

Proceeding Paper

# Investigation of Relationship between Kansei Design Elements of Taiwanese Wooden Furniture and Consumer Demand by Fuzzy Theory <sup>†</sup>

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<sup>†</sup> Presented at the 3rd IEEE International Conference on Electronic Communications, Internet of Things and Big Data Conference 2023, Taichung, Taiwan, 14–16 April 2023.

**Abstract:** This study aimed to investigate the affective Kansei/affective design elements of Taiwanese wooden furniture and the consumer demand and perception for the design using Kansei engineering methodology and fuzzy theory. An online survey was conducted to carry out triangular fuzzy linguistic analysis from fuzzy theory and understand the consumers' demands and perceptions of the design elements of wooden seat shapes. The research results showed that consumers agreed with "sturdy" the most, indicating the element needs to comply with the demand and purchase intention of consumers. In terms of the Kansei design elements of a rectangular seat shape, consumers' agreement on "elegant" was medium, while consumers agreed with "novel" the least. The research results provide the Taiwanese wooden furniture industry and designers with a reference for decision-making, design, and manufacturing.

**Keywords:** wooden furniture; Kansei engineering; fuzzy theory; consumer demand

## 1. Introduction

Facing the ever-changing demands in the consumer market, the furniture industry is urgently seeking how to create and enhance the added value of furniture. Researchers have addressed the current situation of the wooden furniture industry in Taiwan in three major aspects: product materials, production technology, and business philosophy [1]. For product materials, solid wood is used as the main material in the industry. As a retro style obtains popularity in home decoration, the sales of easy-to-process wood furniture continue to grow steadily and account for approximately 50% of the total domestic sales. Wood furniture thus becomes the mainstream of domestic furniture sales [2], and materials for the furniture play an important role in design practice [3].

Human beings attach great importance to feelings. 97% that people's senses are stimulated visually to observe the simulated image [4]. In addition, the appearance of a furniture product attracts consumers and influences their repurchase behavior significantly. It is argued that the functions, aesthetic elements, and design of furniture are important, but, meanwhile, consumers' emotions and demands must also be valued, too, as an important factor [5]. Kansei/affective design explores consumers' minds to abstract perceptual concepts and adds value to the furniture. The development of products with Kansei/affective design is a mandatory development direction in the consumer market with specific Kansei/affective design elements of wooden furniture. Therefore, the application of Kansei/affective design for the wooden furniture design is an issue worth exploring.

At present, Kansei engineering is extensively applied to the Kansei/affective design of products. The Kansei engineering method is used to analyze people's emotional changes and their perception of things, help conduct quantitative analyses of consumer demand,



**Citation:** Lee, A.-S. Investigation of Relationship between Kansei Design Elements of Taiwanese Wooden Furniture and Consumer Demand by Fuzzy Theory. *Eng. Proc.* **2023**, *38*, 64. <https://doi.org/10.3390/engproc2023038064>

Academic Editors: Teen-Hang Meen, Hsin-Hung Lin and Cheng-Fu Yang

Published: 29 June 2023



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and decide the design methods of different design elements based on the customer-centered design concept [6].

This study aims to provide the furniture industry with criteria for the design elements of wooden furniture by applying fuzzy theory to understand consumers' affective perception of wooden furniture. Consumers' perceptions of the Kansei/affective design of Taiwanese wooden furniture are analyzed with the correlation between consumer demand and the Kansei/affective design elements. The design elements reflecting consumers' affective perception can be considered as Kansei/affective design criteria for Taiwanese wooden furniture. Such research result can be used to enhance the business performance of Taiwanese wooden furniture and provides the furniture industry and designers with a reference for decision-making in manufacturing and designing the furniture.

## 2. Literature Review

### 2.1. Wooden Furniture

Compared with other materials such as plastic and steel, wood is a material more appropriate for human life. Wood has excellent insulation and is humidity-proof. It has natural textures and colors which are favored by the public. In addition, it is easy to process. Therefore, wood is used considerably in furniture and home decoration. Research on the American market showed that consumers value environmental protection by purchasing eco-friendly products made of wood [7]. However, wood is imported by many countries. Thus, the wooden furniture industry is vulnerable to the changes in economy, politics, and tariffs. Therefore, the furniture industry is sensitive to consumer demand to have a win-win situation. The furniture industry in Taiwan seeks the concept of innovative design for life. Representative furniture brands in Taiwan emphasize the design concept to value consumers' emotions and needs [5]. Consequently, in developing and designing furniture, functions, and technologies must be valued for aesthetic styles and creativities to compete in the global market. This is an important management direction of the furniture industry in Taiwan [8].

### 2.2. Consumer Demand

Demand drives consumer behavior. Maslow, a psychologist, introduced the concept of a hierarchy of needs, in which needs were classified into five levels of physiological needs, safety needs, love, belonging needs (social needs), esteem, and self-actualization. Nevertheless, demand presents a state of psychological deprivation, and can be divided into needs and wants. Therefore, demands generate consumption to meet the demand of consumers. Consumption is influenced by psychological and substantial factors [9]. Consumers tend to buy items to satisfy their "needs", for example, rice, blanket, and other necessities for their life. These products are purchased according to physiological needs and safety needs. The choice of a product to purchase depends on the demand for the product according to the "consumption value" [10]. Hence, the motivation of consumers' consumption changes by the functions of a product and other factors such as the beauty of a product and emotions for products.

### 2.3. Kansei Engineering

Kansei is the psychological feeling and image generated when a person touches things through the senses. As a psychologically abstract, Kansei in Japanese represents the expression of emotions such as "perception", "feeling", and "impression" [11]. In 1970, Mitsuo Nagamachi, a Japanese scholar, predicted that people would want to satisfy their emotional needs in the age of materialization and civilization. "Kansei" is interpreted as the feeling or image that people have for things, that is, psychological expectation from things [12].

At present, consumers' affective demand is increasing. There has been much research related to Kansei engineering applied to wood which explored the affective imagery of metal, rubber, marble, and wood [3]. The visual features of wood texture by Kansei Engineering were researched [13], and a Kansei engineering evaluation system for furniture design was

constructed [6]. The relationship between floor materials and living space was analyzed [14], and the emotional experience of recliners was investigated based on Kansei/affective design [15]. The previous research results reveal that the applications and methods of Kansei engineering can be used in design evaluation and as a product design method.

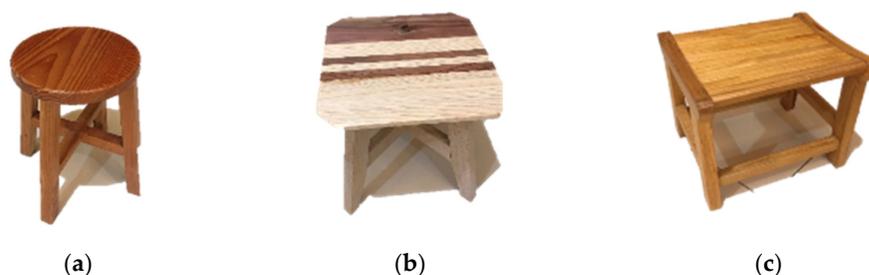
#### 2.4. Fuzzy Theory

Many attributes in real life cannot be precisely explained by traditional concepts due to the existence of fuzziness. The fuzzy theory is thus proposed to deal with fuzzy phenomena. Zadeh first proposed fuzzy sets that were eventually developed into the fuzzy theory to explain the uncertainty and fuzziness of phenomena [16]. A comprehensive fuzzy evaluation is appropriate for what is affected by fuzzy factors and fuzzy transformation and is featured by multiple criteria and ambiguity [17]. The fuzzy theory is used in this research to analyze the Kansei/affective design elements of Taiwanese wooden furniture and the affective perception of consumer demand.

### 3. Research Methodology

The relationship between a decision-making model of the Taiwanese wooden furniture industry and consumers' affective demand was analyzed with Kansei engineering and fuzzy system in this research. Focusing on the design and manufacture of wooden furniture and product shapes in Taiwan, wooden chairs were selected as research objects to explore the Kansei/affective design elements of furniture that meet "consumer demand". Previous literature was reviewed to compile adjectives describing affection, including unique, masculine, futuristic, unconventional, luxurious, fun, modern, crazy, honorable, playful, trendy, distinctive, professional, cute, urban, bold, formal, joyful, splendid, precise, novel, mature, serious, fashionable [18], attractive, fashionable, technical, pleasant, reliable, valuable, convenient, unique, innovative, practical [19], artistic, sturdy, eco-friendly, civilized, rare, elegant, relaxed, harmless, contemporary, high-grade [20], comfortable, stable, soft, relaxed, happy, tall, big, long, perfect, simple, solid, pleasant, hard, pretty, cute, happy, amazing, quiet, cheap, strong, beautiful, and surprising [15]. Experts in furniture design were invited to select the adjectives, and they added the following adjectives: masculine, honorable, playful, novel, attractive, fashionable, artistic, sturdy, elegant, and relaxed.

A complete chair consists of four fundamental elements: backrest, seat, arm, and leg [21]. Among them, seat shapes were chosen for a questionnaire survey and analysis. Appropriate adjectives were selected from the collected adjectives for the seat shape of wooden chairs including round, rectangular, and square (Figure 1). The images of wooden chairs were combined with adjectives. Adopting a convenience sampling method, an online survey was carried out to collect data on consumer demand and perception of the seat shapes of wooden chairs. Maslow classified needs into five levels: physiological needs, safety needs, love and belonging needs, esteem, and self-actualization [22]. low-level physiological needs were first analyzed to identify the connection between the connotation and product design as "the product itself having basic technology or functions, which meet the basic physiological needs of users and satisfy them" [23].



**Figure 1.** Seat shapes of wooden chairs in this research. (a) Round seat (b) Square seat (c) Rectangular seat (The chairs were made by the wood factory of National Chiayi University, and the photos were taken in this research).

In the questionnaire survey, a five-point Likert scale was used. The linguistic fuzziness of the questionnaire items was analyzed by fuzzification mechanism, fuzzy rule base, fuzzy inference engine, and defuzzification [24]. The fuzzy linguistic values were calculated with fuzzy equations to obtain the perception of the Kansei/affective design of wooden chairs by fuzzy evaluation. The values were analyzed to understand the demand of the participants. Triangular fuzzy numbers and the  $\check{J}$  defuzzification equation are described as follows.

$$\text{Assume } \check{J} = (a_1, a_2, a_3), C_{\check{J}} = (a_1 + 2a_2 + a_3) / 4x5 \tag{1}$$

An equation is derived from the fuzzy descriptive statistical equation of the fuzzy questionnaire.

$$C_{\check{J}} = (a_1 + 2a_2 + a_3) / 4x5 \tag{2}$$

Equation (2) is transformed into the fuzzy linguistic mean which is

$$\sum_1^n (a_1 + 2a_2 + a_3) / 4N_x5 (N : \text{number of participants}) \tag{3}$$

Based on the fuzzy equation, the absolute value of utility of each evaluation of the Kansei/affective design element of the shapes of the wooden chair was calculated, and a triangular fuzzy number chart was created for the future analysis of the Kansei/affective design elements.

#### 4. Data Analysis

A convenience sampling method was adopted to design a questionnaire. The online questionnaire was distributed through Google Forms in June and July 2022. 102 questionnaires were retrieved for analysis (Table 1).

**Table 1.** Statistical results of scores of seat shapes of wooden chairs.

	N	Minimum	Maximum	Sum	Mean		Standard Deviation
6-4 Consumers' affective perception and opinion of a round seat shape. [Novel]	102	1.0	4.0	233.0	2.284	0.0716	0.7227
6-2 Consumers' affective perception and opinion of a round seat shape. [Honorable]	102	1.0	5.0	260.0	2.549	0.0820	0.8281
6-6 Consumers' affective perception and opinion of a round seat shape. [Fashionable]	102	1.0	5.0	261.0	2.559	0.0819	0.8274
6-3 Consumers' affective perception and opinion of a round seat shape. [Playful]	102	1.0	5.0	296.0	2.902	0.0898	0.9066
8-9 Consumers' affective perception and opinion of a rectangular seat shape. [Elegant]	102	1.0	5.0	299.0	2.931	0.0851	0.8590
7-6 Consumers' affective perception and opinion of a square seat shape. [Fashionable]	102	1.0	5.0	301.0	2.951	0.0949	0.9583
6-10 Consumers' affective perception and opinion of a round seat shape. [Relaxed]	102	1.0	5.0	391.0	3.833	0.0925	0.9343
8-8 Consumers' affective perception and opinion of a rectangular seat shape. [Sturdy]	102	2.0	5.0	407.0	3.990	0.0830	0.8384
6-8 Consumers' affective perception and opinion of a round seat shape. [Sturdy]	102	2.0	5.0	432.0	4.235	0.0699	0.7061

The mean score of “6-8 Consumers’ affective perception and opinion of a round seat shape is ‘sturdy’” was 4.235, which was the highest. The mean score of “8-8 Consumers’ affective perception and opinion of a rectangular seat shape is ‘sturdy’” was 3.990, which was the second highest. The mean score of “6-10 Consumers’ affective perception and opinion of a round seat shape is ‘relaxed’” was 3.833, which was the third highest. The mean score of “6-3 Consumers’ affective perception and opinion of a round seat shape is ‘playful’” was 2.902, which was the median of the whole score. The mean score of “8-9 Consumers’ affective perception and opinion of a rectangular seat shape is ‘elegant’” was 2.931, which was the median, too. The mean score of “7-6 Consumers’ affective perception and opinion of a square seat shape is ‘fashionable’” was 2.951, which was the median of the next ranking.

The mean score of “6-4 Consumers’ affective perception and opinion of a round seat shape is ‘novel.’” was 2.284, which was the lowest. The mean score of “6-2 Consumers’ affective perception and opinion of a round seat shape is ‘honorable’” was 2.549, which was the second lowest. The mean score of “6-6 Consumers’ affective perception and opinion of a round seat shape is ‘fashionable’” was 2.559, which was the highest.

Descriptive statistics were transformed by the fuzzy theory to obtain the triangular fuzzy linguistic values of consumers’ affective perception. An equation is derived from the fuzzy descriptive statistical equation of the fuzzy questionnaire.

$$C_f = (a_1 + 2a_2 + a_3) / 4x5 \tag{4}$$

Equation (4) is transformed into the fuzzy linguistic mean, that is,

$$\sum_1^n (a_1 + 2a_2 + a_3) / 4N_x5 \tag{5}$$

When  $u(X) = 1$ , the maximum value is 3.20 whereas the minimum value is 1.00. The obtained triangular fuzzy linguistic values and membership function graph of the fuzzy theory are shown in Figure 2. The triangular fuzzy linguistic shows that the triangle is the largest for the mean score (4.235) of “6-8 Consumers’ affective perception and opinion of a round seat shape is ‘sturdy’”, which is the highest, and the weight of the triangular fuzzy linguistic value is also high. The mean score of “8-8 Consumers’ affective perception and opinion of a rectangular seat shape is ‘sturdy’” is 3.990, which is the second highest, and the weight of the triangular fuzzy linguistic value is also the second highest. The mean score of “6-10 Consumers’ affective perception and opinion of a round seat shape is ‘relaxed’” is 3.990, which is the third highest, and the weight of the triangular fuzzy linguistic value is also the third highest. Consumers agreed with “sturdy” for the Kansei/affective design elements of a round seat shape. Therefore, it is necessary to design a “sturdy” chair in the future, and it is suggested that a round shape be used to meet the demand of consumers’ affective perception.

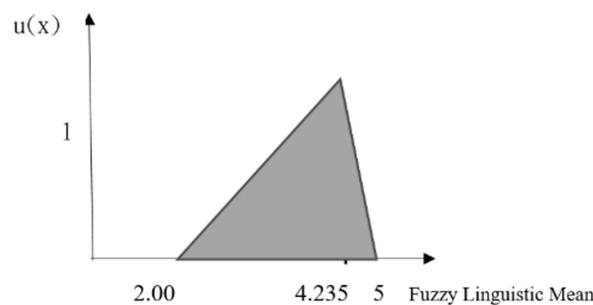
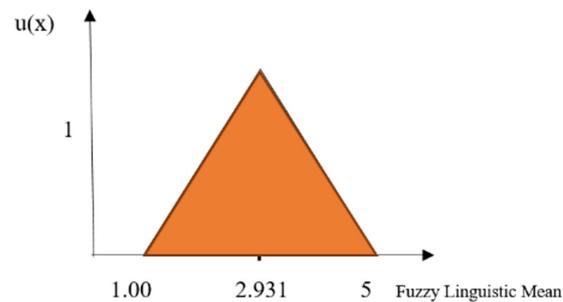


Figure 2. Triangular fuzzy linguistic value (maximum) and membership function graph of “Consumers’ affective perception and opinion of a round wooden chair seat shape is ‘sturdy’.”.

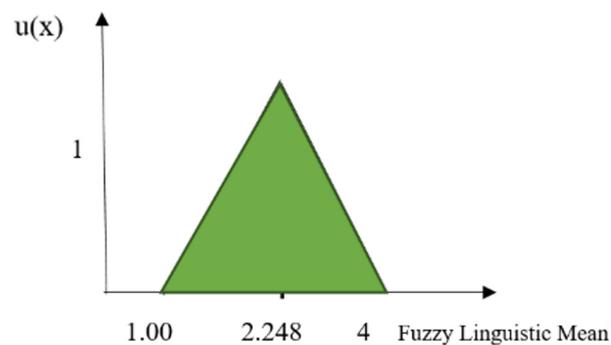
Figure 3 shows that consumers’ agreement on “elegant” is medium in terms of the Kansei/affective design elements of a rectangular seat shape. Hence, it is necessary to

design an “elegant” chair in the future, and it is suggested that a rectangular seat shape be used as the Kansei/affective design element.



**Figure 3.** Triangular fuzzy linguistic value (median) and membership function graph of “Consumers’ affective perception and opinion of a rectangular wooden chair seat shape is ‘elegant’”.

Consumers agreed with “novel” the least in terms of the Kansei/affective design elements of a round seat shape. Thus, designing a “novel” chair seat needs to be considered carefully in the future. A round seat shape may not be used as the Kansei/affective design element (Figure 4).



**Figure 4.** Triangular fuzzy linguistic value (minimum) and membership function graph of “Consumers’ affective perception and opinion of a round wooden chair seat shape is ‘novel’”.

## 5. Conclusions and Suggestions

The Kansei/affective design elements of wooden chairs with different shapes were analyzed to meet consumers’ demands by fuzzy theory. The research result is summarized as follows. Consumers agreed with “sturdy” the most in terms of the Kansei/affective design elements of a round wooden chair seat shape. Therefore, it is necessary to design a “sturdy” chair in the future with a round seat shape to meet the demand and purchase intention of consumers’ affective perception. “Elegant” also needs to be considered to be used as the Kansei/affective design element. However, a “novel” design would not be used for wooden chairs as was agreed on the least.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Acknowledgments:** This research is supported by the National Science Council (NSTC 111-2313-B-415-).

**Conflicts of Interest:** The author declares no conflict of interest.

## References

1. Wang, L.C.; Guan, S.S.; Chen, T.L. A Study on Image and Status Survey of Taiwan Wooden Furniture Industry. *J. Des. Res.* **2011**, *4*, 16–32.
2. Current Situation of Taiwan Furniture Industry. Available online: <http://www.interwood.tw/industryNewsContent.php?ID=83&andln=twzh> (accessed on 12 May 2023).
3. Hsiao, K.A. The Affective Images between Shapes and Materials. *Kaohsiung Norm. Univ. J. Sci. Technol.* **2018**, *45*, 21–42.
4. McKellar, P. *The Investigation of Mental Images*; Penguin Science Survey: Harmondsworth, UK, 2006.
5. Wang, L.C. A Study on Design Image Analysis of Taiwan Furniture Cultural and Creative Brands. *J. Des. Res.* **2018**, *11*, 37–55.
6. Chen, M.; Lyu, J.H.; Li, S.G.; Wu, X. Construction and implementation of a panel furniture design evaluation system at the design stage. *Adv. Mech. Eng.* **2017**, *9*, 1–8. [[CrossRef](#)]
7. Roper Green Gauge Report Summary Brochure. Available online: [http://www.scjohnson.com/Libraries/Download\\_Documents/SCJ\\_and\\_GfK\\_Roper\\_Green\\_Gauge.sflb.ashx](http://www.scjohnson.com/Libraries/Download_Documents/SCJ_and_GfK_Roper_Green_Gauge.sflb.ashx) (accessed on 12 May 2023).
8. Fong, W.C.; Chen, T.L. The Influences of the Bauhaus style on Furniture Design in Taiwan: Using the Furniture Brand “TW.U.C.M.” as an Example. *Int. J. Des.* **2019**, *24*, 17–40.
9. Liu, S.N.; Chu, W.C. A Study on Customers’ Recognition and Demand for Aromatherapy. *J. Beauty Technol.* **2009**, *6*, 43–61.
10. Sheth, J.N.; Newman, B.I.; Gross, B.L. Consumption values and market choice: Theory and application. *J. Mark. Res.* **1991**, *29*, 487–489.
11. Chen, K.S. Kansei Engineering. *Qual. Mon.* **2009**, *45*, 21–22.
12. Chen, K.S.; Guan, S.S.; Deng, Y.S.; Chang, Y.M. Kansei Engineering—A Method of Rationalizing Sensibility. *Ind. Des.* **2001**, *29*, 2–16.
13. Yanfeng, M.; Huiyuan, G. Research on Visual Characteristics about Wood Mountain Peak Texture Based on Kansei Engineering. *Furnit. Inter. Des.* **2013**, 58–60. (In Chinese)
14. Akiyama, A.; Araki, Y.; Hosoya, S. Research into the Relationship between Floor Materials and Living Spaces as Revealed by KANSEI Evaluations. *Int. J. Affect. Eng.* **2017**, *16*, 113–120. [[CrossRef](#)]
15. Kim, W.; Ko, T.; Rhiu, I.; Yun, M.H. Mining affective experience for a Kansei/affective design study on a recliner. *Appl. Ergon.* **2019**, *74*, 145–153. [[CrossRef](#)] [[PubMed](#)]
16. Zadeh, L.A. Fuzzy sets. *Inf. Control* **1965**, *8*, 338–353. [[CrossRef](#)]
17. Chen, W.L.; Chen, T.H. Applying Fuzzy Theory for Design Evaluation of the Gentleman Fashion Design—A Case Study on POLO Shirts. *Taiwan Text. Res. J.* **2016**, *20*, 64–73.
18. Chen, W.L.; Lin, J.J.; Shen, M.C.; Chang, S.M. A Study on the Relationship between Product Form and Image Perception for Personal Digital Assistant. *J. Prof. Mech. Eng.* **2008**, *1*, 38–45.
19. Guo, F.; Qu, Q.X.; Nagamachi, M.; Duffy, V.G. A proposal of the event-related potential method to effectively identify Kansei words for assessing product design features in Kansei engineering research. *Int. J. Ind. Ergon.* **2020**, *76*, 102940. [[CrossRef](#)]
20. Wan, Q.; Li, X.; Zhang, Y.; Song, S.; Ke, Q. Visual perception of different wood surfaces: An event-related potentials study. *Ann. For. Sci.* **2021**, *78*, 25. [[CrossRef](#)]
21. Mortenson, M.E. *Geometric Modeling*; John Wiley and Sons: New York, NY, USA, 1985; pp. 450–451.
22. Maslow, A.H. A theory of human motivation. *Psychol. Rev.* **1943**, *50*, 370. [[CrossRef](#)]
23. Chen, T.Y.; Wu, C.H.; Chen, Y.M. A Maslow’s Hierarchy of Needs-based Networking Reviews Analysis Mechanism for Product Positioning. *J. e-Bus.* **2015**, *17*, 393–422.
24. Klir, G.J.; Yuan, B. *Fuzzy Sets and Fuzzy Logic: Theory and Application*; Prentice Hall: Hoboken, NJ, USA, 1995.

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