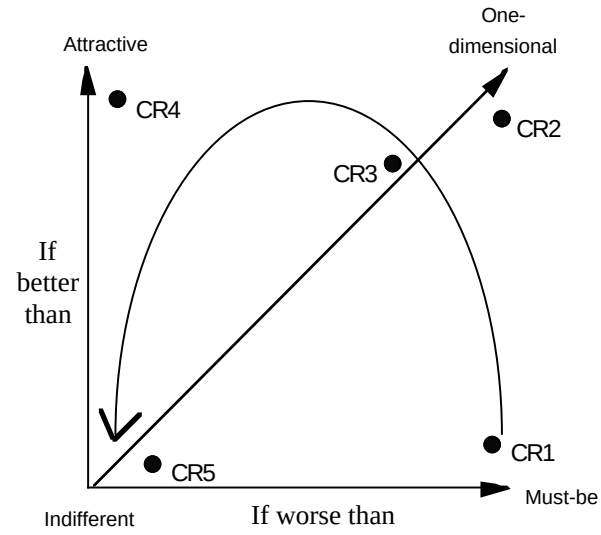


Figure 14

[Editor's Note: I suspect there are cases when an Attractive requirement might be included in the product even when insufficient resources are available to meet adequately all the One-dimensional requirements in a first release. Maybe customers would be more accepting of some

[29] It may be useful to read Section IVb first for a derivation of this approach.
[30] *Ibid.*

weaknesses in meeting One-dimensional requirements if/when an occasional "delighter" were provided.]

IVa. The Desire for Continuous and Graphical Analysis

Many people who have used Kano's methods, or are contemplating doing so, are wary of the simple method given in sections I and II for classifying a given customer requirement as Attractive, One-dimensional, and so on. They typically feel that it seems like a loss of information (and in some cases is misleading) to reduce 25 possible combinations of answers from each respondant into just one of six possible categories, and then to reduce further the category derived for each respondent to just one of six possible categories for all respondents.

Thus, there has been a desire for more "continuous" (finer) methods of analyzing the data from Kano questionnaires. In some cases the more continuous methods have been subjective and qualitative; for example, using common sense to choose the Kano category for a particular customer requirement when the category selected by the mode seems misleading. In other cases people have suggested and used more quantitative methods. The next two subsections, IVb and IVc, describe several of these.

After a quantitative, more continuous method for analyzing Kano questionnaires is derived, a natural next step is to show the results graphically, since graphical methods are often better to indicate trends (which may be hidden in a forest of individual numbers) and to show more dimensions of the data simultaneously than can often be comprehended from the raw numbers.

Thus, using what we are calling continuous variables and representing the results graphically offer at least three powerful advantages:

- A continuous approach can summarize the data without losing resolution. For example, in the Kano Evaluation Table there are nine response pairs that equate to the Indifferent category, and each may have a somewhat different emphasis.
- A continuous representation deals more comfortably with situations where there is no dominant response to a question (e.g., 37 percent Must-be, 33 percent Attractive, 30 percent One dimensional) by allowing for intermediate points, or hybrids. See the caveat below, however.
- A graphical representation can often convey more information simultaneously than a nongraphical approach.

The more continuous approaches described in subsection IVb may be best applied after you inspect responses for evidence of discrete market segments. Lumping together distinctly different perspectives to form an average may produce confusing results. Take, for example, a case where votes are evenly split between Attractive, Must-be, and One-dimensional. One way to check for the existence of distinct segments is to run a test of correlation between this response variable and some of the demographic data collected with the questionnaire. When different segments are identified, it may be best to handle the data separately. (Of course, the same consideration could be given to processing of the Kano data using the simplest of methods.)

It also would be useful for someone with a strong mathematics and extensive testing background to consider and explain the relationship, if any, between Kano-type questionnaires and more mathematical techniques of anaylzing and organizing customer analysis, such as, cluster analysis, multidimensional scaling, or correspondence analysis.

IVb. An Experiment in Continuous Analysis

[Editor's Note: Mike Timko of Analog Devices has generously provided a blow-by-blow description of some ideas he and his colleagues at Analog Devices used to try to improve processing of Kano survey responses. At first he was hesitant to provide a description of what he considers to be a trial use of some ideas. However, he was able to be convinced of the value of making this informally available so that others can try to build on his work or find ways to improve it.]

During the past year I have been involved in a voice-of-the-customer project in the Converter Operating Group (COG) at Analog Devices, exploring "12-bit general purpose ADC" product definitions. There were about six of us on the team, with Gary Burchill as our facilitator.

When the Kano questionnaires came back, I volunteered to put the results in a form that the team could use. During that process, I came up with a way to crunch the data that is easier to implement while, I think, preserving the voice of the customer a little better than simply scoring the answers as Attractive, Must-be, and so forth.

First, the Kano questionnaires were typed into a computer program, written in C by Reddi Penumalli of our CAD department. This program took the two answers to each pair of questions and looked up the resulting score

Mike Timko is a division fellow at the Semiconductor Division of Analog Devices. His responsibilities include the definition, design and development of high resolution Analog-to Digital Convertors for the data acquisition market. He holds SB and SM degrees in EE from MIT.

(Attractive, Must-be, etc.) in the Kano Evaluation Table. Another program then compiled the results so that the data I got was a histogram of the number of responses in each Kano dimension for each question, plus an average importance value for each question from the Self-stated Importance questionnaires that were gathered at the same time as the Kano questionnaires.

I wanted to put this information into a spreadsheet where it could be manipulated in various ways, as our development team saw fit. My goal was to be able to compile a score for the various solutions the team had come up with by writing spreadsheet functions (in Excel on a Macintosh).

I immediately encountered a problem. The basic Kano guidelines in the Concept Engineering manual assume some use of judgment in classifying each customer requirement into one of the Kano dimensions by the majority of the responses. The examples shown in the book are all pretty clear-cut. However, many of our responses tended to be spread out over several categories (A, O, M, and I)—see CR1 in the figure 15. Simply using the mode statistic didn't seem appropriate. Also, it didn't seem quite fair to classify a customer requirement that was 90 to 10 Attractive to Indifferent the same as one that was 60 to 40 Attractive to Indifferent, as illustrated by CR2 and CR3 in figure 15 (below).

Examples where Mode Statistic seems Inadequate

CR	A	M	O	R	Q	I	total	grade
1.	33	21	30			16	100	A
2.	90					10	100	A
3.	60					40	100	A

Figure 15

I wanted to calculate an average of some sort while also preserving some idea of the spread over Attractive, One-dimensional, and Must-be features. This gave me the idea to reduce the data to two numbers: a positive number that is the relative value of meeting this customer requirement (versus the competition), and a negative number that is the relative cost of not meeting this customer requirement. I labeled these columns "If we're better ..." and "If we're worse ...", abbreviated Better and Worse.

To calculate the Better value, I added the Attractive and One-dimensional columns and divided by the total number of Attractive, One-dimensional, Must-be, and Indifferent responses. (That is, I ignored Reverse and Questionable responses.) I then added the Must-be and One-dimensional columns, divided by the same normalizing factor, and put a minus sign in front of the result to get the number for Worse. These may be written as the following formulas:

$$\text{Better} = \frac{A+O}{A+O+M+I} \qquad \text{Worse} = -\frac{O+M}{A+O+M+I}$$

Example where Better and Worse have been calculated for Seven Customer Requirements

CR	A	M	O	I	Better	Worse
6	53	20	35	6	.77	-.48
5	40	17	33	24	.64	-.44
4	59	8	26	18	.77	-.31
3	55	3	20	30	.69	-.21
2	69	4	16	27	.73	-.17
1	40	2	2	60	.40	-.04
7	63	1	1	20	.75	-.02

Figure 16

The positive Better numbers are indicative of the situation where, on average, customer satisfaction will be increased by providing these (Attractive and One-dimensional) elements. The negative Worse numbers are indicative of the situation where customer satisfaction will be decreased if these (One-dimensional and Must-be) elements are not included. To look at it from a slightly different angle, Better indicates how much customer satisfaction is increased by our providing a feature (i.e., "If we're better" [than the competition], increase our score by this positive number); and Worse indicates how much customer satisfaction is decreased by our not providing the feature (i.e., "If we're worse" [than the competition], decrease our score by this number).

Pairs of Better and Worse points for each customer requirement can be plotted on a two-dimensional graph as shown in figure 17 on the next page (the minus sign in front of Worse has been ignored in this graph for purposes of clarity).[31]

[31] A representation of Better and Worse can also be overlaid on the traditional Kano diagram (see figure 2; however, we will not here illustrate and describe the derivation of this overlay.

Two Dimensional Representation of Kano Quality Categories

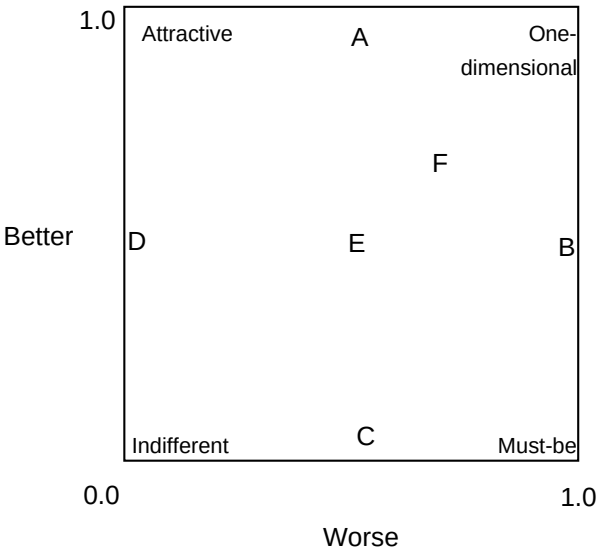


Figure 17

In the graph in figure 17, Better runs from 0.0 to 1.0 up the vertical axis, and Worse runs from 0.0 to 1.0 along the horizontal axis (remember, the minus sign has been left off Worse on this graph). If there are 20 responses regarding a particular customer requirement, and all of them when looked up in the Kano Evaluation Table result in an Attractive rating, then Worse=(0+0)/(20+0+0+0)=0 and Better=(20+0)/(20+0+0+0) =1, or the point 0,1; this point is plotted at the top left corner of the graph, the purely Attractive corner.[32] This and a number of other points are described in figure 18 (below).

Finally, I decided to multiply each of these numbers by the Self-stated Importance average. If the Self-stated Importance scale runs from 0 to 1.0,[33] then potential requirements judged less important will be scaled toward the Indifferent corner of the graph shown in figure 17.

The team then used the scaled Better and Worse numbers in two ways.

First, most of the features on our customer requirements list are independent of one another. That is, the only decision to be made is whether

[32] Notice the parallels between this graph and the similar graph in Section IIIc (figure 13).

[33] In our work we actually multiplied by the unscaled Self-stated Importance rating. I have scaled this rating into the interval 0 to 1.0 here to avoid redrawing figure 15 on a new scale and then having to explain the meaning of that scale. To scale the 1 to 9 ratings typically used in a Self-stated Importance survey into the interval 0 to 1.0, subtract 1 from each rating on the 1 to 9 scale and then divide by 8.

Description of Points in Figure 17

Distribution of response	**XY pair**	**Location on the graph of the point**
All Attractive	0,1	top left corner
All One-dimension	1,1	top right corner
Evenly split between Attractive and One-dimensional	.5,1	middle of top edge, halfway between attractive and one-dimensional-point A
All Must-be	1,0	bottom right corner
Evenly split between One-dimensional and Must-be	1,-5	middle of right edge, halfway between one-dimensional and must-be-point B
All indifferent	0,0	bottom left corner
Evenly split between Must-be and Indifferent	.5,0	middle of bottom edge, halfway between must-be and indifferent-point C
Evenly split between Indifferent and Attractive	0,.5	middle of left edge, halfway between indifferent and attractive-point D
Evenly split among Attractive, One-dimensional, Must-be, and Indifferent	.5,.5	exact middle of graph-point E
Evenly split between Attractive and Must-be	.5,.5	exact middle of graph, halfway between attractive and must-be, without an influence of one-dimensional or independent-point E
Evenly split among attractive, one dimensional, and must-be	.67,.67	equally spaced between attractive and must-be, but influenced by one-dimensional-point F

Figure 18

to include the feature or not. Based on the data, we went back and decided which features were most worth including. In general, one wants to include customer requirements with higher positive Better scores because they add the most to customer satisfaction, and customer requirements with higher (more negative) Worse scores because they prevent the most customer dissatisfaction.

Second, we compiled total grades for our best solution versus the competition. If our solution had a feature that the competition didn't, then we increased our relative score by the amount of Better for that feature; if our solution didn't have a feature that the competition did, then we decreased our relative score by the amount of Worse for that feature. If both we and the competition had a feature, or neither we nor the competition had a feature, our relative score was unaffected.

In summary, I came up with a pair of formulas that can be used to calculate two numbers that appear to be useful in evaluating Kano questionnaire results. We used these numbers in both the solution generation and concept selection phases of our voice-of-the-customer efforts.

While I think that this method has merit, I also have several reservations:

1. The primary usefulness of the resulting numbers is in their relative values; that is, in prioritizing the customer requirements. Because the resolution of the Kano data is so low, however, I suspect that the statistical uncertainty of the averages is quite large (tens of percent). Don't count on these numbers to differentiate between close results.
2. This analysis is still based on assigning a single category (e.g., Attractive, Must-be) to the Kano questionnaire results. Why should Attractive be the single result for three different combinations of answers (like/must-be, like/neutral, like/live-with)? I see this as a basic problem with Kano theory, but I ignored it.[34]
3. For some people, it seems redundant to both multiply by the Self-stated Importance number *and* include the Indifferent category in the denominator of the Better and Worse calculations.
4. To be more statistically "correct," one should perhaps sum the Self-stated Importance numbers in the appropriate Kano dimension for each response instead of summing the number of instances of a dimension and multiplying by the Self-stated Importance average at the end. However, I didn't want to go back and rework the data, so I assumed that it would average out.

IVc. Thoughts on Graphical and Continuous Analysis

[Editor's Note: This section is based on ideas presented by William DuMouchel at a CQM Research Committee meeting on September 10, 1991]

1. Establish the basic plot.

The form of analysis described in this section assumes there are Q pairs of questions, $j = 1, ..., Q$, and N respondents, $i = 1, ..., N$. It also assumes that a Self-stated Importance questionnaire may have been used in parallel with the Kano questionnaire. Thus, there may be three scores for each potential customer requirement being investigated—*Functional*, *Dysfunctional*, and *Importance*. These three scores are coded as follows:

Functional: Y_{ij} =-2 (Dislike), -1 (Live with), 0 (Neutral), 2 (Must-be), 4 (Like)

Dysfunctional: X_{ij} =-2 (Like), -1 (Must be), 0 (Neutral), 2 (Live with), 4 (Dislike)

Importance: W_{ij} =1 (Not at all Important), ..., 9 (Extremely Important).

Thus, if respondent number 8 answered for potential customer requirement number 6 that he liked good gas mileage, could live with bad gas mileage, and felt the issue of gas mileage was of medium importance, then

$$Y_{8,6} = 4,$$

$$X_{8,6} = 2, \text{ and}$$

$$W_{8,6} = 5$$

Note that X and Y take on the values -2, -1, 0, 2, 4 only. The logic for the asymmetrical scale (beginning from -2, rather than -4) is that Must-be and One-dimensional are stronger responses than Reverse or Questionable. Therefore, the scaling should give less weight to the less strong responses to diminish their influence on the average. The Reverse-type responses are given less weight by being pulled toward 0.[35]

[34] This issue appears to be at least partially addressed by the ideas discussed in subsection IVc on this page.

[35] It is assumed that only a few of the people responding to the questionnaire got a Reverse score for the requirement under consideration. If most of those responding got a Reverse score, the answers to that requirement could be rescored as described in subsection IIa; see also the discussion of Reverses in subsection Vc.

Figure 19 (below) should help to clarify the positioning of the various dimensions.

Functional (-2 to 4) vs. Dysfunctional (-2 to 4)

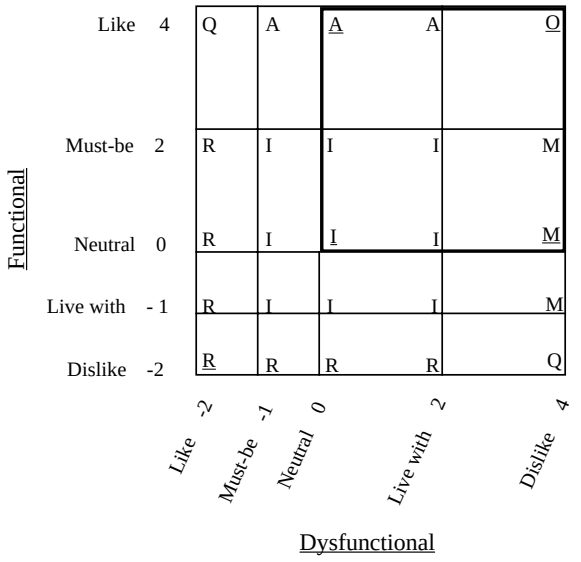


Figure 19

Compare this figure to the Kano Evaluation Table (figure 4) to understand the parallels between the two tables. In particular, note that the interiors of the two tables (the Rs, Is, Ms, etc.) are laid out in identical fashion. In the method described in section I, the answers to the functional and dysfunctional questions (e.g, like/like, must-be/neutral) are used to look up a single "score" (e.g., R, I) in the Kano Evaluation Table. In the method being described in this section, the answers to the functional and dysfunctional questions are used to specify a point in a two-dimensional coordinate system.

The most pure or prototypical representations of the Reverse, Indifferent, One-dimensional, Must-be, and Attractive points in this two-dimensional coordinate system categories are identified with the points, respectively:

Reverse	X = -2,	Y = -2
Indifferent:	X = 0,	Y = 0
One-dimensional	X = 4,	Y = 4
Must-be	X = 4,	Y = 0
Attractive:	X = 0,	Y = 4

These points are underlined and in bolder print in figure 19. All the other combinations of *XY* points appear as interpolations between these points.

Now, for all questions, $j = 1, ..., Q$, compute the averages of the *X* (dysfunctional) and *Y* (functional) answers across all respondents:

$$Xave[j] = \frac{\sum_i X_{ij}}{N} \quad \text{and} \quad Yave[j] = \frac{\sum_i Y_{ij}}{N}$$

Then plot the *Q* points $(Xave[j], Yave[j])$ and use the number j as the plotting symbol, so you can identify which question each point represents.

The averages should mostly fall in the range 0 to 4, since negative values are either Questionables or Reverses. Questionables will not be included in the averages. Reverses may be transformed out of the Reverse category by reversal of the sense of the functional and dysfunctional questions over all respondents. Otherwise, as described above, there will likely not be enough Reverses to pull the average negative.

In figure 20 (below) the square where *Xave* and *Yave* range from 0 to 4 is naturally divided into quadrants, with the prototypical Attractive, One-dimensional, Must-be, and Indifferent points considered to be at the four corners. This square comes from the upper right part of figure 19.[36]

Plots of Average Functionality and Average Dysfunctionality Points for Question *J*

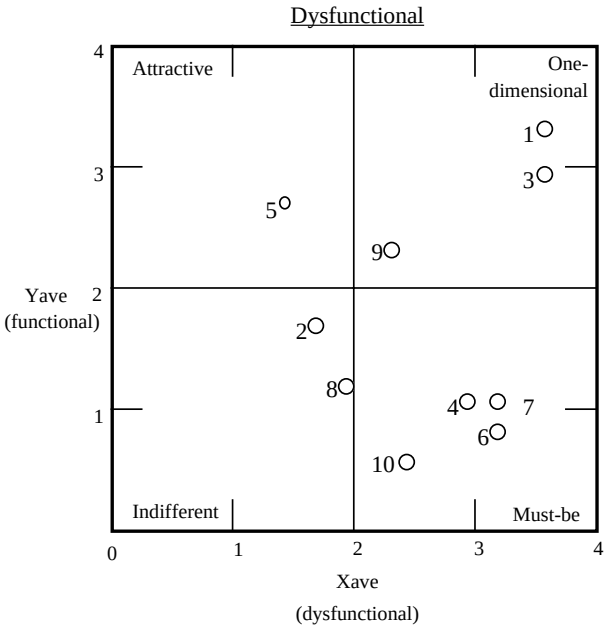


Figure 20

[36] Note the similarity of this figure to figure 17 in subsection IVb.

Bill DuMouchel originally presented the material in this section to members of the CQM Research Committee while he was employed by Bolt Beranek and Newman Inc. He is now an independent statistical consultant based in Belmont, Mass.

When the pairs of coordinates representing the average responses to each of the Kano questions have been plotted on the grid as shown in figure 20, the nature of each requirement is clearly delineated by the quadrant into which that point falls. For instance, a requirement such as number 5, which falls into the upper left quadrant, should be viewed as an Attractive element. The closer a point falls to one of the four labeled corners (the prototypes), the more unanimous the survey respondents must have been in their views. Conversely, a point such as number 9, which falls near the center of the diagram, is a fuzzier result which indicates disagreement among respondents.

The above is the basic plot. Following are a few possible refinements.

2. Show within question variation

For the *j*th question, compute

Xstdv[*j*]= Standard deviation of the *N* scores X_{ij},

Ystdv[*j*] = Standard deviation of the *N* scores Y_{ij}, and

XYcor[*j*]= Correlation coefficient of the *N* pairs (X_{ij},Y_{ij}.)

Then, on the basic averages graph described in the previous subsection, plot horizontal error bars (*Xave*[*j*]±*Xstdv*[*j*]) and vertical error bars (*Yave*[*j*]±*Ystdv*[*j*]) around each point (*Xave*[*j*], *Yave*[*j*]).

A fancier version of this is to use the correlation as well as the standard deviation and, instead of error bars, plot an ellipse representing the distribution of XY values. The equation of the ellipse is:

$$\left\{(X,Y)\left|\left(\left(\frac{X-Xave}{Xstd}\right)^2-2\right.\right.\right.$$

$$*XYcor*\frac{X-Xave}{Xstd}*\frac{Y-Yave}{Ystd}$$

$$\left.\left.\left.+\left(\frac{Y-Yave}{Ystd}\right)^2\right)=1-XYcor^2\right\}\right.$$

If the correlation is zero, the ellipse should pass through where the ends of the error bars would be. In any case, it should enclose the central 40-50 percent or so of the *N* points on which it is based.

3. Show the respondents' average importance assigned to each question

From the Self-stated Importance survey that was done in parallel with the Kano survey, compute the average importance, $Wave[j]=\frac{\sum_i W_{ij}}{N}$, of each question and represent its value near the plotted points $(Xave[j],Yave[j])$, as in figure 21 (next page). For example, draw a filled circle with radius proportional to $\sqrt{Wave[j]}$, so the area of the jth circle would be proportional to $Wave[j]$. Alternatively, plot the values of j used to identify the questions in different colors or shades of gray, representing the range of low to high values of $Wave$.

There is no hard-and-fast way to interpret the diagram in figure 21 for development priorities. The best approach might vary with the number of points falling into each quadrant, with the clustering of the points within a quadrant, or with the degree of differentiation of importance levels within a quadrant. For instance, in figure 21 there is only one Attractive element. Although that element ranks only as medium in importance, the team might believe that the product needs a differentiating characteristic.

What makes the most sense is for your group to view the grid (perhaps without the points numbered, in order to maintain objectivity about which requirements should be pursued), and then agree on a decision rule that will work for your data.

4. Weight the means for each question according to how important that question is rated by each respondent.

Instead of plotting $(Xave,Yave)$ defined as above, compute

$$Xwave[j]=\frac{\sum_i W_{ij}*X_{ij}}{\sum_i W_{ij}} \text{ and}$$

$$Ywave[j]=\frac{\sum_i W_{ij}*Y_{ij}}{\sum_i W_{ij}}$$

and plot points $(Xwave[j],Ywave[j])$ as before. This gives those respondents who think a question is important more voice in deciding whether the question is One-dimensional, Must-be, Attractive, and so on. You should use weighted versions of standard deviations and correlation coefficients if you want to add error bars or ellipses to this graph.

Plots of Average Functionality and Average Dysfunctionality Points for Question *J* with Average Importance Indicated for Each Point

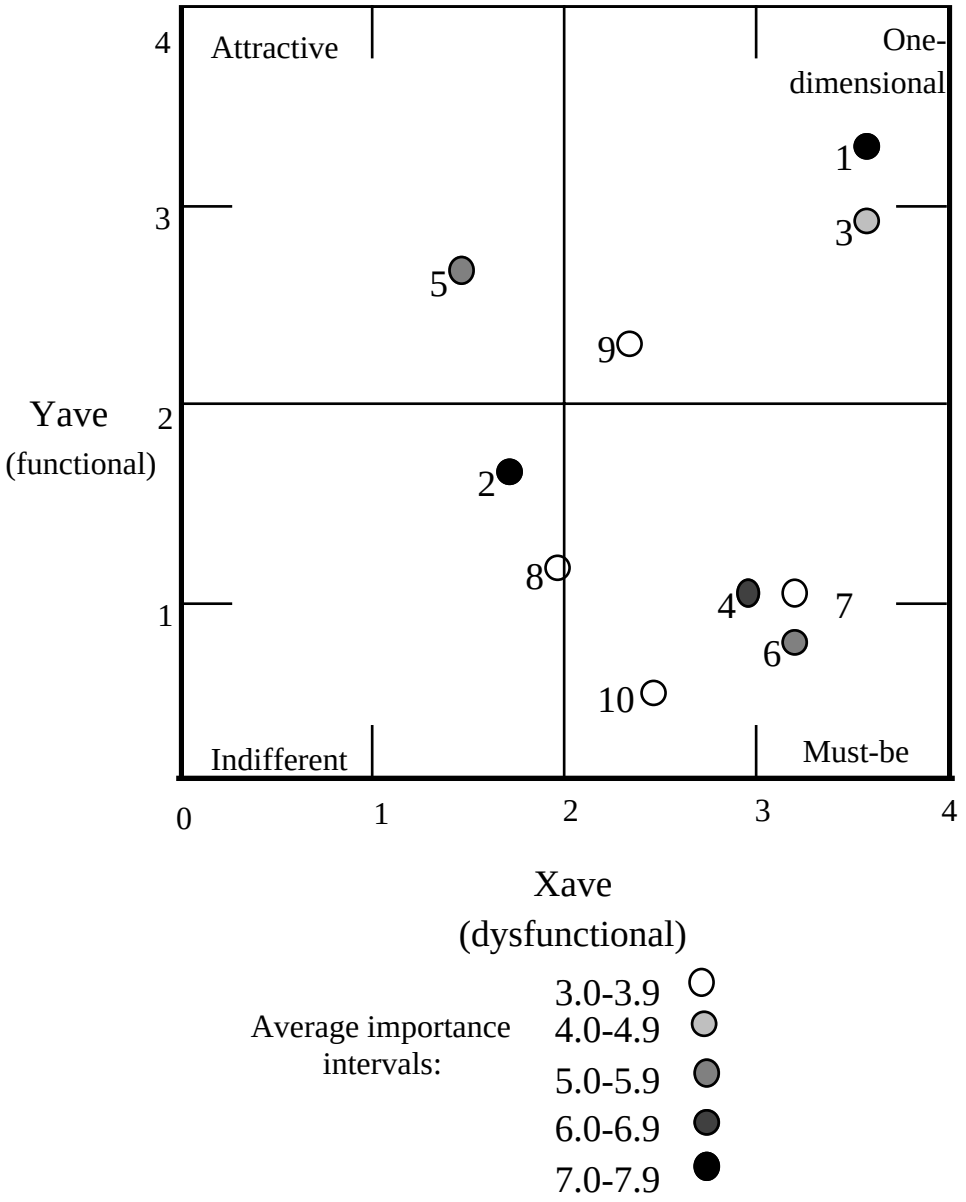


Figure 21

5. Overlay the basic plot for different groups of respondents

Compute the points $(Xave, Yave)$ separately for two or three subsets of the respondents, grouped by background information (demographic data). Then plot the points for the different groups in different colors. For example, a *red* "15" would mark the average answer to question 15 for one group, and a *green* "15" would mark the average answer to question 15 for another group. To avoid clutter here you might omit the extra information on variation or importance suggested in parts 2 and 3 above.

Va. Theoretical Parallel's between Kano's and Herzberg's Theories

[Editor's note: Christopher Bolster has considered Kano's theories in comparison with the theories of Herzberg which Kano studied.]

Kano analysis helps us understand the relationship between the fulfillment (or nonfulfillment)

Chris Bolster is a recent graduate of the MIT Sloan School of Management, where he was teaching assistant to Dr. Shoji Shiba. He spent last summer working on a field study of Concept Engineering at CQM companies and helped rewrite the Concept Engineering User's Guide.

of a requirement and the satisfaction or dissatisfaction experienced by the customer. Working with social science theories on satisfaction developed by Frederick Herzberg, Kano concluded that the relationship between fulfillment of a need and the satisfaction or dissatisfaction experienced is not necessarily linear. He found that he could sort requirements into distinct classes, and that each class would exhibit a different relationship with respect to satisfaction. According to the Kano's model, a product induces various distinct types of satisfaction or dissatisfaction, depending on whether certain customer needs are completely fulfilled, are only partially met, or go unserved. Kano's theory, originally termed the "M-H Property of Quality," was first proposed in a paper published in 1979.[37] The basis of knowledge about Kano's theories within the CQM comes from a subsequent article, entitled "Attractive Quality and Must-be Quality,"[38] and from teaching by Shoji Shiba.

As mentioned above, the model underlying Kano's theory has its roots in social psychology and Motivation-Hygiene theory (M-H theory)[39], developed in 1959 by Frederick Herzberg. Herzberg created the theory to explain the way employees feel about their work.

Herzberg expounds on his theory at length and provides much supporting evidence in his book *Work and the Nature of Man*,[40] Herzberg observes that the set of factors that produce job satisfaction are separate and distinct from the set of factors that produce job dissatisfaction. In effect there are two independent axes (figure 22, below).

How Motivational/Hygiene Factors correlate to Job Satisfaction

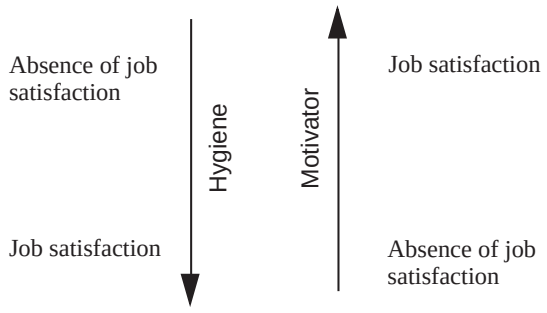


Figure 22

Herzberg thinks of the one axis as the motivator axis. In this dimension the employee seeks personal growth from the tasks being performed; however, absence of this growth does not cause pain. The other axis is the hygiene axis. In this dimension the employee tries to avoid pain from the environment; however, avoidance of this pain or the environmental issues that cause the pain does not produce satisfaction.

Some of the issues reported in Herzberg's research as causing increasing levels of satisfaction are: growth, advancement, responsibility, work itself, recognition (of work), achievement. Some of the issues cited as causing increasing levels of dissatisfaction are security, status, relationship with subordinates, personal life, relationship with peers, salary, work conditions, relationship with supervisor, supervision, and company policy and administration.

Herzberg goes on to generalize job attitudes to mental health which he notes are similarly on distinct, parallel lines.

Herzberg's depiction of Mental Health

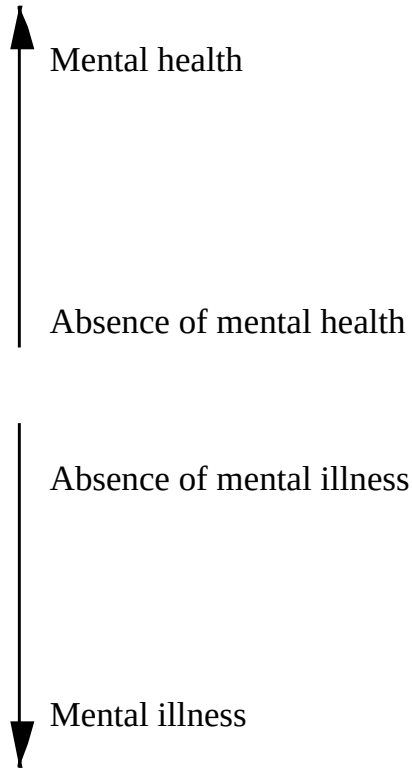


Figure 23

[37] Noriaki Kano, "On M-H Property of Quality," Nippon QC Gakka, 9th Annual Presentation Meeting, Abstracts, pp. 21-26, 1979.
[38] Noriaki Kano et al., "Attractive Quality and Must-be Quality," research summary of a presentation given at Nippon QC Gakka: 12th Annual Meeting (1982), January 18, 1984.
[39] Hence the name Kano gave his theory in his 1979 paper.
[40] Cleveland, World Publishing Co., 1966; see particularly chapter 6, pp.71-91. This book is actually the third in a trilogy on this subject. See also "One more time: How do you motivate employees." Frederick Herzberg, *Harvard Business Review*, January-February 1968.

At the time he wrote his book, Herzberg noted that many clinicians treated patients with mental health problems as if resolving the conflicts resulting mental illness would bring mental health. This approach results in doing the hygiene work to avoid environmental issues but does not address psychological growth and self-fulfillment.

Clearly, Kano and M-H theory share some key features:

- Kano's *satisfaction* axis is analogous to Herzberg's *mental health* axis. Both extend from the origin (a neutral feeling about the product or job) through various gradations of satisfaction. In Kano's theory, the factors that produce only satisfaction are called attractive elements. The corresponding element in Herzberg's theory is the *motivator*, sometimes called a "satisfier."
- Kano's *dissatisfaction* axis is analogous to Herzberg's *mental illness* axis. Both extend from the origin through various gradations of dissatisfaction. In Kano's theory, the factors that, through their absence, create dissatisfaction are called *Must-be* elements. The corresponding element in Herzberg's theory is the *hygiene* factor, sometimes referred to as a "dissatisfier."

In both Kano and M-H theory, there is an asymmetry between the positive and negative axes on which the above factors are scaled. Dissatisfaction is not the opposite of satisfaction. For instance, fulfilling a hygiene or Must-be requirement does not lead to satisfaction—in the healthy individual—because hygiene factors are those which, when fulfilled, help only to avoid dissatisfaction.

Kano's theory also, however, includes a third class of requirements that behave as if the positive and negative axes were continuous: one-dimensional factors. These requirements can cause reactions ranging from dissatisfaction, through indifference, to satisfaction, depending on how well they are fulfilled.

The *one-dimensional* element appears to have no direct analog in M-H theory. Herzberg states repeatedly that the axes of mental health and mental illness are distinct. Although he identifies cases where hygiene factors actually provide satisfaction, this occurs only in "maladjusted" individuals.[41] Likewise, highly "growth-oriented" individuals can actually experience dissatisfaction when motivating factors are not present.[42]

Herzberg notes that the hygiene satisfactions experienced by maladjusted individuals are short-lived and similar in character to opiates.[43] The corollary in Kano theory might be that a product designed to satisfy only "must-be" requirements would not satisfy mainstream consumers. Herzberg also states that the unhappiness experienced by highly growth-oriented individuals at the lack of motivator factors is qualitatively different from that they experience at the lack of hygiene factors.[44] This is another way of saying that the satisfaction and dissatisfaction axes are distinct (satisfaction and dissatisfaction are not simple opposites). That is also true in Kano theory.

Vb. Wording of the Kano Questionnaire

The order of the five answers to the pairs of Kano questions seems odd to many people.

1 I like it that way.
2. It must be that way.
3. I am neutral.
4. I can live with it that way.
5. I dislike it that way.

The question most frequently posed is: Why is "I like it that way" a stronger statement of satisfaction than "It must be that way?" Consider these responses in the context of the functional question in a pair of questions on a Kano questionnaire. The thought behind the ordering is that the first response signifies a type of positive satisfaction, while the last relates to avoidance of displeasure. In other words, the logic behind the arrangement of these responses has to do with the level of pleasure experienced by the customer. A scale of pleasure is known as a hedonic scale.

An alternative wording of the answers that seems to differentiate better among the responses is:

1. I enjoy it that way.
2. It is a basic necessity or I expect it that way.
3. I am neutral.
4. I dislike it, but I can live with it that way.
5. I dislike it, and I can't accept it.

Some Kano surveys have used this wording. However, while this alternative wording clarifies the difference between "I like it" and "It must be," it may confuse the answers to customer requirements that are straight forwardly one-di-

[41] Herzberg, p 84.
[42] *Ibid.*
[43] *Ibid.*
[44] *Ibid.*

mensional, such as gas mileage. In the one-dimensional case, the "I like it" and "I dislike it" pair of answers may be more appropriate that "I enjoy it" and "I can't accept it".

The BBN RS/1 5.0 team[45] felt that the CQM-recommended wording of the survey answers was confusing, and they decided to deviate from it. They thought phrases such as "I like it that way" were too ambiguous and they used the following wording instead:

1. This would be very helpful to me.
2. This is a basic requirement for me.
3. This would not affect me.
4. This would be a minor inconvenience.
5. This would be a major problem for me.

Fred Pouliot of Analog Devices (see subsection Vc) likes a set of wordings he heard from a participant (name unknown) in a session of the CQM six-day course:

1. I like it.
2. I expect it.
3. I'm neutral.
4. I can tolerate it.
5. I dislike it.

This wording appears to distinguish between "like" and "must be" ("expect") without becoming too extravagant ("enjoy").

Professor Asbjørn Aune of the Norwegian Technical University (in Trondheim, Norway) has drawn an annotated version of a Kano diagram (figure 24, below) illustrating some of the ways to think about the Attractive, One-dimensional, and Must-be curves and what they may mean in different situations.[46]

Prof. Aune's version of the Kano Diagram

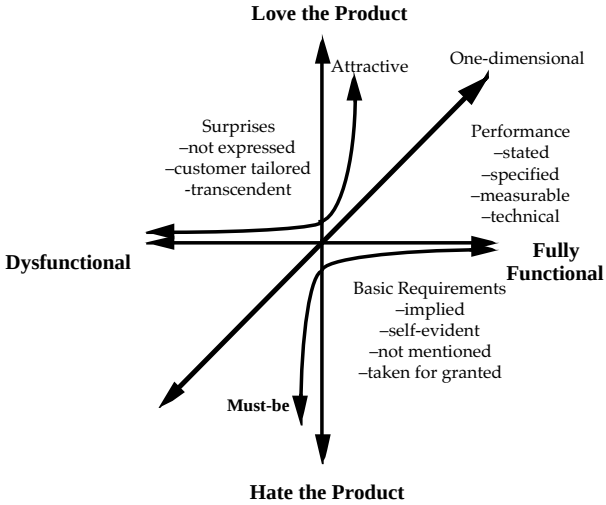


Figure 24

Professor Aune's figure both illustrates some of the difficulty in the wording of the standard answers to the functional and dysfunctional questions, and may suggest some wording for the standard answers that will help makes things more clear for the person responding to a Kano questionnaire. Slightly paraphrasing Professor Aune, "The One-dimensional class consists of what customers say they want. The Must-be class can be considered *expected* quality; it consists of expectations that customers do not verbalize because they assume them to be evident. Attractive is the class of *exciting* quality; customers do not expect the quality characteristics in this class, but they recognize them as improvements and like them."

Reinhart Richter of BBN suggested that answers that don't make sense for a particular pair of questions should perhaps be left off in the interests of clarity. It might also be useful to change the wording of the standard answers to make them better match certain questions, or at least to change the standard wording depending on the general context of a particular questionnaire. Such changes in wording could be dangerous if they are done casually, leading to inconsistent or biased answers. On the other hand, it would be useful to have the results of a systematic effort to see which wording of the standard answers works best and whether changes from question to question improve the usefulness of Kano questionnaires or bias the answers.

Given the unfamiliarity customers have with Kano surveys and the confusion that customers seem to have with the answers to the question, it is especially important to provide good instructions for answering a Kano survey. A sample Kano questionnaire, based largely on instructions provided by Charles Berger of BBN Software Products, is shown on the facing page.

One might consider expanding Berger's questionnaire with as follows:

- Do not be distracted with the order of the standard answers. Simply select the answer that seems most appropriate to you for the question being answered.
- Do not be distracted by answers that don't seem to apply. Simply select the most appropriate answer that does apply.

[45] See section III.

[46] Seminar Proceedings, "World Class Quality—the Role of Top Management," the Norwegian Academy of Technological Sciences, November 7-8, 1991, Oslo, Norway, pp. 13-14.

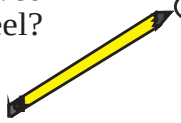
Example Instructions on How to Fill Out the Kano Survey

This questionnaire asks pairs of multiple-choice questions about potential product capabilities. Half of each pair of questions asks how you would feel if the product we hope to supply in the future included a particular capability; the other half of each pair asks how you would feel if the capability were not provided.

"Kano Survey"

Circle the number in front of the option that best describes how you feel, for each question.

1a. If the eggs are served hot, how do you feel?



1. I like it that way.
2. It is a basic necessity or I expect it that way
3. I am neutral.
4. I dislike it but can except it.
5. I dislike and can except it.

1b. If the eggs are not served hot, how do you feel?

1. I like it that way.
2. It must be that way.
3. I am neutral.
4. I can live with it that way.
5. I dislike it that way.

2a. If the eggs are offered in a variety of ways (e.g. poached, fried, scrambled, hard-boiled, omelet, soft-boiled), how do you feel?

1. I like it that way.
2. It must be that way.
3. I am neutral.
4. I can live with it that way.
5. I dislike it that way.

2b. If the eggs are offered as only fried or scrambled, how do you feel?

1. I like it that way.
2. It must be that way.
3. I am neutral.
4. I can live with it that way.
5. I dislike it that way.

The breakfast menu example shown here demonstrates how one customer might answer such pairs of questions. In this example, question 1a (the eggs are served hot) asks how the customer would feel if a capability or feature were provided, and the customer's answer is circled, while question 1b (the eggs are not served hot) asks how the customer would feel if a capability were somehow limited or absent and the customer's answer is circled.

The second question, 2a, asks how the customer would feel if there were a variety of cooking options for the eggs (poached, fried, scrambled, hard-boiled, omelet, etc.), and question 2b asks how the customer would feel if eggs were offered only as fried or scrambled.

From collecting responses from many customers we can derive detailed information about customers' needs.

Charles Berger is an employee of BBN's Software Products Division, and has used Kano's methods in the specification of products.

- The pairs of questions will be used to classify each customer requirement so we can decide how best to handle it. The pairs are questions are not used to rank-order the customer requirements. Therefore, do not try to "second guess" the survey in order to indicate higher priority for the customer requirements you care about most.
- The first answer to each question applies when the question is about something that would mean at least a little something special to the respondent. The second answer applies when the question is about something that the respondent takes for granted should be in the product.

Vc. Theoretical Issues of Kano's Methods

[Editor's note: Fred Pouliot has considered the theoretical details of Kano's methods. His suggestions for the wording of the five questions were given in section Vb, and he uses this wording in his theoretical analysis.]

It is possible to derive the curves in the Kano diagram from the Kano Evaluation Table as follows.[47] Plot the axes of the Kano Diagram and label vertical levels of the graph with the wordings of the answers to questions on a Kano questionnaire, as in figure 25 (below).

In figure 25, the "Must-be" level is only a little above neutral because Must-be is only a weak statement of satisfaction—it is more a statement of lack of dissatisfaction, though certainly more positive than neutral. Symmetrically, "can live with" is not a strong statement of dissatisfaction, but its grudging acceptance is more negative than neutral.

It is now possible to plot lines representing all 25 combinations of answers represented in the Kano Evaluation Table. For instance, the lines represented by the following three pairs of end points

(functional, like); (dysfunctional, must be)
(functional, like); (dysfunctional, neutral)
(functional, like); (dysfunctional, can live with)

are shown in figure 26 on the facing page (and labeled by their cell numbers in the Kano Evaluation Table—reproduced for the reader's convenience in figure 27 on the facing page). From these three lines one can roughly envision Kano's Attractive curve which is shown in bold in figure 26.

The other 22 lines implicit in the Kano Evaluation Table (figure 27) can be plotted similarly and the general shapes of the rest of the Kano curves can be imagined from these lines.

But there is a more systematic and, I believe, more well-founded derivation of the Kano

[47] Dave Walden of BBN circulated informal notes on this simple derivation in May 1991.

Plotting the Kano Answers on the Kano Diagram Axes

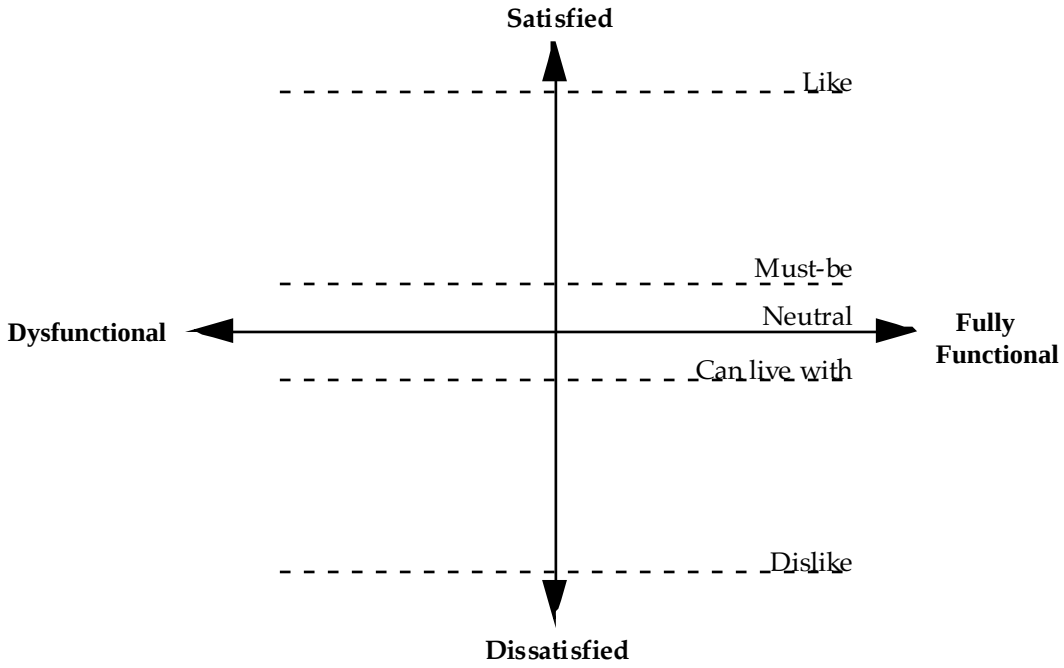


Figure 25

Plot of the three Attractive cells from the
Kano Evaluation Table

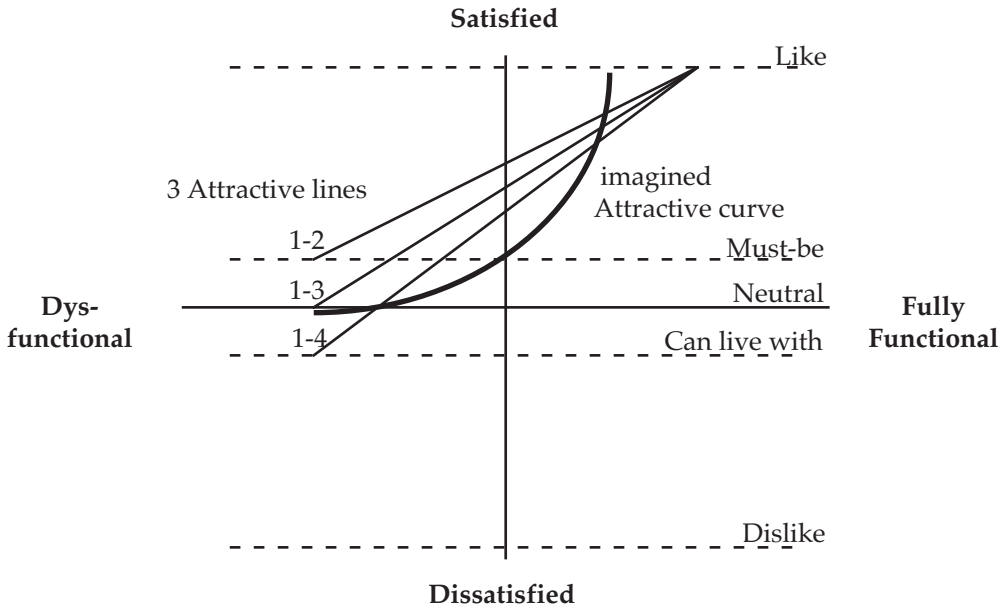


Figure 26

Kano Evaluation Table

Customer Requirements		Dysfunctional 1. like	2. must-be	3. neutral	4. live with	5. dislike
Functional	1. like	Q	A	A	A	O
	2. must-be	R	I	I	I	M
	3. neutral	R	I	I	I	M
	4. live with	R	I	I	I	M
	5. dislike	R	R	R	R	Q

Customer Requirement is:

A: Attractive
M: Must-be
R: Reverse
O: One-dimensional
Q: Questionable
I: Indifferent

Figure 27

curves. What follows is an explanation of this derivation, together with some observations on how to improve the use of Kano's methods.[48]

The shape of the Kano curves as usually presented (see figure 28, next page) is somewhat inconsistent with the Kano Evaluation Table used to translate pairs of answers to the questions (see figure 27). This is clear from figure 26 where we had to stretch to image the Attractive curve as being representative of the three lines derived from the Kano Evaluation Table.

This inconsistency has led to some confusion. For example, consider the Attractive curve in Figure 28. It starts above the X axis on the dysfunctional side, and then proceeds asymptoti-

[48] Fred Pouliot's ideas have been circulating informally in the CQM since late 1991.- Ed.

Fred Pouliot is division manager of the IC Test System Division of Analog Devices Inc. He has frequently volunteered as a CQM 6-Day Course leader and is very much involved with TQM training at Analog.

Kano Diagram

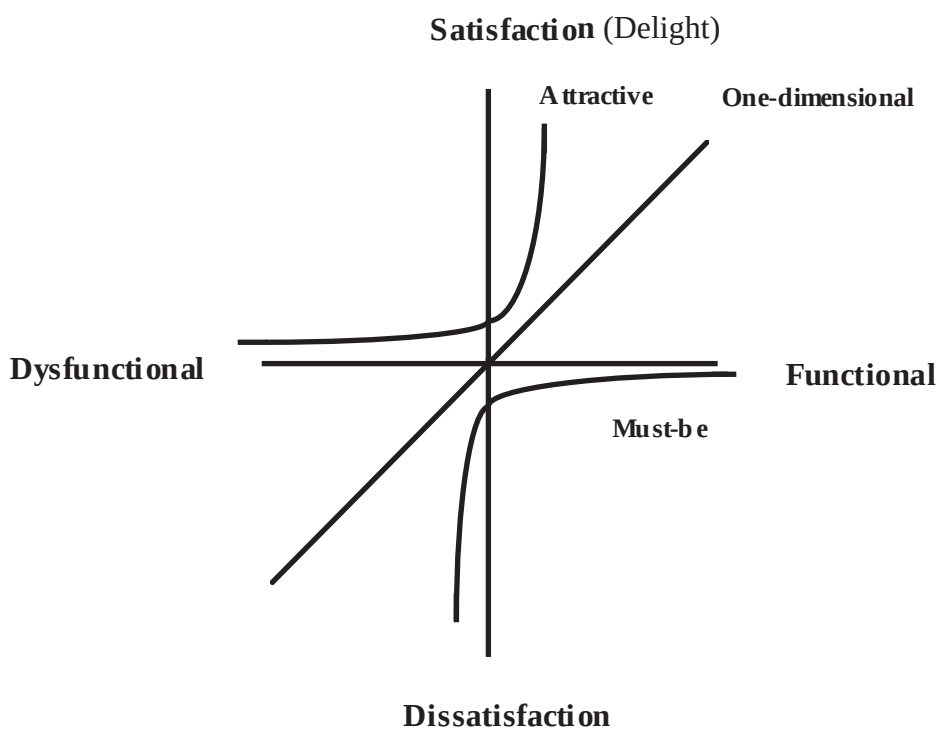


Figure 28

Attractive, Must-be, and One-dimensional Curves

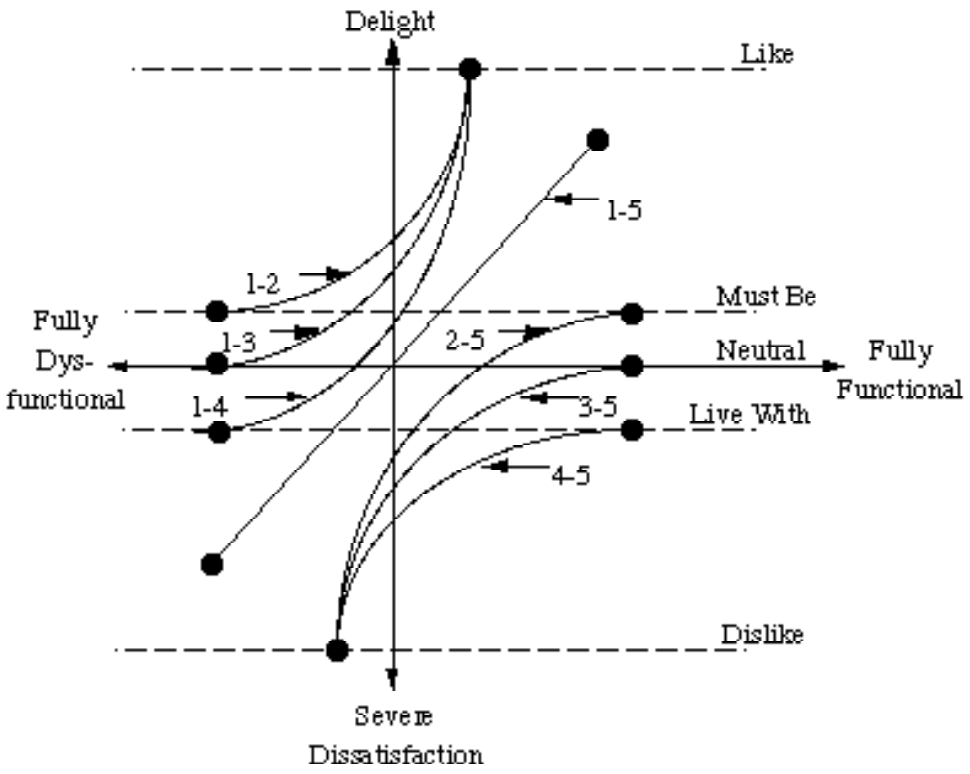


Figure 29

cally to Delight on the functional side. The curve consists of all positive values. This is inconsistent with the dysfunctional/live with aspect of cell 1-4 in the Kano Evaluation Table (Figure 27). There is a similar inconsistency with the Must-be curve. The curve comprises all negative values, yet, one cell, 2-5, implies a positive value (functional/must-be).

Figure 29 (facing page) illustrates a detailed derivation of the Attractive, Must-be and One-dimensional curves. The data points (big black dots) are plotted from the Kano Evaluation Table and are labeled with functional-dysfunctional number pairs from that table, but there are some assumptions that make the derivation in figure 29 work well.

- Assumption 1: The word "like" is meant to be a very strong like, which in the limit becomes complete customer "delight." It can therefore be considered to be a point that exists at +infinity. A point close to the top of the Y axis is shown to get across the concept of rapid improvement in satisfaction as functionality increases; that is, the concept that an exponential relationship exists.
- Assumption 2: The word "dislike" is as strong in the negative direction as "like" is in the positive direction, i.e., severe dissatisfaction. As with "like", the curves for "dislike" coincide at a point close to, and near the bottom of, the Y axis.
- Assumption 3: A relatively small difference is represented between the terms "must-be" and "neutral". Similarly there is a small difference between "can live with" and "Neutral".

Cells 2-2 and 4-4 of the Kano Evaluation Table are also logically inconsistent; for example, a requirement that is rated as Must-be functional cannot simultaneously be rated as Must-be dysfunctional. *I suggest that cells 2-2 and 4-4 in the Kano Evaluation Table be changed from "I" to "Q."*

The points discussed thus far in my detailed derivation are shown in the partially completed Kano Evaluation Table in figure 30, along with fundamental combinations for Indifference, "I."

The four Indifferent points that have been included in figure 30 are straight lines shown in bold in figure 31 (next page).

The lines for "Q" derived from the Kano Evaluation Table in Figure 24 are shown in bold in Figure 32 (next page).

The upper right half of the Kano Evaluation Table can be viewed as the positive half, since all combinations are the result of customer responses being more positive for the Functional question than for the Dysfunctional question. There is symmetry about the diagonal as shown in figure 33 (page 63).

Each element on the positive half has a corresponding element on the negative side that is the exact opposite of the original. These are "Reversals," i.e., for each Kano dimension, $K_{m,n}$, there is a reversal dimension, $R_{n,m}$. The table at the end of this paragraph shows the original Kano dimension on the positive half (above main diagonal) of the matrix, its corresponding rever-

Partially Derived Kano Evaluation Table

		Dysfunctional				
		1. I like it	2. I expect it	3. I'm neutral	4. I can tolerate it	5. I dislike it
Functional	1. I like it	Q	A	A	A	O
	2. I expect it		Q	I	I	M
	3. I'm neutral			I	I	M
	4. I can tolerate it				Q	M
	5. I dislike it					Q

Requirement is:

A: Attractive
M: Must-be
R: Reverse
O: One-dimensional
Q: Questionable result
I: Indifferent

Figure 30

Neutral Lines

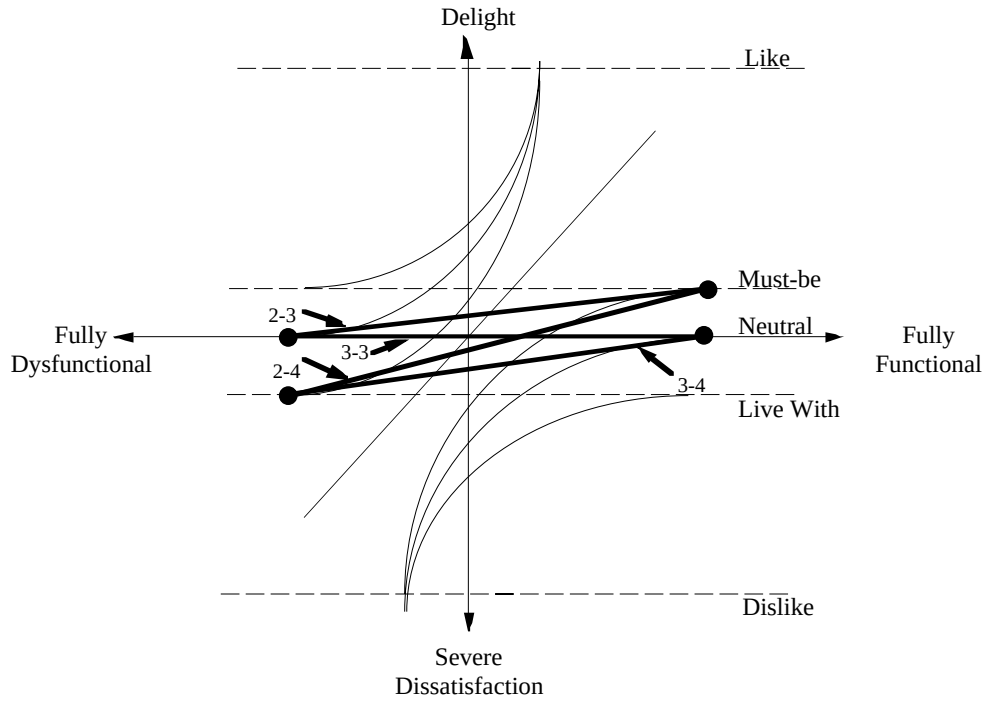


Figure 31

Questionable Lines

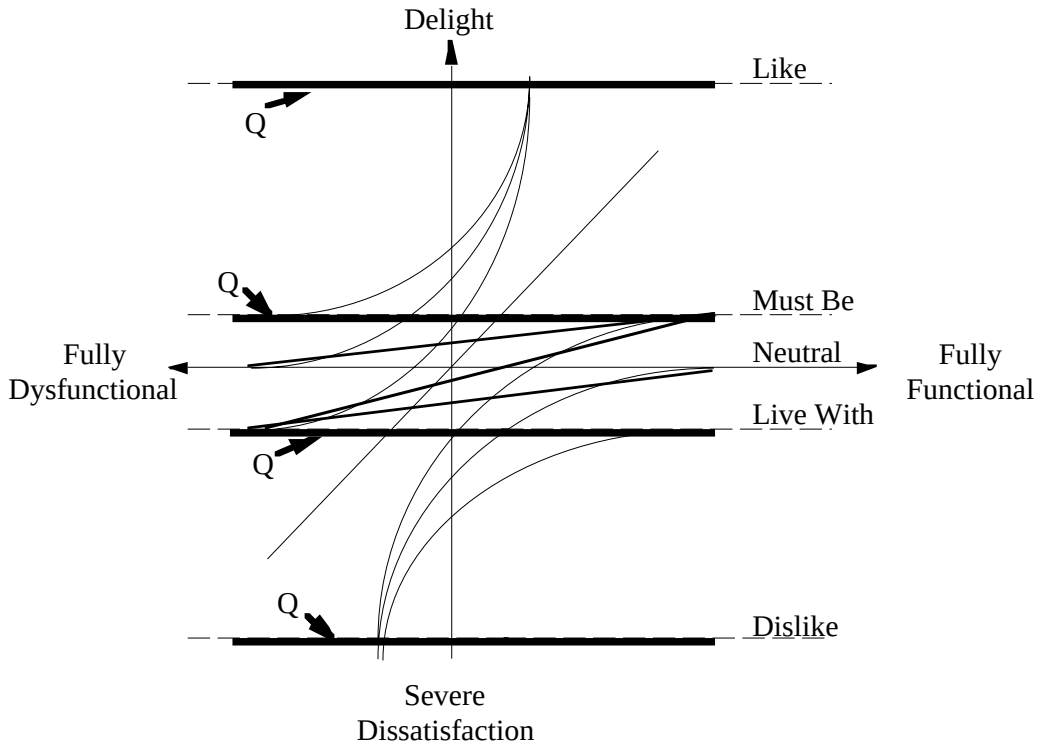


Figure 32

Partially Derived Kano Evaluation Table with Diagonal Shown

		Dysfunctional				
		1.	2.	3.	4.	5.
		I like it	I expect it	I'm neutral	I can tolerate it	I dislike it
Funct-ional	1. I like it	Q	A	A	A	O
	2. I expect it		Q	I	I	M
	3. I'm neutral			I	I	M
	4. I can tolerate it				Q	M
	5. I dislike it					Q

There is symmetry about this diagonal

Requirement is:

A: Attractive **O: One-dimensional**
M: Must-be **Q: Questionable result**
R: Reverse **I: Indifferent**

Figure 33

sal element (below main diagonal), and the subscript of the reversal element.

Location of Kano Dimension on (+) Half	*Location of Reversal on (-) Half*	*Reversal Dimension*
1-2	2-1	R_A
1-3	3-1	R_A
1-4	4-1	R_A
1-5	5-1	R_O
2-3	3-2	R_I
2-4	4-2	R_I
3-4	4-3	R_I
2-5	5-2	R_M
3-5	5-3	R_M
4-5	5-4	R_M

It can be argued that the reversal of an Indifferent is still an Indifferent. Therefore, nothing is lost by leaving cells 3-2, 4-2, and 4-3 as Indifferent. The Kano Evaluation Table appropriately extended is shown in figure 34 (below).

The reversals result in mirror images of the original Kano curves, as shown by the dashed curves in Figure 35 (next page).

As we now complete the derivation of the revised Kano diagram, we can ignore all of the Q lines in figure 32 and figure 35, since they are for the most part the result of poorly phrased questions or poorly developed requirements. Through the concept engineering process, for instance, we strive to eliminate or minimize their occurrence.

Kano Evaluation Table with Reversals Shown

		Dysfunctional				
		1.	2.	3.	4.	5.
		I like it	I expect it	I'm neutral	I can tolerate it	I dislike it
Functional	1. I like it	Q	A	A	A	O
	2. I expect it	R_A	Q	I	I	M
	3. I'm neutral	R_A	I	I	I	M
	4. I can tolerate it	R_A	I	I	Q	M
	5. I dislike it	R_O	R_M	R_M	R_M	Q

Requirement is:

A: Attractive O: One-dimensional
M: Must-be Q: Questionable
R: Reverse I: Indifferent

Figure 34

Cells in Upper Right Portion of Kano Evaluation Table
and their Reversals

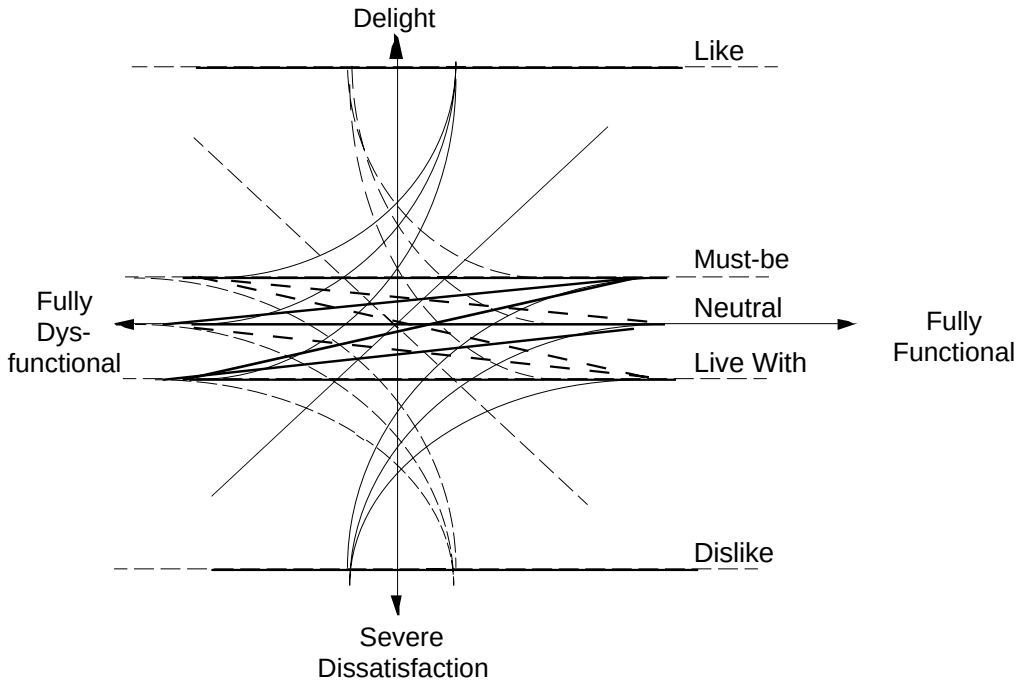


Figure 35

"Average" Attractive, Must-be, and One-dimensional Curves

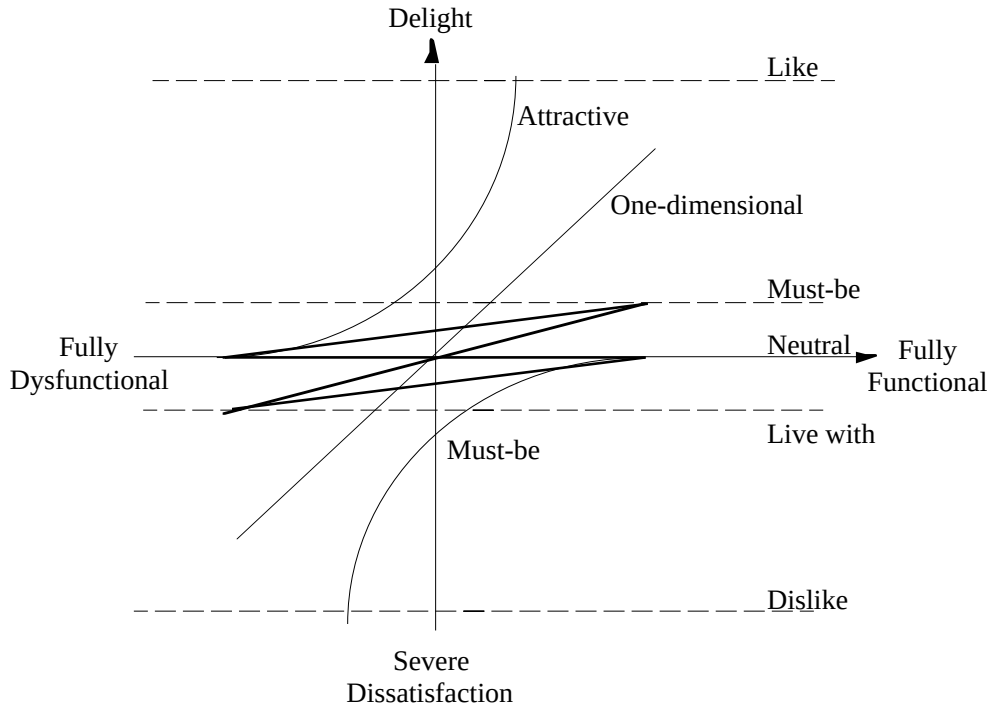


Figure 36

Degenerate Indifferent Line

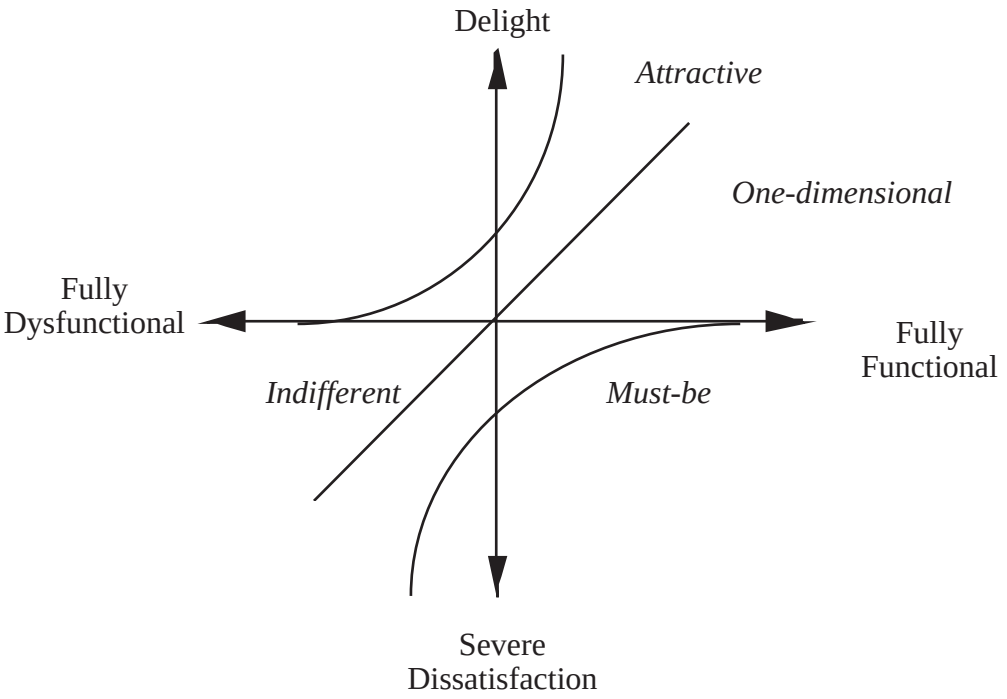


Figure 37

Next, averaging the set of curves for Attractive, and Must-be, in figure 34 results in the diagram shown in figure 36, on the facing page (the Indifferent lines haven't yet been averaged):

To simplify the Indifferent curves we can go back to assumption 1 on page 31, and consider the difference between Like and Must-be to be so great as to render the distance between the Indifferent lines to be near zero. In the limit the curves for Indifferent become the abscissa; that is, the curve for Indifferent is a straight line existing along the X axis.

Thus, we have derived the Modified Kano Diagram shown in figure 37, above (without reversal items). Note: The Attractive and Must-be curves are coincident with the X axis rather than being asymptotic.

Finally, in figure 38 (next page) we show the curves from figure 37 with the reversal curves.

From the revised Kano Evaluation Table in figure 34 and figure 38 the reader may deduce why retroactively reevaluating survey questions that resulted in a Reverse rating can produce useful data, as if the reverse of those questions had been asked. ■

Kano Diagram with Reversal Items

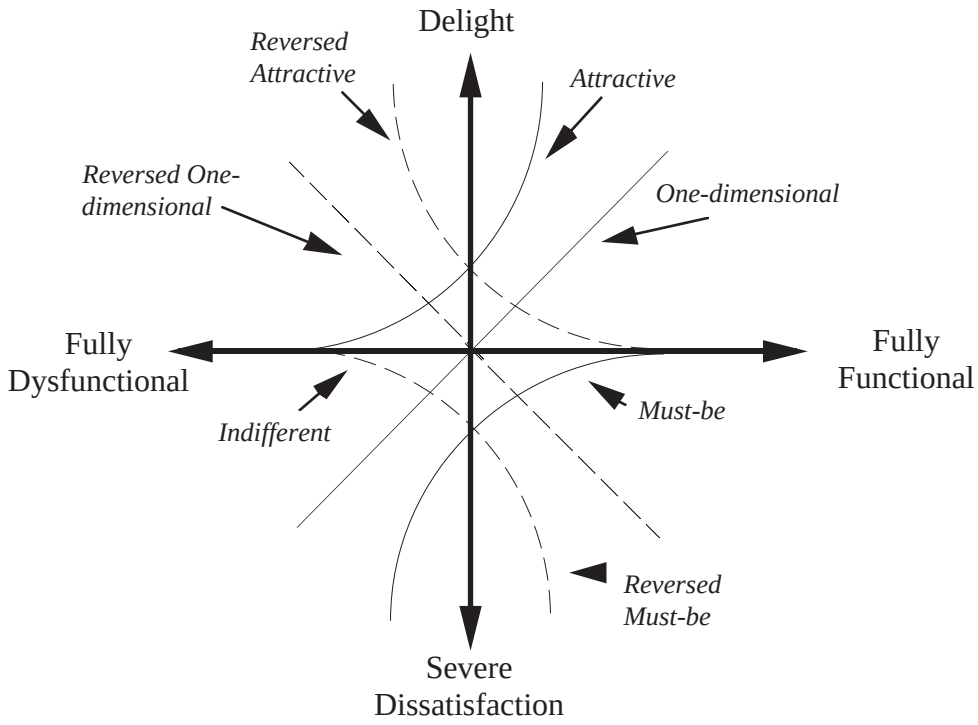


Figure 38

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