A REVIEW OF STATE-OF-ART ON KANO MODEL FOR RESEARCH DIRECTION

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Abstract:
Voice of Customer is the important for product development. Product development is a complex task in which a great deal of human physical resources, methods, and tools are involved. One of the well- appreciated models is Kano model for customer needs study for product development. This study is to identify a research gap from existing literature regarding Kano Model. For this reasons, a review of state-of-art is done regarding Kano Model aspect.

Keywords: Kano Model; Product development, A Monte Carlo Simulation, Human-Physical Interactions, Probability, Logical Rules;

1. INTRODUCTION

Customer needs with producer capacity assessment is essential for product development. The voice of the customer (VoC) and relevant information can be improved the customer satisfaction according to market segmentation (Garibay et al. 2010, Heo et al., 2007, Huiskonen et al.,1998). In this regards, leveraging strategy is essential for product development with respect to the target market segments considering the customer trends (Weck et al., 2005). Product development is an integrated result of design, manufacturing, research and development, and compliance with Voice of Customers (VoC). Product development is considered main challenge to comply among satisfaction, affordability of customer, production rate, technical ability, human error , production cost, shorter reaction time, selling price, organizational complexity and bureaucracy, value chain and competitor of manufacturer in various customer segments (Browing, 2003; Prasad, 2000; Burlikowska and Szewieczek, 2009; Willcox and Wekayama, 2003; Meier and Kroll, 2008; Matt, 2009).Various challenges are raised from different customer segments according to their individual customer needs. In this respect, manufacturers have been following laws of consumer needs (Petro, 2005), customer pain points (Handfield and Steininger, 2005), and attention of changing customer needs by adapting design requirements (Hintersteiner, 2000). Another challenge of product development is to a volatile and diversified market behavior (Cochran et al., 2000) and the demographic and psychographic factors of customers. Thus, VoC, Organizational Aspects, Peripheral Aspects, Methods and Tools are considered appropriately for product development. (Fujita and Matsuo, 2006). Product development society is working for integrating VoC for real product. For instance, Transitional Business Model (TBM) is developed to incorporate the customer needs into the concept generation processes for aerospace product development (Guenov et al., 2006). Data mining techniques are identified for product development by the researchers Jiao et al., 2007. A knowledge management model is developed by Fagerström and Olsson, 2002 for using Soft System Methodology (SSM) and emphasized the need for effective collaboration between main supplier and customers for adding value to a product development process. Identified factors are explained or significantly contributed to successful launch of product development of an innovation by another research group Haapaniemi and Seppanen, 2008. Integrated design knowledge is applied for reuse framework, bringing together elements of best practice reuse, design rationale capture and knowledge-based support in a single coherent framework by Baxter et al., 2007. A formal basis for the creation of an automated reasoning system is also supported for creative engineering design by Sushkov et al., 1995. Mannion and Kaindle, 2008 developed a formal logic-based approach to deal with the VoC in term of product requirement. The start-up technology-based firm's theory (STBFs) is introduced for undertaking their new product development (NPD) the relationship between corporate strategy and NPD process features by Beven, 2007. Sivaloganathan et al., 2000 carried out a study for the effectiveness of systematic and conventional approaches to design. A stepwise procedure based on quantitative life cycle assessment is integrated of environment aspects in product development by Nielsen and Wenzel, 2002. A model is developed for concurrent product and process design. There are various design concepts to evaluate for identify the 'Best' concept with application of fuzzy logic for design evaluation and proposes an integrated decision-making model for design evaluation at developing a computer tool for evaluation process to aid decision-making (Green and Mamtami, 2004). A design structure matrix (DSM) is provided by Browing, 2003 a simple, compact, and visual representation of a complex system that supports innovative solution to decomposition and integration problems for product development. The rapid change of technology has been led to shorter product life cycles for many products most particularly in consumer electronics. A product definition and customization system (PDCS) is established to meet rapid change of competitive and globalism business climate (Minderhond and Fraser, 2005; Chen et al., 2005). Moreover, an information technology (IT) framework is solved the product development problem through automatic generation of information. The framework is used the concept of information templates or models and a rule based system to generate manufacturing instructions (Dean et al., 2008). But information cannot be summed for decoupled designs and overcome the problem was applied joint probability density function and uniformly distributed design parameters (Frey et al., 2000).Two important issues in configuration product design are considered including requirement configuration and engineering configuration by Shao et al., 2005 . A deliberate business process is involved hundreds of decisions and supported by knowledge and tools for product development, where a new composition of fuzzy relations that is defined by using the drastic product development (Krishnan and Ulrich, 2001; Mizumoto, 1981). The products model is solved two essential problems redundancy of both technical and marketing effort and lack of long term consistency and focused for an approach to managing new products (Meyer, 1992). Reused design is applied by Ong et al., 2008 for product development modeling and analysis and optimization. Off drape and hand off fabrics are applied by Palicska, 2008 for 3D material simulation for garment manufacture. Integrated design of products and their underlying design processes are provided for a systematic fashion, motivating the extension of product life cycle management (PLM) (Panchal et al., 2004). 'Validation Square' is validated by testing its internal consistency based on logic in addition to testing its external relevance based on its usefulness with respect to a purpose (Pedersen et al., 2000). Concept-knowledge (C-K) theory is applied by Hatchuel and Weil, 2003 for innovative design. The development of a framework is incorporated of different models for environmental analysis, with the option of a broader scope that also includes economic and social aspects, thus covering the three pillars of sustainability (Heijungs et al., 2010). The concept of Lean (Womack and Jones, 1996) has influenced the research of VOC and its implementation. The focuses of all activities are turned to customer needs rather than job-at-hand (Oppenheim, 2004). Browning, 2003 recommend that removing one activity or changing its focus as because it is a non-value adding activity does not help improve overall value of a product. Sireli et al., 2007 developed a detailed procedure to integrate Kano model with QFD for simultaneous development of multiple products for designing a weather information system for cockpit. Chen and Chuang, 2008 integrated Kano model with the concept of robust design so that the relative weights of product performance parameters become more meaningful. Li et al., 2008 integrated Kano model to make AHP (Analytical Hierarchy Process) and rough-set based calculations more meaningful. Xu et al., 2009 developed a variant of Kano model called "analytical Kano model" for making optimal tradeoff between customer's satisfaction and producer's capacity. The effectiveness of this model is demonstrated by redesigning a car dashboard. Nevertheless, the empirical studies (Chen and Chuang, 2008; Li et al., 2008; Xu et al., 2009; Sireli et al., 2007) of Kano model are in a sense helpful in materializing the issues that have been emphasized by the holistic frameworks of product development (Womack and Jones ,1996; Fagerström and Olsson, 2002; Browning, 2003; Oppenheim, 2004; Guenov et al., 2006). The above review leads to obtain, process, and determine a set of customer needs correlating the proper levels of satisfaction of targeted customer segments. Kano model is able to identify a set of product attributes satisfying a set of customer needs (Kano et al., 1984; Berger et al., 1993; Matzler and Hinterhuber, 1998; Jiao and Chen, 2006; Kai, 2007). In this regard, the Kano model is one of the choices for compliance customer needs with producer capacity, because Kano model is done to non-linear relationship between product performance and customer satisfaction. Following section is discussed only Kano model oriented review study.

2. A CONCLUSIVE REVIEW ON KANO MODEL

From above section, there are many models for customer needs assessments. One of the Kano model has been appeared into one of the most popular quality models now days since its introduction in 1984. Kano et al., 1984 has been for two aspects of quality such as subjective and objective. Kano's model of attractive quality (Kano et al., 1984) has been taken the researchers of industries for quality product development (Berger et al., 1993; Matzler and Hinterhuber, 1998; Jiao and Chen, 2006; Kai, 2007; Fuchs and Weiermair, 2004). Based on the information from Kano questionnaire, it provides a quantitative approach to observe and follow the change over time (Raharjo et al., 2009). An investigation is done for 3G mobile services perceive on the market (Baek et al., 2009). The major difference in contrast to other wide spread quality models, such as the technical and functional quality model (Gronroos,1984) or the Gap model (Parasuraman et al., 1985), is that Kano's model is based on the assumption of existence of nonlinear and asymmetric relationships between attribute-level performance of products/services and overall customer satisfaction (OCS). The outcome has been reflected potential weakness of traditional questionnaire of Kano model (Au et al., 2006). Baek and Otto, 2009 has been endeavored to categorize key attributes of Mobile services into five qualities Attributes: attractive, one-dimensional, must-be, indifferent and reverse by using three functional and dysfunctional questions for each attribute, i e., satisfied, neutral and dissatisfied. Berger et al., 1993 derived a Kano model for more effective use. A robust design approach incorporating the Kano model can enhance customer satisfaction and aesthetic product qualities with multiple –criteria characteristics (Chen and Chuang, 2008). Fuzzy approaches can cope between customer requirements (CRs) and design requirement (DRs) of product development (Chen and Ko, 2008) but they are not study regarding generic unknown customer. A Kano and customer knowledge management (CKM) model is introduced for innovative product development (Chen and Su, 2006). A Kano and neural networks model is applied for web personalization (Chang et al., 2009). The result of TRIZ and Kano model is shown that the home life industry is very competitive (Chen et al., 2010). Gap measures are taken between the professor's expectations and students' perceptions of those expectations in an attempt to explore a variety of performance in terms of basic needs, satisfiers and delighters as well as a variety of demographic variables e.g., gender, age, discipline, course level and teaching experience (Emery, 2006) . Lee and Huang, 2009 is considered fuzzy recommended Kano questionnaires functional side of the questionnaire like, must-be and neutral respectively 20%, 50% and 30%; dysfunctional side of the questionnaire live-with and dislike respectively 50% and 50%. Lee and Huang, 2009 has used fuzzy questionnaire to enhance the deficient of typical Kano's two dimensional quality attribution in questionnaire linguistic scale. Li et al., (2009) developed an integrated method of rough set, Kano's model and AHP for rating customer requirements final importance. All quality attribute are not viewed as equally important to customer (Lin et al., 2010). Lee et al., 2008a developed a decision making trial and evaluation laboratory (DEMATEL) to identify the causality of order winners and qualifiers and the extent to which they interact. Lee et al., 2008b is applied fuzzy Kano model for product life cycle management. Zultner and Mazur, 2006 is derived recent developments of Kano model. Moreover, a list of study regarding Kano model is shown in table 1,encompassing authors (column 1), industry (object)or field of research (column 2), the model type (column 3).

Table 1. Research studies and conceptual papers on the Kano Model

Author	**Industry/ Fields**	**Model type**
Kano et al. (1984)	technical products	A model of quality (Q)
Berger et al. (1993)	technical products	A model of customer requirements (CR)
Matzler et al. (1996)	sports products	A model of customer satisfaction(CS)
Sauerwein et al (1996)	to delight customer	A model of customer satisfaction(CS)
Vavra (1997)	concptual paper on importance grid analysis	A model of quality (Q)
Huiskonen and Pirttila (1998)	customer service strategy planning	A model of production
Matzler and Hinterhuber (1998)	sports products	A model of customer satisfaction(CS)
Sauerwein (1999)	product design optimization	A model of product design
VonDran et al. (1999)	web site design	A model of quality (Q)
Tan et al. (1999)	IT (web page)	A model of quality (Q)
Rust and Oliver (2000)	delight for customer	A model of customer satisfaction(CS)
Martensen and Gronholdt (2001)	employee satisfaction	A model of quality (Q)
Ting and Chen (2002)	services (hypermarket) using regrssion analysis	A model of quality (Q)
Jane and Dominguez (2003a)	health care	A model of customer satisfaction(CS)
Rahman (2004)	bank services	A model of customer need(CN)
Lilja (2005)	focus on customer	A model of quality (Q)
Yang (2005)	technical products	A model of quality (Q)
MacDonald et al. (2006)	kano methods in product decision theory	A model of customer satisfaction(CS)
Zultner and Mazur (2006)	Using in QFD	A model of quality (Q)
Chen and Su (2006)	customer knowledge discovery for innovative PD	A model of product development (PD)
Au et al.(2006)	to foot wear design	A model of product design
Riviere et al. (2006)	an optimized preference analysis	A model of customer satisfaction(CS)
Emery (2006)	examination of faculty expectation	A model of customer satisfaction(CS)
Eskildsen and Kristensen (2006)	employee satisfaction	A model of customer satisfaction(CS)
Heo et al. (2007)	kano model to physical usability interaction (PUI)	A model of customer need(CN)
Rejeb et al. (2008)	to manage innovation project	A model of customer requirements (CR)
Lee et al.(2008)	product life management	A model of product development (PD)
Chen and Ko (2008)	a fuzzy nonlinear model	A model of quality (Q)
Chen and Chuang (2008)	computational approach	A model of customer need(CN)
Chang et al.(2009)	web personalization	A model of customer need(CN)
Lee and Huang (2009)	fuzzy mode	A model of quality (Q)
Raharjo et al. (2009)	kano model dynamics for multiple product design	A model of product design
Li et al.(2009)	imprecision of customer requirements	A model of product planning
Slevitch and Oh (2009)	attribute performance and CS	A model of customer satisfaction(CS)
Garibay et al.(2010)	evaluation of digital library	A model of quality (Q)
Xu et al. (2009)	analytical and computational approach	A model of customer need(CN)
Lin et al. (2010)	a moderated regression approach	A model of quality (Q)
Li et al.(2010)	CR in mature period PI	A model of product improvement (PI)
Chen et al.(2010)	home life industry innovation	A model of product design
Ullah and Tamaki (2010)	to simulate unknown customer answer	A method of customer need analysis

Martensen and Gronholdt, 2001 tested the Kano model among more than 300 employees, and achieved a very good explanation of employee satisfaction. Matzler et al. 1996 is striving for customer satisfaction. It means understanding and anticipating what customers' wants of the products in the future but do not expect of them. Matzler and Hinterhuber, 1998 have been made product development projects more successful by integrating Kano's model of customer satisfaction into quality function deployment. Raharjo et al., 2009 integrated Kano's model dynamics into QFD for multiple products design. Rejeb et al., 2008 introduced a new methodology based on Kano model for needs evaluation and innovative concepts comparison during the front-end phases of product development. Riviere et al., 2006 considered adaptive preference target to be a methodology which reduces the number of products to be tested while remaining precise in the definition of the ideal product. Sauerwein, 1999 examined the reliability of test-retest, alternative forms and stability of interpretation. The results are supportive for the Kano model. Sauerwein et al. 1996 is provided an evaluation rule for delighting the customer. Sireli et al. 2007 is integrated of Kano's model into QFD for multiple product design in a robust manner. Tan et al., 1999 developed of Innovative Products using Kano's Model and Quality Function Deployment. Wang and Ji, 2010 was increased understanding Customer Needs for product development through quantitative analysis of Kano's Model. Xu et al., 2009 demonstrated Analytical Kano Model can incorporate customer preferences in product design, while leading to an optimal trade between customer's satisfaction and producer's capacity. Yang, 2005, refined Kano's model and its application of I-S model firms for valuable information. As seen from above literature, that researcher yet could not find generic unknown customer evaluation computer system regarding Kano model based. Ullah and Tamaki, 2010 presented a proposition that the respondents of unknown answers might have selected the states randomly from the functional/dysfunctional sides of Kano model. Thus, all states of functional answer (FA) and dysfunctional answer (DFA) of Kano model; Like(L), Must-be(M), Neutral (N),Live-with (Lw), and Dislike(D) are equally likely.

2.1 A Study the Frame of Kano Model to Meet the Research Gap

Kano model of customer satisfaction defines the relationship between product attribute and customer satisfaction and provides five types of product attributes: 1) *Must-be*, 2) *One-dimensional*, 3) *Attractive*, 4) *Indifferent*, and 5) *Reverse*, as schematically illustrated Fig.1, and Table 2.

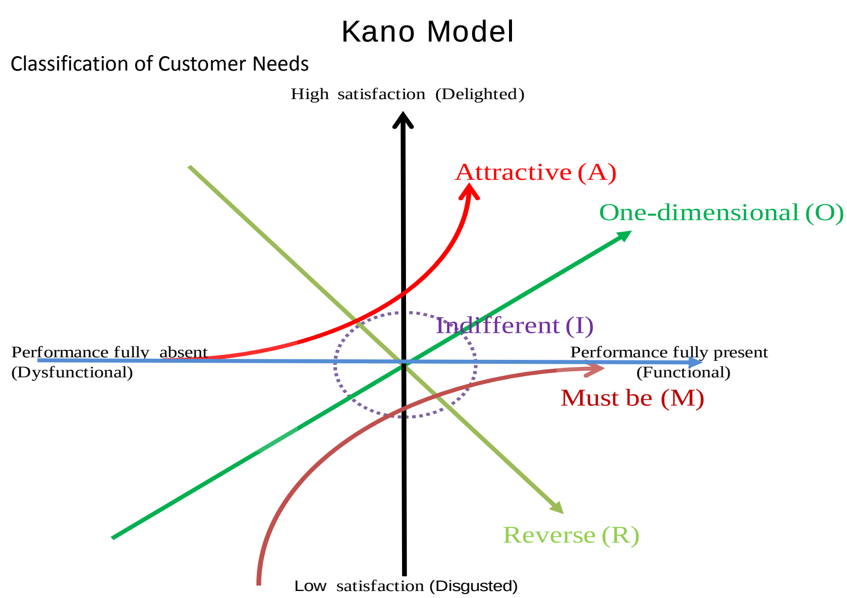

Fig. 1. Kano Model for Customer Satisfaction

The combination of *functional* and *dysfunctional* answers is then used to identify the status of the attribute in term of: 1) *Must-be*, 2) *One-dimensional*, 3) *Attractive*, 4) *Indifferent*, or 5) *Reverse*.

Table 2. Five categories of product attributes based on Kano et al. (1984)

Product attributes	Definition	Recommendations
Attractive	An *Attractive* attribute leads to a better satisfaction, whereas it is not expected to be in the product.	Include a good number of *Attractive* attributes
One-dimensional	A *One-dimensional* attribute fulfillment helps enhance the satisfaction and vice versa.	Include a good number of *One-dimensional*
Must-be	A *Must-be* attribute absence produces absolute dissatisfaction and its presence does not increase satisfaction	Continue *Must-be* attributes
Indifferent	An *Indifferent* attribute, that result neither in satisfaction nor dissatisfaction, whether fulfilled or not.	Avoid *Indifferent* attributes as many as possible
Reverse	A *Reverse* attribute presence causes dissatisfaction and its absence causes satisfaction.	Avoid *Reverse* attributes

All possible combinations of customer answers and the corresponding type of product attribute are summarized in following Table 3.

Table 3. Kano Evaluation

Functional	**Dysfunctional**				
	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					

As seen from Table 3, besides the above mentioned five types of attribute in Table 2, there is one more type of attribute called *Questionable*. This occurs when one selects Like or Dislike from both *functional* and *dysfunctional* sides (i.e., when an answer does not make any sense). As mentioned earlier, Kano model is accommodating for integrating the VOC into the succeeding processes of product development. Thus, for the meaningful integration of VOC into the succeeding processes of product development, it is important to follow of recommendation of Table 2. The straight forward relationship is shown table 4 among functional answer (FA), dysfunctional answer (DFA) and Kano evaluation (KE). This table is also exposed a frame among functional answer (FA), dysfunctional answer (DFA) and Kano evaluation (KE).

Table 4. FA, DFA and KE of Kano Model: Separation and Combination Aspect or Kano Rules

Sl	**FA**	**DFA**	**Combination of FA and DFA**	**KE**
1	Like	Like	Like Like	Questionable (Q)
2	Like	Must-be	Like Must-be	Attractive (A)
3	Like	Neutral	Like Neutral	Attractive (A)
4	Like	Live-with	Like Live-with	Attractive (A)
5	Like	Dislike	Like Dislike	One-dimensional (O)
6	Must-be	Like	Must-be Like	Reverse (R)
7	Must-be	Must-be	Must-be Must-be	Indifferent (I)
8	Must-be	Neutral	Must-be Neutral	Indifferent (I)
9	Must-be	Live-with	Must-be Live-with	Indifferent (I)
10	Must-be	Dislike	Must-be Dislike	Must-be (M)
11	Neutral	Like	Neutral Like	Reverse (R)
12	Neutral	Must-be	Neutral Must-be	Indifferent (I)
13	Neutral	Neutral	Neutral Neutral	Indifferent (I)
14	Neutral	Live-with	Neutral Live-with	Indifferent (I)
15	Neutral	Dislike	Neutral Dislike	Must-be (M)
16	Live-with	Like	Live-with Like	Reverse (R)
17	Live-with	Must-be	Live-with Must-be	Indifferent (I)
18	Live-with	Neutral	Live-with Neutral	Indifferent (I)
19	Live-with	Live-with	Live-with Live-with	Indifferent (I)
20	Live-with	Dislike	Live-with Dislike	Must-be (M)
21	Dislike	Like	Dislike Like	Reverse (R)
22	Dislike	Must-be	Dislike Must-be	Reverse (R)
23	Dislike	Neutral	Dislike Neutral	Reverse (R)
24	Dislike	Live-with	Dislike Live-with	Reverse (R)
25	Dislike	Dislike	Dislike Dislike	Questionable (Q)

Following tables 5 and 6 are derived from table 4.

Table 5. Probability of FA and DFA regarding Kano Model

Events (E)	Frequency, f	Probability, Pr (.)	Cumulative Probability, CPr (.)
Like (L)	5	0.2	0.2
Must-be (M)	5	0.2	0.4
Neutral (N)	5	0.2	0.6
Live-with (Lw)	5	0.2	0.8
Dislike (D)	5	0.2	1

Table 6. Probability of KE regarding Kano Model

Events (E)	Frequency, f	Probability, Pr (.)	Cumulative Probability, CPr (.)
Attractive (A)	3	0.12	0.12
Indifferent (I)	9	0.36	0.48
Must-be (M)	3	0.12	0.6
One-dimensional (O)	1	0.04	0.64
Questionable (Q)	2	0.08	0.72
Reverse (R)	7	0.28	1

2.2Traditional Use of Kano Model

Figure 2 shows an example of a format of Kano model at a glance. To implement Kano model, a two dimensional questionnaire is prepared for each product attribute. As seen from Fig. 2, a customer (respondent) can to select one of the states out of *Like*, *Must-be*, *Neutral*, *Live-with*, and *Dislike* from the *functional* side stating his/her level of satisfaction, if the attribute is added to the product. The customer also can to select one of the states (out of the same choices) from the *dysfunctional* side stating his/her level of satisfaction, if the attribute is not added to the product. It is important that Fig. 2 shows the Kano model-based questionnaires distributed among 27 individuals for their opinion. A customer selects "Dislike" from the *functional* side (your bicycle wheel is triangular shape) and "Live-with" from the *dysfunctional* side (your bicycle wheel is not triangular shape). This combination is determined Reverse attribute from table 3. However, while responding to Kano questionnaires the respondents are allowed to choose any combination of the answers from *functional* and *dysfunctional* sides. The answers may vary a lot because the respondents are driven by demographic factors (age, profession, income, education level, sex, etc.) psychographic factors (attitude, value, life-style, etc.) and so on (Carrillat et al., 2009).

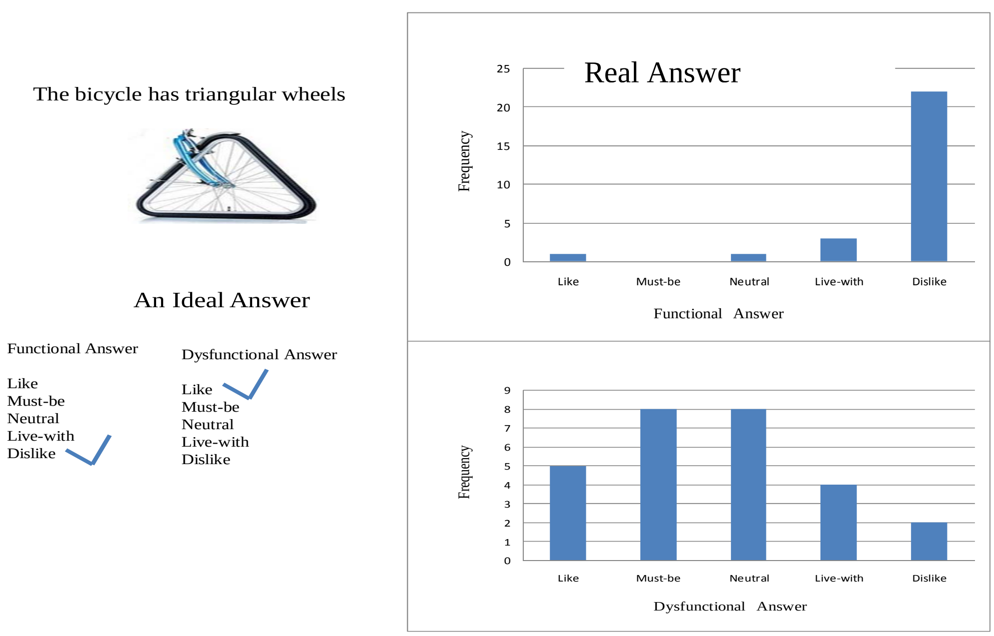

Fig.2. A Kano Questionnaire

For example, another case shown in Fig 2, wherein a respondent has chosen "Like" from the *functional* side and "Live-with" from the *dysfunctional* side for attribute of bi-cycle wheel triangular shape. This combination makes the underlying attribute an Attractive *attribute* (see to Table 3). Figure 2 shows for triangular shape wheel are also Attractive. While Attractive attribute for triangular wheel , it is not practical. In Figure 2, another respondent might choose “Like” from the *functional* side and “dislike” from the *dysfunctional* side for head light of bicycle attribute. This makes the attribute (bicycle) a *one-dimensional* attribute. One-dimensional for triangular wheel is also not consistent. While all majority of answer is concerned Reverse. Therefore, triangular shape bicycle makes Reverse attribute than One-dimensional/attractive. It is concluded that triangular wheel bicycle is Reverse Attribute, it is consistent conclusion.

2.3 Research Directions

A Kano model has been captured capability of the non-linear relationship between product performance and customer satisfaction, while a straightforward frequency based calculation in aggregating the customer answers (Matzler and Hinterhuber, 1998). Up to date literature do not pursue this idea (Raharjo et al.,2009; Lin et al., 2010 ; Sireli et al., 2007; Chen and Ko, 2008 ; Lee et al., 2008; Heo et al., 2009; Lee and Huang ,2009; Li et al., 2009; Xu et al., 2009; Chen and Chuang, 2008; Sakao, 2009). Complex mathematical procedures suggested in this regard wherein both analytical (Xu et al., 2009) and computational intelligence based (Li et al., 2009; Lee and Huang, 2009) approaches are available. All individuals received a Kano questionnaire may not be able to submit their answers because of time pressure or any other practical reasons *i.e.*, lack of interest, understanding etc. As a result, some of the answers remain unknown; it is caused for a great of uncertainty in the analysis. Moreover, sample of the questionnaire is not covered usually whole population. Data collection from whole population is almost impossible for a research group. Besides sample data is not capable to represent the whole population for decision. Consideration of VoC is crucial for the design of product development. However, how to deal with unknown customer opinion is an important question that needs investigations in details. A model can developed from Kano Model to consider uniform vector probability of FA and DFA, which are Like (L), Must-be (M), Neutral (N), Live-with (Lw) and Dislike (D). Moreover, in this regard, Ullah and Tamaki, 2010 concluded a proposition for generic unknown customer evaluation. The proposition is that the respondents of unknown answers might have selected the states randomly from the functional/dysfunctional sides of Kano model. In this case, all states (Like, Must-be, Neutral, Live-with, and Dislike) are equally likely to occur in the simulated answer. In this aspect, a numerical simulation process regarding Kano Model is desired to compute the various answers and finally decide the status of the underlying product attribute. It is done by two ways: (1) this system can to simulate functional (FA) and dysfunctional answers (DFA) independently and then calculate the probability of Kano evaluation (KE) using Monte Carlo Simulation. (2) A system can to simulate the functional (FA) and dysfunctional (DFA) answers for a given Kano evaluation (KE) (Must-be, Attractive, One-dimensional, Indifferent, or Reverse and Questionable) using Monte Carlo Simulation. Therefore, Monte Carlo simulation, probability, random numbers, logical rule of the model are main component for the model adapted with computer.

3. CONCLUSIONS

A Kano model can be adapted with computer using Monte Carlo Simulation to determining the product attribute from virtual customers. This model can be framed by the logical rules of computer for customer evaluation regarding product development.

4. REFERENCES

[1] Autonsson, E.K.; Otto, K.N. (1995): Imprecision in Engineering design, ASME Journal of Mechanical of Mechanical Design, **117**(B), pp.25-32.

[2] Berger, C.; Blauth, R.; Boger, D.; Bolster, C.; Burchill, G.; Du-Mouchel, W.; Pouliot, F.; Richter, R.; Rubinoff, A.; Shen, D.; Timko, M.; and Walden, D.; (1993): Kano's Methods for Customer Defined Quality, The Center for Quality Management Journal, **2**(4), pp. 2-36.

[3] Beven, P.W. (2007): New Product Development in Start-up Technology-Based Firms (STBFs), Doctoral Thesis, Faculty of Business, University of Southern Queensland, Australia.

[4] Browning, T.R. (2003): On Customer Value and Improvement and Improvement in Product Development Processes, Systems Engineering, **6**(1), pp. 49-61.

[5] Baxter, D.; Gao, J.; Case, K.; Harding, J.; Young, B.; Cochrane, S.; Dani, S. (2007): An Engineering Design Knowledge Reuse Methodology using Process Modeling, Res Eng Design,**18** (1),pp. 37–48.

[6] Burlikowska, M. D.; Szewieczek, D. (2009): The Poka-Yoke Method as an Improving Quality Tool of Operations in the Process, Journal of Achievements in Materials and Manufacturing Engineering, **36**(1) , pp. 95-102.

[7] Baek, S.I.; Paik, S.K. ;Yoo, W.S. (2009): Understanding Key Attributes in Mobile Service: Kano Model Approach, Human Interface and the Management of Information, Information and Interaction, Book Chapter, pp.355-364

[8] Carrillat, F.A.; Riggle, R.J.; Locander, W.B.; Gebhardt, G.F.; Lee J.M. (2009): Cognitive segmentation: Modeling the structure and content of customer’s thoughts, Psychology and Marketing, **26**(6), pp.479-506

[9] Chen, C.C. ;Chuang, M.C. (2008): Integrating the Kano Model into a Robust Design Approach to Enhance Customer Satisfaction with Product Design, International Journal of Production Economics, **114**(2), pp.667-681

[10] Cooman, G. ; Hermans, F. (2008): Imprecise Probability Trees: Bridging Two Theories of Imprecise Probability, Artificial Intelligence, **172**(11), pp.1400-1427

[11] Chen, L.H.; Ko, W. C. (2008): A Fuzzy Nonlinear Model for Quality Function Deployment Considering Kano's Concept, Mathematical and Computer Modelling, **48**(3-4),pp. 581-593

[12] Cochran, D.S.; Eversheim, W.; Kubin, G. ; Sesterhenn, M.L (2000): The Application of Axiomatic Design and Lean Management Principles in the Scope of Production System Segmentation, The International Journal of Production Research, 38 (6), pp. 1377-1396
[13] Chen, C.H.; Khoo, L.P.; Yan W. (2005): PDCS—A Product Definition and Customization System for Product Concept Development, Expert Systems with Applications, **28** (3), pp. 591–602.
[14] Chang, C.C.; Chen, P.L.; Chiu, F.R.; Chen, Y.K. (2009): Application of Neural Networks and Kano's Method to Content Recommendation in Web Personalization, Expert Systems with Applications, Vol.36, pp.5310-5316.
[15] Chen, H.C.; Lee, T.R.; Lin, H.Y.; Wu, H.C. (2010): Application of TRIZ and the Kano Method to Home Life Industry Innovation, International Journal of Innovation and Learning, Vol.7, No.1, pp.64-84.

[16] Coolen, F.P.A.; Troffaes, M.C.M. ; Augustin, T. (2010): Imprecise Probability, International Encyclopedia of statistical Sciences, spring 2010, http://www.springer.com/statistics/book/978-3-642-04897-5
[17] Dean, P.R.; Tu, Y.L; Xue D. (2008): A Framework for Generating Product Production, Information for mass customization, Int J Adv Manuf Technol , **38**(12), pp.1244–1259
[18] Eskildsen, J.K.; Kristensen, K. (2006): Enhancing importance-performance analysis, International Journal of Productivity and Performance Management, **55**(1), pp. 40-60
[19] Fagerström, B. ; Olsson, L.E. (2002): Knowledge Management in Collaborative Product Development, Systems Engineering, **5**(2), pp.274-285
[20] Fujita, K.; Matsuo, T. (2006): Survey and Analysis of Utilization of Tools and Methods in Product Development, Transactions of the Japan Society of Mechanical Engineers, Series C, 72 (713), pp. 290-297 (In Japanese)
[21] Fuchs M. and Weiermair K.(2004): Destination Benchmarking: An indicator-System's Potential for Exploring Guest Satisfaction, Journal of Travel Research, **42**, pp.212-225
[22] Frey, D.D et al. (2000): Computing the Information Content of Decoupled Designs, Research in Engineering Design, 12, pp.90-102
[23] Guenov, M.D.; Barker, S.G.; Hunter, C.; Horsfield, I. ; Smith, N.C. (2006): An integrated approach to customer elicitation for the aerospace sector, Systems Engineering, **9**(1), pp.62-72
[24] Green, G.; Mamtami, G. (2004): An Integrated Decision Making Model for Evaluation of Concept Design, Acta Polytechnica, **44** (3), pp. 62-65
[25] Gronroos, C. (1984): A service quality model and its marketing implications, European Journal of Marketing, **18**(4), pp.36-44
[26] Heijungs, R.; Huppes, G.; Guinee, J.B. (2010): Life Cycle Assessment and Sustainability Analysis of Products, Materials, Polymer Degradation and Stability and Technologies, Polymer Degradation and Stability,**95**(3), pp.422-428
[27] Hintersteiner, J. D. (2000): Addressing Changing Customer Needs by Adapting Design Requirements, Proceedings of First International Conference on Axiomatic Design, June21-23,MA,USA
[28] Hari, A.; Kasser, J.E.; Weiss, M.P. (2007): How Lessons Learned from Using QFD Led to the Evolution of a Process for Creating Quality Requirements for Complex Systems, System Engineering, **10** (1), pp 45-63.
[29] Heo, J.; Park, S.; Song, C. (2007): A Study on the Improving Product Usability Applying the Kano's Model of Customer Satisfaction, in Human-Computer Interaction: Interaction Design and Usability, Springer, Berlin, pp.482-489. (DOI: 10.1007/978-3-540-73105-4_53)
[30] Haapaniemi, T.; Seppanen M. (2008): Antecedents and Key Success Factors in Adoption of Consumer Electronics Industry Innovations, Euro MOT 2008 Proceedings, International Association for Management of Technology, September 17-19, Nice, France
[31] Handfield, R.B.; Steininger W. (2005): An Assessment of Manufacturing Customer Pain Points: Challenges for Researchers, an International Journal of Supply Chain Forum, **6**(2), pp. 6-15.
[32] Helander, M.G.; Jiao J. (2002): Research on E-product Development (ePD) for Mass Customization, Technovation, **22**(11), pp. 717-724.
[33] Jane, A.C., Dominguez, S.M. (2003a): Citizens' Role in Health Services: Satisfaction Behavior: Kano's Model, Part1, Quality Management in Health Care, **12**(1), pp.64-71.
[34] Jane, A.C.; Dominguez, S.M. (2003b): Citizens' Role in Health Services: Satisfaction Behavior: Kano's Model, Part2, Quality Management in Health Care, **12**(1), pp.72-80.
[35] Jiao, J. (R.); Chen C.H. (2006): Customer Requirement Management in Product Development: A Review of Research Issues, Concurrent Engineering, 14(3), pp.173-185
[36] Jia, J.; Tseng M.M. (2000): Fundamentals of Product Family Architecture, Integrated Manufacturing Systems, **11**(7), pp.469-483.
[37] Jiao, J.; Simpson, T.W.; Siddique, Z.(2007): Product Family Design and Platform-Based Product Development: A State of the Art Review, Special issue on Product Family Design and Platform-Based Product Development, Journal of Intelligent Manufacturing, **18**(1), pp. 5-29.
[38] Jia, J.; Tseng, M.M. (1999): An Information Modeling Framework for Product families to Support Mass Customization Manufacturing, Annals of the CIRP, **48**(1), pp. 93-98.
[39] Kai, Y. (2007): Voice of the Customer: Capture and Analysis, MacGraw-Hill, New York, 2007.
[40] Kano, N.; Seraku, N.; Takahashi, F.; Tsuji, S. (1984): Attractive quality and must-be quality, Hinshitsu, **14**(2), pp.39-48. (In Japanese)
[41] Krishnan, V.; Ulrich, K.T. (2001): Product Development Decisions: A review of the Literature, Management Science, **47** (1), pp. 1-21
[42] Lee, T. (2003): Complexity Theory in Axiomatic Design, Doctoral Thesis, Massachusetts Institute of Technology, USA
[43] Lilja, J. (2005): Quality Practice and Customer Value Strengthening the Ideal Linkage, Doctoral Thesis, Luleå University of Technology, Department of Business Administration & Social Sciences, Sweden
[44] Lee, Y. C.; Huang, S.Y. (2009): A new fuzzy concept approach for A new fuzzy concept on Kano's model, Expert Systems with Applications, **36**(3), pp.4479-4484.
[45] Lee, Y.C.; Shew, L.C.; Tsou, Y.G. (2008): Quality function deployment implementation based on Fuzzy Kano model: An application in PLM system, Computers & Industrial Engineering, **55**(1), pp.48-63.
[46] Li, Y.; Tang, J.; Luo, X; Xu, J. (2009): An Integrated Method of Rough Set, Kano's Model and AHP for Rating Customer Requirements' Final Importance, Expert Systems with Applications, **36**(3), pp.7045-7053.
[47] Lin, S.P.; Yang, C.L.; Chan, Y.H.; Sheu, C. (2010): Refining Kano's Quality Attributes Satisfaction Model: A Moderated Regression Approach, International Journal of Production Economics, Accepted 23 march 2010, http: www.elsevier.com/locate/ijpe.
[48] Meier, H.; Kroll, R.G.M. (2008): Approach of the Design for the Structure of Global Distribution of Industrial Services, 6th CIRP International Conference on Intelligent computation in Manufacturing Engineering, 23-25 July, Naples, Italy
[49] Martensen, A.; Gronholdt, L. (2001): Using Employee Satisfaction Measurement to Improve People Management: An Adaption of Kano's Quality Type, Total Quality Management, **12**(7/8), pp.949-957.
[50] Matzler, K.; Hinterhuber, H.H.; Bailom, F.; Sauerwein, E. (1996): How to Delight Your Customers, Journal of Product and Band Management, **5**(2), pp. 6-18.

[51] Matt, D.T. (2009): Reducing the Time Dependent Complexity in Organizational Systems using the Concept of Functional Periodicity, The Fifth International Conference on Axiomatic Design, March 25-27, 2009, Campus de Caparica, and Portugal.
[52] Matzler, K.; Hinterhuber, H.H. (1998): How to Make Product Development Projects More Successful by Integrating Kano's Model of Customer Satisfaction into Quality Function Deployment, Technovation, **18**(1), pp.25–38.
[53] Meyer, M.H. (1992): The Product Family and the Dynamics of Core Capability, Working Paper, Sloan School of Management, Massachusetts Institute of Technology, MA, USA.
[54] Mizumoto, M. (1981): Fuzzy Sets and Their Operations, II, Information & Control, **50**, (2), pp.160-174.
[55] Minderhoud, S.; Fraser, P. (2005): Shifting Paradigms of Product Development in Fast and Dynamic Markets, Reliability Engineering and System Safety, **88**, pp.127–135.
[56] Mannion, M. ; Kaindle, H. (2008): Using Parameters and Discriminant for Product Line Requirements, Systems Engineering, **11**(1), pp.61-80
[57] Matzler, K. ; Hinterhuber H.H. (1998): How to Make Product Development Projects More Successful by Integrating Kano's Model of Customer Satisfaction into Quality Function Deployment, Technovation, **18**(1) (1998), pp. 25-38
[58] Nielsen, J.; Kimura, F. (2006): A Resource Capability Model to Support Product Family Analysis, JSME International Journal, Series C, **49**(2), pp.568-574.
[59] Nielsen, P.H; Wenzel, H. (2002): Integration of Environmental Aspects in Product Development: A Stepwise Procedure Based on Quantitative Life Cycle Assessment, Journal of Cleaner Production, **10**, pp.247–257.
[60] Oppenheim, B.W. (2004): Lean Product Development Flow, Systems Engineering, **7**(4), pp.352-376.
[61] Ong, S.K.; Nee, A.Y.C.; Xu. Q.L. (2008): Design Reuse in Product Development Modeling and Analysis & Optimization, Series on Manufacturing systems and Technology, Vol-4, books.google.com.
[62] Palicska (2008) : Examination off Drape and Hand off Fabrics for 3D Material Simulation for Garment Manufacture, Doctoral Thesis, József Cziráki Doctoral School of Wood Sciences and Technologies, University of Western Hungary, Hungary
[63] Panchal, J.H.; Fernández, M.G.; Paredis, C.J.J.; Allen, J.K.; and Mistree, F. (2004): Designing Design Processes in Product Lifecycle Management: Research Issues and Strategies, 2004 ASME Computers and Information in Engineering Conference, 2004, Salt Lake City, Utah.
[64] Parasuraman, A.; Zeithamal, V.A.; Berry L.L. (1985): A Conceptual Model of Service Quality and Implications for Future Research, Journal of Marketing, **49**, pp. 41-50.
[65] Pedersen, K.; Emblemsvag, J.; Bailey, R.; Allen, J.K.; Mistree, F. (2000): Validating Design Methods & Research: The Validation Square, Proceedings of ASME Design Engineering Technical Conferences September 10-14, Baltimore
[66] Petro, M. V. (2005): Laws of Development of Needs, published in the proceedings of the ETRIA TRIZ conference, November 2005, Graz, Austria,
[67] Poel, I.V.D. (2007): Methodological Problems in QFD and Directions for Future Development, Research in Engineering Design, **18**(1), pp.21-36.
[68] Prasad, B. B. (2000): Building Blocks for a Decision-Based Integrated Product Development and System Realization Process, Systems Engineering, **5**(2), pp.123-144.
[69] Parsopoulos, K.E.; Vrahatis, M.N. (2004): On the Computation of all Global Minimizers through Particle Swarm Optimization, IEEE Transactions on Evolutionary Computation , **8**(3), pp. 211-224.
[70] Rahman, Z. (2004): Developing customer oriented service: a case study, Managing Service Quality, **14**(5), pp.426-435.
[71] Raharjo, H.; Brombacher, A.C.; Goh, T.N.; Bergman, B. (2009): On integrating Kano's model Dynamics into QFD for Multiple Product Design, Quality and Reliability Engineering International, in press. DOI: 10.1002/qre.1065.
[72] Rejeb, H.B.; Guimaraes, L.M.; Boly, V. (2008): A New Methodology Based on Kano Model for Needs Evaluation and Innovative Concepts Comparison during the Front-End Phases, EuroMOT 2008, September 17-19, Nice, France
[73] Rzevski, G. (2003): On Conceptual Design of Intelligent Mechatronics Systems, Mechatronics, **13**, pp.1029–1044.
[74] Shao, X.Y.; Wang, Z.H., Li, P.G.; Feng, C.X.J. (2005): Integrating Data Mining and Rough Set for Customer Group-based Discovery of Product Configuration Rules, International Journal of Production Research, Special Issue on Data Mining and Applications.
[75] Sakao, T. (2009): Quality Engineering for Early Stage of Environmentally Conscious Design, The TQM Journal, **21**(2), pp.182-193.
[76] Sauerwein, E.(1999): Experiences with the Reliability and Validity of the Kano-Method: Comparison to Alternate Forms of Classification of Product Requirements, The Eleventh Symposium on Quality Function Deployment, 12-18 June, Novi, MI
[77] Sushkov, V.V.; Mars, N.J.I.; Wognum, P.M. (1995): Introduction to TIPS: A theory for Creative Design. Artificial Intelligence in Engineering, **9**(3), pp.177-189.
[78] Sivaloganathan, S.; Shahin, T.M.M.; Cross, M.; Lawrence, M. (2000): A Hybrid Systematic and Conventional Approach for the Design and Development of a Product: A Case Study, Design Studies, **21**(1): pp. 59–74.
[79] Slevitch, L.; Oh H. (2009): Asymmetric Relationship between Attribute Performance and Customer Satisfaction: A New Perspective, International Journal of Hospitality Management, No of Pages 11, Article in press, available on http//:> www.elsevier.com/locate/ijhosman
[80] Sellgren, U. (2008): Agile Design for Variety, Machine Elements, Doctoral Thesis, Department of Machine Design, KTH, Royal Institute of Technology, Stockholm, Sweden.
[81] Sireli, Y.; Kauffmann, P. ; Ozan, E. (2007) : Integration of Kano's Model into QFD for Multiple Product Design, IEEE Transactions on Engineering Management, **54**(2), pp.380-390.
[82] Ting, S.C.; Chen, C.N. (2002): The Asymmetrical and Nonlinear Effects of Store Quality Attributes on Customer Satisfaction, Total Quality Management, **13**(4), pp.547-569.
[83] Tan, K.C.; Xie, M. ; Shen, X.X. (1999): Development of Innovative Products using Kano's Model and Quality Function Deployment, International Journal of Innovation Management, **3**(3), pp.271-286.
[84] Ullah, A.M.M.S.; Tamaki, J. (2010): Analysis of Kano-Model-Based Customer Needs for Product Development, System Engineering, Accepted March 23, 2010, DOI 10.1002/sys.20168.
[85] Ullah, A.M.M.S. ; Tamaki, J. (2009): Uncertain Customer Needs Analysis for Product Development: A Kano Model Perspective, Proceedings of the Sixth International Symposium on Environmentally Conscious Design and Inverse Manufacturing, 7-9 December ,Sapporo, Japan
[86] VonDran, G.M.; Zhang, P.; Small, R. (1999): Quality Websites: An Application of the Kano Model to Website design, Proceedings of the Fifth Americas Conference on Information Systems, August 13-15, 1999.
[87] Vavra, T.G. (1997). Improving Your Measurement of Customer Satisfaction: A Guide to Creating, Conducting, Analyzing and Reporting Customer Satisfaction Measurement Program, ASQC Quality Press, and Milwaukee, WI.
[88] Wang, T. and Ji, P.(2010): Understanding Customer Needs Through Quantitative Analysis of Kano's Model, International Journal of Quality & Reliability Management, **27**(2), pp.173-184.
[89] Willcox, K.; Wekayama S. (2003): Simultaneous Optimization of a Multiple- Aircraft Family, Journal of Aircraft, **41**(4), pp.616-622.

[90] Walley, P. (1991): Statistical Reasoning with Imprecise Probabilities, Chapman & Hall, London
[91] Womack, J.P. ; Jones, D.T. (1996): Lean Thinking: Banish Waste and Create Wealth in Your Corporation, Simon & Schuster, New York, 1996.
[92] Weck, O.L.D.; Suh, E.S.; Chang D. (2005): Product Family Strategy and Platform Design Optimization, Special issue on Product Family Design, MIT Publications, USA.
[93] Xu, Q.; Jiao, R.J.; Yang, X.; Helander, M.; Khalid, H.M.; Opperud, A. (2009): An Analytical Kano Model for Customer Need Analysis, Design Studies, **30** (1), pp.87-110.
[94] Yang, C.C. (2005): The Refined Kano's Model And its Application, Total Quality Management and Business Excellence, **16**(10), pp.1127-1137.

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