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A KANO MODEL BASED CUSTOMER NEEDS SIMULATION SYSTEM FOR INVESTIGATING MUST-BE ATTRIBUTE

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***Abstract**-All the key features, functions, characteristics, and spirit of a design are needed for a full concept for a product. Moreover, every product serves a certain purpose; if a product can't serve its purpose, then it's useless. This is the basis of design, though it can hardly be evaluated and coped with properly. Thus, computational tools are needed to assist a product development team to determine beforehand the critical number of respondents to make a right decision. In this regard, absolutely this paper presents a numerical Kano model for the design of product for investigating must-be attribute.*

Keywords*:* Product Development, Customer Needs, Kano Model, Monte Carlo Simulation, Imprecise Probability, Fuzzy Logic.

1. INTRODUCTION

Product development is a complex engineering task wherein a great deal of intellectual and physical resources, methods, tools, and processes are involved to tackle the technical and business issues in an integrated manner so that the targeted group of customers can be satisfied [1,4,12-18]. Many technical issues of Product Conceptualization and Product Realization are handled after assessing the customer needs. Therefore, the success of a product development process (i.e., desired customer satisfaction) is sensitive to the customer needs assessment process. In some cases, customer needs of a product (or a product family) are incorporated by setting the customer requirements and their relative importance in the first house of quality of QFD [6-7,11] This process is somewhat *ad hoc* and does not provide a clear link between customer satisfaction and product attribute [6,11]. Besides, there is a lot of research that also shows that it is a mistake to try to put too much effort into determining what customers want? In this regard, Kano Model [8] is one of the choices. A great deal of research has been carried out to get benefitted from Kano Model while setting the customer needs with respect to customer satisfaction [2-3, 5, 9, 10, 22, 25].

Yadav, O.P. & Singh, N. (2008) [26] have drawn an attention for creating convergent environments from dynamic nature of market and globalization for product development process. Non-conformities (NC) must be removed for product development [21] for creating convergent dynamic market. Roy et al. (2009) [20] was applied one dimensional questionnaire for user centric design by using Kansei Engineering .In this perspective, Kano model and two dimensional questionnaire regarding Kano model can help to remove Non-conformities (NC) of the product and control the dynamic nature of market, i.e. people, customers, users than one dimensional questionnaire of Kansei. Therefore, both functional and dysfunctional questionnaires answer simulating independently are applied to identify critical number of respondents/sampling of survey through simulating kano evaluation namely: *Attractive*, *Must-be*, *One-dimensional*, *Indifferent*, and *Reverse*. In this paper, circular wheel bi-cycle is considered to determine the number of respondents for must-be attribute of Kano model. For this purpose, a method of the numerical system illustrates in section 2. Section 3 describes a case study about the must-be attribute. Section 4 concludes.

2. NUMERICAL SIMULATION METHOD

Simulation method is formulated in the following way by using Monte Carlo simulation principle [12-18].

Inputs:

E$= (E_1,\ldots, En)$ //Event Vector

Pr(E)$= (Pr\ (E_1),\ldots,\ Pr\ (E_n))$ //Event Probability Vector

N //Number of Trials

Calculate:

$CPr\ (E_i)\ = Pr\ (E_1)\ +\ldots+ Pr\ (E_i),\ i=1,\ldots,\ n$ //Cumulative Probability of Events

For $j=1,\ldots, N$

Do $r_j \in [0, 1]$ //r_j is a random number in the interval [0, 1]

If $r_j \le CPr\ (E_1)$ *Then* $S_j = E_1$

Otherwise

For $i=2,\ldots, n$

If CPr $(E_{i-1}) < r_j \leq CPr (E_i)$ *Then* $S_j = E_i$

It is note that a stopping rule is applied for the Monte Carlo Simulation, than the cumulative probability of the last event *Sn* is 1, *i.e.* C*Pr (Sn) =1*; then automatically stop the simulation The both functional side and the dysfunctional side are shown of Kano model in Table 1.

Table 1: Kano Evaluation

Functional Answer (x_i)	*Dysfunctional Answer* (y_j)				
	Like	*Must-be*	*Neutral*	*Live-with*	*Dislike*
Like	*Q*	*A*	*A*	*A*	*O*
Must-be	*R*	*I*	*I*	*I*	*M*
Neutral	*R*	*I*	*I*	*I*	*M*
Live-with	*R*	*I*	*I*	*I*	*M*
Dislike	*R*	*R*	*R*	*R*	*Q*

A=Attractive, I=Indifferent, M=Must-be, O=One-dimensional, Q=Questionable, and R=Reverse

This method is modified with computer for determination virtual customer for specific indifferent attribute according to five steps:

Step 1: Choices of FA and DFA of unknown customer, *FA, or DFA* $\in$ *{Like (L), Must-be (M), Neutral (N), Live-with (LW), Dislike (D)}*

Step 2: Generate a set of random inputs

Step 3. Simulation of dysfunctional answer of customer independently

Step 4. Simulation of functional answer of customer independently

Step 5. Simulation of customer evaluation by using combination of FA and DFA

According to step 2, a set of random inputs has been generated by using the formula=RAND () in a cell of Microsoft office Excel.

4. A CASE STUDY ON MUST-BE ATTRIBUTE: RESULTS AND DISCUSSION

Consider the case shown in Fig. 1. As seen from Fig. 1, there is a questionnaire regarding a product (bicycle) attribute (circular wheel). It is well-known that circular wheel of a bicycle is a “Must-be” (in Japanese “Atarimae”) attribute. Therefore, the ideal answer of a respondent would be “must-be” from functional side (i.e., the bicycle should have circular wheel) and “dislike” from dysfunctional side (i.e., other shapes of wheel it is not at all desirable). This combination of answer (must-be, dislike) yields a “Must-be” attribute according to Kano Evaluation (see Table 1).

In reality, respondents exhibit a rather fuzzy behavior and sometimes answer different than the ideal one. For example, see the frequency of the answers of 27 respondents shown in Fig. 1 obtained during this study. Some respondents answer makes the attribute Must-be, some others answers make it “Attractive,” and so on. This raises a fundamental question that is how many respondents should be asked to know for sure that the given attribute is a Must-be attribute.

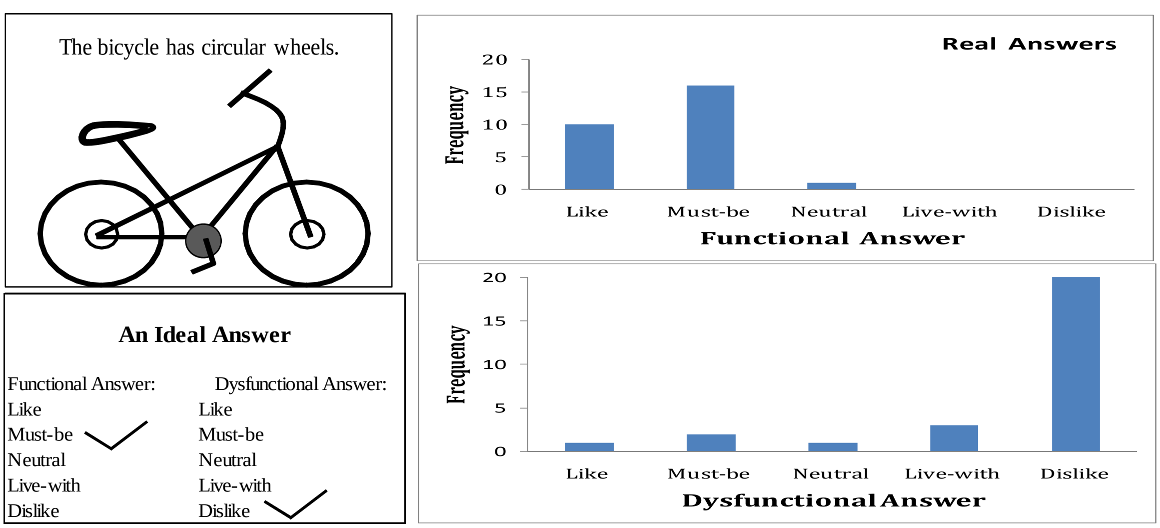


Fig. 1: The questionable sampling in survey

This question can be answered using the system shown in the previous section. To use the system shown in the previous section, the first step is to input the probability vectors of functional answers and dysfunctional answers. To determine the probability vectors of functional/dysfunctional answers the following procedure can be used.

As it is seen from the case shown in Fig. 1, from the functional side, the respondents are "most-likely" to choose Must-be, "some-likely" to choose "Like" and "less-likely" to choose Neutral, Live-with, or Dislike. On the other hand, from the dysfunctional side, the respondents are "most-likely" to choose Dislike, "some-likely" to choose Live-with, and "less-likely" to choose Neutral, Must-be, or Like. These linguistic likelihoods ("most-likely", "some-likely", "less-likely", and so on) can be converted into numerical (crisp) probability using the fuzzy logic. Ullah and Tamaki, 2011 and Ullah and Harib, 2006 [23-24] have provided a fuzzy-logic-based method. The author used this method here. Figure 2 illustrates the fuzzy numbers defining such linguistic likelihoods as "most-likely," "quite-likely," "some-likely," and "less-likely." The membership functions denoted by μ :[0,1]→[0,1] of these linguistic likelihoods.

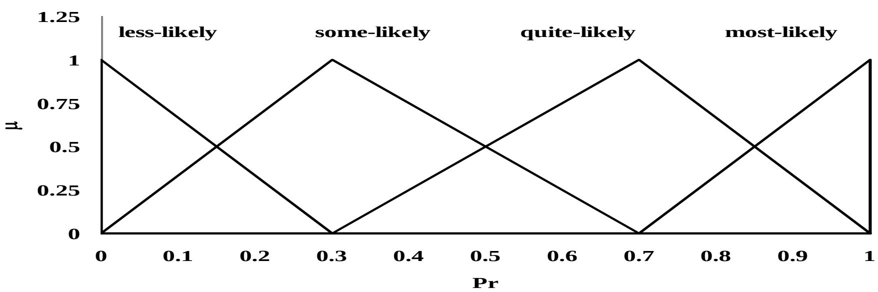


Fig. 2: Defining linguistic likelihoods by fuzzy numbers

From the linguistic likelihoods shown in Fig. 2, the average value and lower and upper limits of are determined using centroid method and α-cuts at α=0.5, respectively. See the reference [24] for more details. The results are shown in Table 1.

Table 1 Numerical probability of linguistic likelihoods

Linguistic likelihoods	Pr		
	Lower limit	Upper limit	Average
most-likely	0.85	1	0.9
quite-likely	0.5	0.85	2/3
some-likely	0.15	0.5	1/3
less-likely	0	0.15	0.1

Table 2 shows the probabilities of functional answers for average and worst-case scenarios. For average scenario the average probabilities of linguistic likelihoods (shown in Table 1) are used. These probabilities are normalized to calculate crisp probabilities shown in 4-th column in Table 2. For worst-case scenario, the lower limit of most-likely is used and upper limits of some-likely and less-likely are used. These limits are normalized to calculate the crisp probabilities for worst-case scenarios, as shown in last column in Table 2.

Table 2 Probabilities of functional answers for average and worst-case scenarios.

		average scenario		worst-case scenario	
Functional Answers	Linguistic likelihoods	average Pr	Crisp Pr	upper/lower limits of Pr	Crisp Pr
Like	some-likely	1/3	0.217391304	0.5	0.277777778
Must-be	most-likely	0.9	0.586956522	0.85	0.472222222
Neutral	less-likely	0.1	0.065217391	0.15	0.083333333
Live-with	less-likely	0.1	0.065217391	0.15	0.083333333
Dislike	less-likely	0.1	0.065217391	0.15	0.083333333

Similarly the probabilities of dysfunctional answers for average and worst-case scenarios are determined and listed in Table 3.

Table 3 Probabilities of dysfunctional answers for average and worst-case scenarios.

		average scenario		worst-case scenario	
Dysfunctional Answers	Linguistic likelihoods	average Pr	Crisp Pr	upper/lower limits of Pr	Crisp Pr
Like	less-likely	0.1	0.065217391	0.15	0.083333333
Must-be	less-likely	0.1	0.065217391	0.15	0.083333333
Neutral	less-likely	0.1	0.065217391	0.15	0.083333333
Live-with	some-likely	1/3	0.217391304	0.5	0.277777778
Dislike	most-likely	0.9	0.586956522	0.85	0.472222222

The results shown in Tables 2-3 provide two sets of probabilities for simulating functional/dysfunctional answers. These probabilities are illustrated in Fig. 3. Using these probabilities a study has been carried out to determine the minimum number of respondents to conclude that whether or not an attribute is Must-be attribute or else. Figure 4 shows the results for average scenario. As seen from Fig. 4, for 20 respondents there is overlaps among the probabilities of Must-be, Attractive, and Indifferent. This means that using the results of 20 respondents it is not possible to conclude that the attribute is a Must-be attribute. For the case of 50 respondents, still there is an overlap between the probabilities of Must-be and Indifferent. On the other hand, when 100 respondents are used, the overlap disappears and the trend remains more or less the same even if more respondents are used (e.g., compare the results of 100 respondents and 200 respondents shown in Fig. 4).

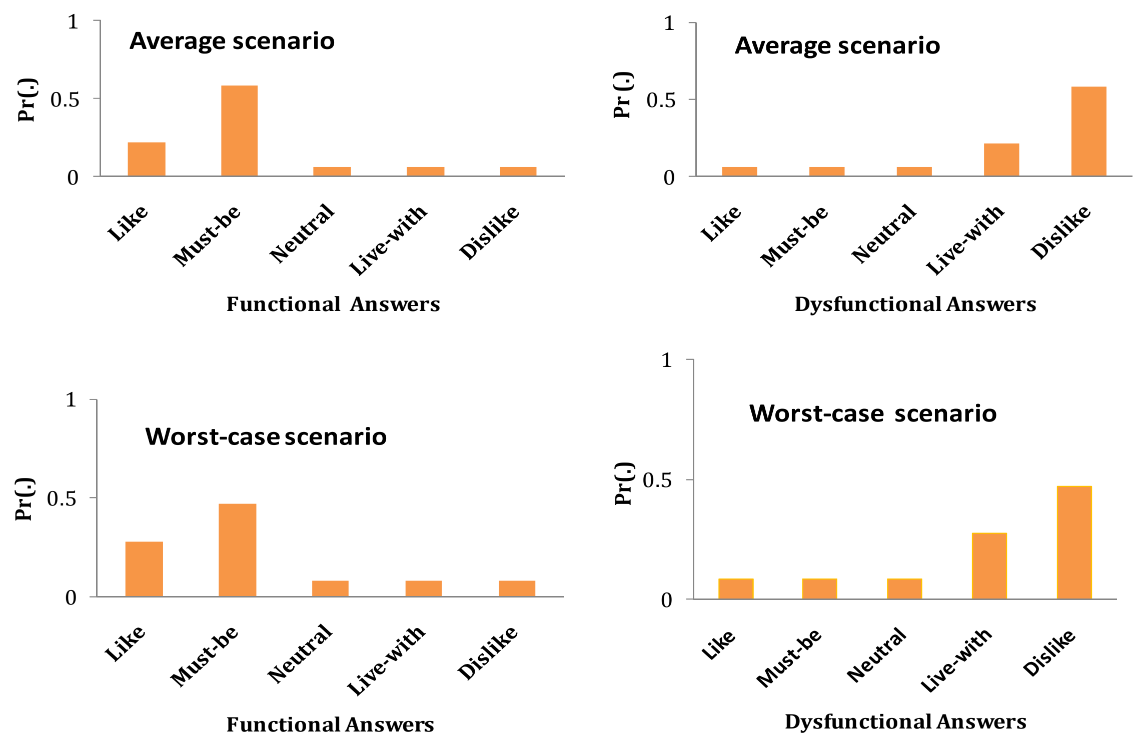
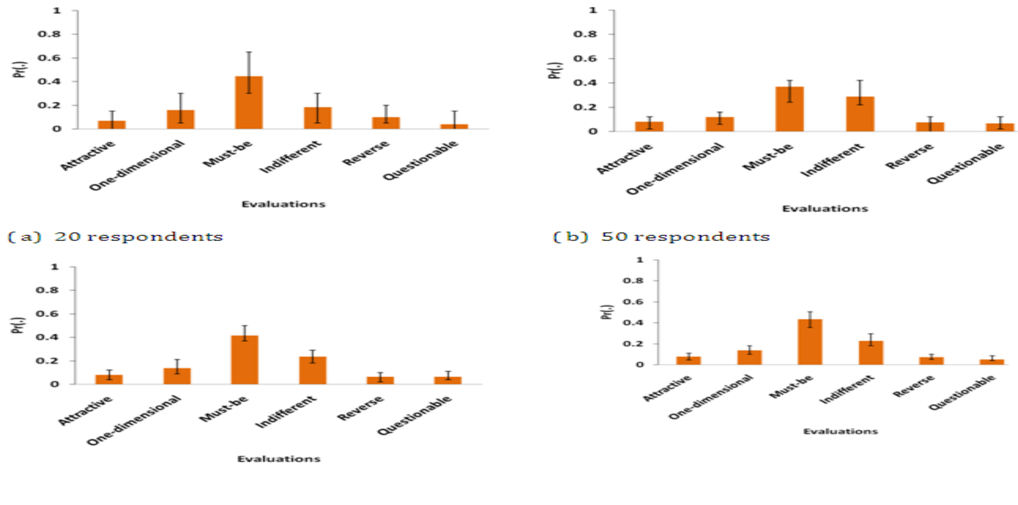


Fig. 3: Probabilities of functional/dysfunctional answers for two scenarios

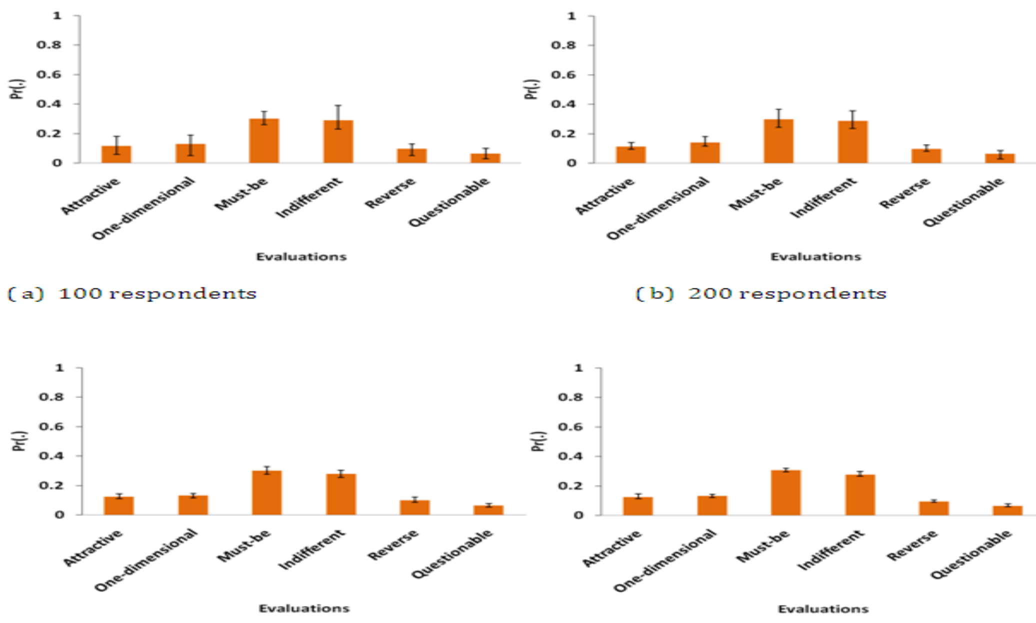
Therefore, at least answers from 100 respondents should be collected to determine that an attribute is a Must-be attribute. What if the other set of probabilities (probabilities for worst-case scenario) is used? Figure 5 shows the results for this case. As seen from Fig. 5, even though a large number of respondents are used, an overlap between the probabilities of Must-be and Indifferent remains.



(a) 20 respondents (b) 50 respondents

(c) 50 respondents (d) 200 respondents

Fig. 4: Number of respondents versus Kano Evaluation for average scenario



(a) 100 respondents (b) 200 respondents

(c) 1000 respondents (d) 2000 respondents

Fig.5: Number of respondents versus Kano Evaluation for worst-case

This means that if the there is tie between Must-be and Indifferent, the attribute should be considered a Must-be attribute. Otherwise, the probability of Indifferent should have been much higher than that of Must-be.

Based on the above results it can be concluded that if the answers of at least 100 respondents show a tie between must-be and Indifferent (worst-case scenario) or probability of Must-be is greater than that of others, then the attribute should be considered a Must-be attribute. This working principle can be used as a guideline while distinguishing a Must-be attribute from others in all kinds of product. Similar study can be carried out for other types of attributes [17, 19].

Moreover, the presented system can be used to simulate customer answers wherein the customers are taken from different demographic and/or psychographic background factors of the respondents of known and unknown answers are similar. This issue remains open for further study. A system can to simulate the functional and dysfunctional answers for a given kano evaluation [18]. A combination of the known answer and random selection can be used to develop a computer system. This issue is also open for further study. In Kano model, a questionnaire is a two-dimensional one wherein a combination of two answers determines the level of satisfaction. Sometimes, one-dimensional questionnaire are used to know the level of satisfaction (see for example the questionnaire in Roy et al. 2009[20]). The system can be customized for other customer needs assessment model that uses one-dimensional questionnaire or multi-dimensional questionnaire.

4. CONCLUDING REMARKS

The presented customer needs assessment system can assist a product development team by providing an answer to the question: at least how many respondents should be asked to determine whether or not an attribute is must-be, attractive[17], one-dimensional [27], indifferent [28] and reverse [19] attribute in accordance with Kano Model. In particular, it is found that at least 100 respondents should be asked to determine whether or not an attribute is a must-be attribute for sampling in survey. It can be stated that this study attempt to show a use of Kano method for assessing product attributes and describes a rationale to develop an electronic tool to assist in eliciting customer requirement. This computational approach results may also be applied in commercially successful. Therefore, it can be implemented early stage for any design of product.

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