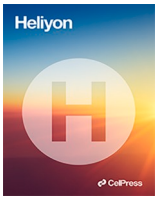
Heliyon 10 (2024) e29129

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

Emotional matching model construction of the interior interface form of age-friendly housing in Jinan city examined using Kansei engineering

Feng Wang [a,b], Isarachai Buranaut [b], Bo Zhang [a], Jie Liu [c,*]

[a] School of Art Design, Shandong Youth University of Political Science, Jinan, Shandong Province, China
[b] Faculty of Decorative Arts, Silpakorn University, Bangkok, Thailand
[c] Qilu Normal University, Jinan, Shandong Province, China

ARTICLE INFO

Keywords:
Quantitative transformation model
Form
Emotional needs
Age-friendly design
Kansei engineering

ABSTRACT

To better meet the emotional needs of older residents and to improve the design of age-friendly indoor interface forms, this study uses Kansei engineering as the theoretical basis for an exploration of the mapping relationship between emotional needs and interface forms. First, we collected spatial interface forms through in-home research, and using focus groups, we summarized and produced test samples for interface forms; at the same time, we screened out adjective word pairs that could fully represent the emotional needs of older people in the city of Jinan, drawing on expert interviews; then, we invited 500 older adults living in Jinan all year to evaluate each interface form using representative adjective word pairs as the emotional evaluation criteria, following the semantic differential method. Subsequently, the participants were invited to evaluate and score the interface form samples using representative adjective word pairs as the standard of emotional evaluation, employing the semantic differential method. Finally, the evaluation scores were input into SPSS software for the Kruskal–Wallis test to explore the relationships between various interface forms and emotional needs. The experimental results showed that the assessment scoring results for each interface form in each set of pairs of adjectives that differed significantly, where each interface had a clear emotional tendency. This study successfully established a mapping model for matching indoor interface forms with emotional needs in age-friendly housing in Jinan. These findings can provide a reference for future practice of designing residential indoor interface forms to match the emotional needs of older people in Jinan.

1. Introduction

The practice of imbuing architectural spaces with emotion can often elevate general construction to a creative design activity [1]. From the perspective of Environmental Psychology, the concept of affective spatial design refers to spatial design works that acknowledge and prioritize the psychological requirements of those who occupy and use them. This approach underlines the significance of empowering individuals in shaping their own perceptions of their surroundings [2]. The core focus of Positive Psychology is on the subjective psychological needs of space users. It aims to ignite an individual's internal psychological drive, integrating findings

* Corresponding author.
E-mail address: 20188528@qlnu.edu.cn (J. Liu).

https://doi.org/10.1016/j.heliyon.2024.e29129
Received 14 December 2023; Received in revised form 21 March 2024; Accepted 1 April 2024
Available online 4 April 2024

from sociological research, including quantitative data and statistical analysis, with insights from cognitive psychology and neuroscience. This interdisciplinary approach seeks to uncover both the internal and external influences on human emotional satisfaction, as well as strategies for external interventions to enhance this [3]. Empirical analyses into this theory have demonstrated that external environments that align with an individual's emotional needs can sustainably nurture a positive state of mind [4]. Professor M. Powell Lawton, notable for his contributions to psychology and gerontology, evaluates Environmental Gerontology. His research explores the physical and psychological requirements and adaptive capabilities of older people in relation to their environments. He advocates for the creation of age-friendly spaces that thoroughly respect and leverage the proactive engagement of the older people, urging for environments that are designed with the elderly's specific physical and psychological needs in mind. This approach not only acknowledges but also emphasizes the importance of involving the older people in the spatial design process, catering to their unique needs [5]. The process of aging is associated with declines in certain physiological and psychological capacities. However, regarding emotional needs, Professor Laura L Carstensen, a psychologist and proponent of the Socioemotional Selectivity Theory, observes that older people do not follow a simple declining pattern as they age. Instead, the emotional requirements of adults tend to remain stable or even increase over time [6,7], a phenomenon described as the "Paradox of Aging [8]." Elderly prioritize emotional needs more compared to other personal needs and are more inclined to employ emotional strategies in problem-solving. Aging thus leads to a recalibration of objectives, with emotional objectives gaining precedence. This shift highlights the importance of aligning living environments with the emotional needs of older people to foster more positive subjective evaluations of their living spaces.

The most direct and frequent emotional evaluation of residential spaces by older people is directed toward their interior interfaces. The form of the interface is the most fundamental component of interface design [9]. In the field of architectural design, the form of interface refers to the expression of the internal skin form of a building, acting as a crucial tool for architects to convey the essence and purpose of spaces through their designs. Present practices in architectural space design advocate for surpassing previous standards in art and technology in the field, yet there appears to be a reduced focus on understanding and addressing the emotional requirements of the general populace. The theories surrounding everyday architectural aesthetics, along with the cognitive and emotional strategies towards aesthetics introduced by the American environmental aesthetician Allen Carlson in the early 21st century, highlight the aesthetic differences between professional architects, critics, and those who occupy buildings without a background in architecture [10]. In addition, the framework for aesthetic experience developed by Leder and his team at the Department of Psychology at the University of Vienna, Austria, in their research into the psychological and biological underpinnings of aesthetics—termed neuroaesthetics—more accurately indicates that in the innate aesthetic judgement process of an individual lacking professional artistic expertise, the brain's activity is grounded in sensory analysis and the integration of implicit memory, centered around emotional evaluation. The result is a positive aesthetic feeling and an indistinct aesthetic judgement [11]. This insight into the aesthetic mechanism highlights the importance and practicality of envisioning the emotional design of architectural spaces with the emotional needs of the users in mind [12]. The significance of addressing the emotional needs of older people is garnering more attention.

Typically, as shown in Fig. 1, the design process initiates with a verbal description of these emotional requirements by the consumer [13]. Designers then interpret these verbal cues into design concepts based on their understanding. This process usually necessitates several iterations for the designer to fully understand the consumer's needs. Following this first stage of communication, the following phase involves computer-aided design, which brings various spatial concepts to life through computer simulations. These are then reviewed by the consumer for either approval or suggestions for changes. Should the proposals not meet the consumer's expectations, a cycle of re-evaluation and redesign ensues, often requiring the process to start afresh. This cycle continues until a design solution secures the consumer's final nod. in the prevailing design methodology, the creation of the design concept is heavily influenced by the designer's personal judgement and experience. This can lead to significant discrepancies between the designed solution and the consumer's original requirements. Moreover, this approach typically demands extensive back-and-forth communication and continuous tweaks to the design, which can be both time-consuming and financially burdensome. The more effective translation of customers' emotional needs into design elements is an important question in design fields.

Kansei engineering theory provides a more reliable approach to this transformation process [2,14]. Entering the 21st century, the

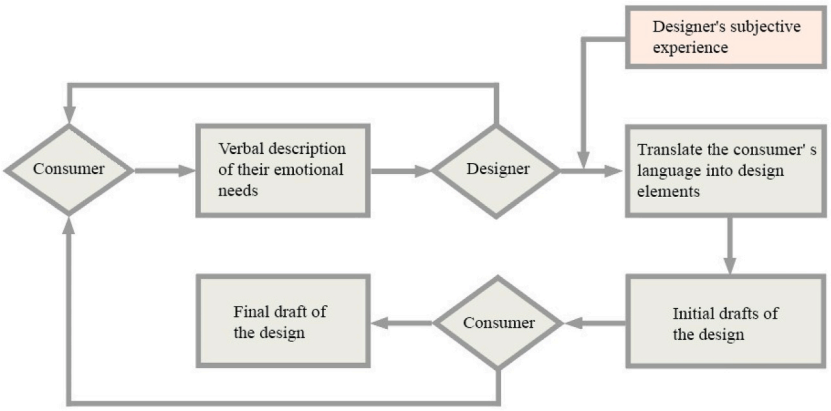


Fig. 1. Flowchart of existing design model.

global design landscape has evolved, embracing a more holistic view that extends beyond mere functionality and quality to include the emotional resonance of products. This shift has motivated the growth of Kansei Engineering, a significant movement in contemporary design practices. The concept of the Kansei engineering system was originally proposed by Nagamachi [15,16] to quantify human emotional needs and establish a mapping relationship between the quantity of emotional needs and the physical quantity (form) of a stimulus that triggers emotional perception [17]. In other words, Kansei engineering quantifies the customer's emotional needs and accurately translates them into design elements [6,7]. Kansei engineering stands as a methodology that steers design outputs towards aligning with the emotional aspirations of consumers, marking a significant stride in the field of design. The successful application of Kansei engineering hinges on the accurate acquisition and analysis of consumer emotional responses specific to the design in question. This involves a structured approach to gathering psychological data.

As shown in Fig. 2, Nagamachi divides Kansei engineering into three main steps [18]: 1. stimulation test sample selection, 2. Kansei word selection (extraction of emotional dimensions), and 3. emotional evaluation and the construction of mapping relationships. Affective expressions are quantified using Kansei words, and relationships are identified with design elements [19]. In most Kansei engineering studies, the design of the form has formed the core of the analysis.

The first thing that is needed for the design of the form is the production of test samples. This study focuses on the interface form of age-friendly residential space. The design elements of the space interface form contain three main interfaces: top, side, and bottom. Most mainstream civil space interior design schemes promote a human-centered design concept [20]. This is especially the case for age-friendly residential interior design. Design of the interface form design should, therefore, pay closer attention to the physiological and psychological characteristics of elderly owners. Physiologically, older people exhibit different degrees of decline phenomenon [21]. Among these are the decline of lower limb strength, leading to difficulties in coping with changing height differences at the bottom interface (e.g., going up and down the stairs) in the daily life of older people [22]. Changes in the bottom interface are often the main trigger for accidental falls in older adults. Therefore, the bottom of an age-friendly interior space should remain the same as far as possible [23]. At the same time, the deterioration of the eyesight causes difficulties for older people in distinguishing smaller shapes and observing a narrow range of things simultaneously [24]. At present, most houses in China are unit-type houses [25]. The limited dimensions of the openings and the depths of the single spatial planes in these types of dwelling make it impossible for older people to recognize the overall shape of the space when the viewing distance is increased. In other words, due to the limitations of space and vision loss, it is difficult for older people to observe both the top and side interfaces of the residential space in their daily life. Therefore, test samples of interface forms in this study focus only on interface forms that account for a more significant portion of the top and side interfaces. The test samples of the two types of interfaces are produced separately to maximize the simulation of the actual observation perspective of older adults' daily life at home.

Extracting emotional dimensions is another essential component of Kansei engineering. Many scholars have explored emotional dimension extraction: Yu-Ming Chang et al. examined the semantic cognition of steering wheel styling design [26]; Paolo Caratelli et al. summarized the semantic preferences of interior spaces with special functions [27]; and Lai et al. collected extensive information on the emotional needs [28]. These explorations extracted emotional dimensions using perceptual adjective word pairs with explicit emotional intentions, providing a good foundation for subsequent mapping model building. However, the wide range of user objects thus defined has reduced the relevance of the mapping models that were built by these studies. Studies have shown that people with similar backgrounds tend to have similar emotional perceptions of the same things [29]. The emotional needs of people of different backgrounds are influenced by their different ages and geographies, and they tend to have different emotions for the same things [30].

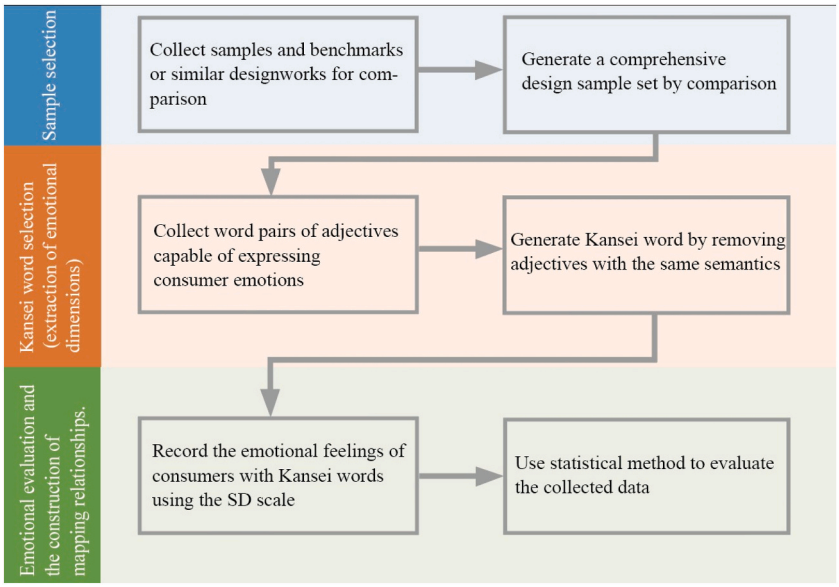


Fig. 2. Flowchart of main work process in Kansei engineering.

Some other scholars began to conduct research on Kansei engineering for the specific styling preferences of particular groups of people: for example, Yoon et al. limited the research object to youth in China and examined the interior styling preference of automobiles that were suitable for this group [31]; Dewi limited the research object to rehabilitated patients following a stroke and investigated the styling design of rehabilitated bicycles [32]; Chen et al. conducted a study of home professional women's vests [33]; and Li et al. conducted a survey of collar design in professional women's clothing [34]. Thus, Kansei engineering research on styling design can be targeted at specific populations or single attribute spaces [35], and it can use a quantitative approach to establish a model of the relationship between the features of product styling and semantic features. This mathematical model is beneficial for designers seeking to develop design strategies.

However, it is worth noting that most current studies need to filter the dimensions of user emotions, as dealing with them all will result in information that is too cumbersome, leading to an excessively long research time, which is not friendly to elderly groups. This may lead to a decrease in the accuracy of the results. Thus, the number of emotional dimension reviews in the extraction of emotional dimensions must be minimized while the emotional needs are adequately represented. Complex emotional needs can be streamlined into a few most representative need features. In this paper, we streamline the requirements for the form of the interface using the Delphi method to reduce the burden in an invited official Semantic differentials (SD) test for older people in Jinan.

This study establishes a mapping relationship between the interface forms that account for a relatively large area in the interior side and the top interfaces of age-friendly residences in Jinan City with the emotional needs of older people in the region using a Kansei engineering approach. The two main objectives were: (1) to collect and summarize the primary forms of interface shapes in the residential spaces of older adults in Jinan; (2) to try to construct a model of the mapping relationship between the top interface forms, the side interface forms, and the semantics of preferences. Ultimately, it may come to provide an operational reference for the design of interior interface forms that match the emotional needs of older people in Jinan.

2. Method

2.1. Ethics statement

This study was approved by the Ethics Committee of the School of Art Design, the Shandong Youth University of Political Science (APPROVAL NUMBER: 01,030,023). All the work in this study follows the procedures approved by the committee. All participants provided informed consent to participate in the study.

2.2. Experimental procedure for emotional matching model construction

As shown in Fig. 3, this study adopts Kansei engineering methods, segmenting the study into three processes. 1. stimulation test sample selection, 2. Kansei word selection, and 3.emotional perception assessment of appearance data.

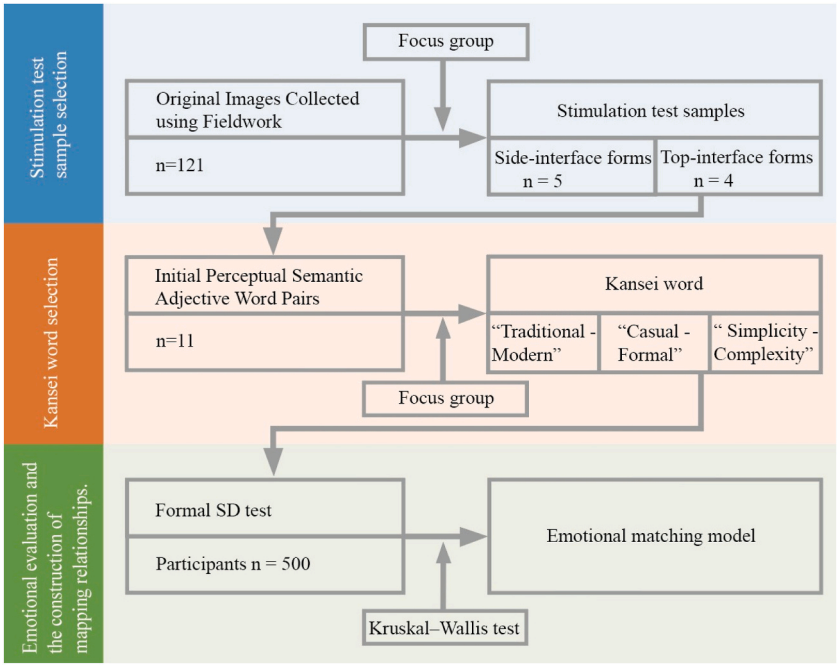


Fig. 3. Flowchart of the emotion matching model building experiment.

2.3. Stimulation Test Sample Selection

In any design process, the method that enables the designer to create a suitable image for the design work to allow it to be communicated to the user and the way in which it thus is communicated are always the critical issue [36]. For this study, original images of spatial interface forms in older people's housing were collected through fieldwork.

Photography was used to record random field observations of the interiors of 70 homes of Jinan seniors. Fig. 4 presented 121 samples. Of these, representative samples were selected using focus groups study.

The focus group was composed of seven industry design specialists comprised the focus team; these were five men and two women with postgraduate degrees specializing in architectural, spatial, and visual communication design with more than five years of practical design experience. The focus group categorized test samples by visual appearance. Fig. 5 depicts five side-interface forms and four top-interface forms.

Final simulation of test sample production. We created separate samples for the side and top interfaces to maximize the natural appearance of the images to the field of view of seniors living at home [14]. We made independent samples for the side and the top interfaces. As shown in Fig. 6, according to the nine kinds of interface forms extracted, five test samples of side-interface forms (A1–A5) and four test samples of the top-interface forms, named A1-A5, were produced. Because the design elements of this research regard the forms of interfaces, the test samples are uniformly de-colored.

2.4. Kansei Word Selection

First, we collected a wide range of emotional adjective word pairs. Drawing on various channels. including the market and relevant forums, 31 pairs of perceptual adjective word pairs (Table 1) were collected as emotionally descriptive vocabulary used to describe age-friendly spatial modeling; following this, focus groups were convened to identify adjective word pairs according to the denotations.

Pairs of adjectives with similar meanings were grouped into six clusters, as shown in Table 2. The most representative adjective word pairs extracted from each category of the adjective word pair clusters were: "Traditional - Modern"; "Simplicity–Magnificence"; "Warm–Cold"; "Crowded–Broad"; "Casual–Elaborate"; and "Normal–Specific." The Delphi method is a structured technique for decision-making. It is used to collect messages, opinions, or insights from specialists making independent, repeated, and subjective judgments. The word pairs that had a clear tendency toward imagery that is most closely related to the form of the interface in residential interiors were retained. Experts generally agreed that the "Crowded–Broad" visual impression was primarily influenced by the size of the space and the placement of late–career furnishings, while the "Warm–Cold" visual impression is more related to the color of

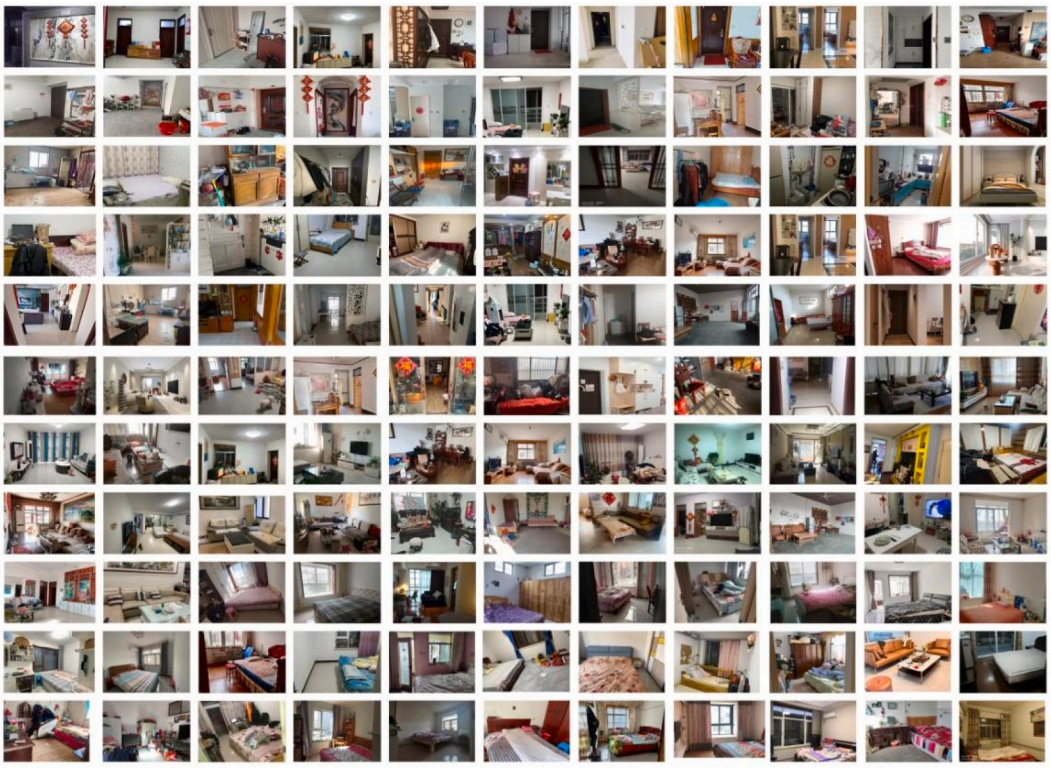


Fig. 4. Original Images Collected using Fieldwork.

Fig. 5. Categorization of similar interface forms.

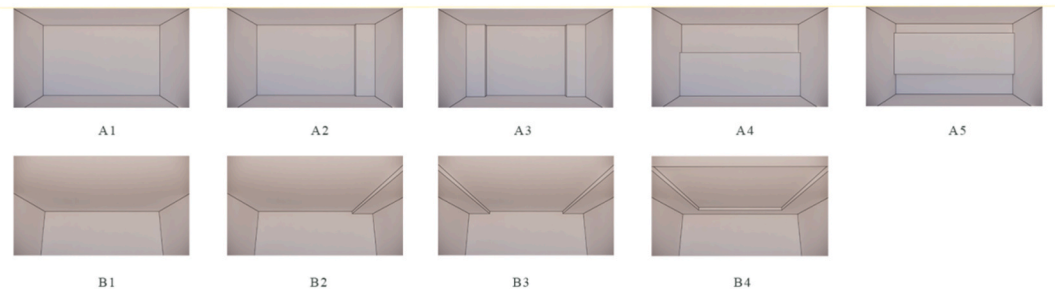


Fig. 6. *Stimulation Test Samples*.

Table 1
Initial perceptual semantic adjective word pairs.

Thirty-one contrasting pairs of adjectives				
Traditional - Modern	Basic - Gorgeous	General - Particular	Thrift - Luxury	Mass - Niche
Understatement - Showy	Retro - Trendy	Astringent - Exuberant	Nostalgia - Neophilia	Casual - Elaborate
Depression - Openness	Quaint - Updated	Lively - Silent	Crowded - Broad	Warm - Cold
Narrow - Spacious	Natural - Abrupt	Antiquity - Avant-garde	Warmth - Sanity	Common - Rare
Constraints - Freedom	Cleanliness - Clutter	Old-fashioned - Forward-thinking	Familiar - Novel	Mild - Sensible
Normal - Specific	Squeeze - Stretch	Classical - Contemporary	Plain - Magnificent	Natural - Artificial
Simplicity - Complexity				

Table 2
Acquisition of representative contrasting pairs of adjectives.

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Cluster 6
Traditional - Modern	Simplicity - Complexity	Warm - Cold	Crowded - Broad	Casual - Formal	Normal - Specific
Classical - Contemporary	Basic - Gorgeous	Mild - Sensible	Depression - Openness	Natural - Artificial	Mass - Niche
Nostalgia - Neophilia	Cleanliness - Clutter		Narrow - Spacious	Arbitrarily - Elaborate	Natural - Abrupt
Old-fashioned - Forward-thinking	Understatement - Showy		Squeeze - Stretch	Random - Official	General - Particular
Retro - Trendy	Plain - Magnificent				Common - Rare
Quaint - Updated	Thrift - Luxury				Familiar - Novel
Antiquity - Avant-garde	Constraints - Freedom				
	Astringent - Exuberant				

the interface and the local climate. These two adjective pairs were therefore eliminated first. At the same time, most of the experts believed that age-friendly spaces should generally try to continue previous spatial impressions of older people, especially because the relatively fixed interface form is only suitable to undergoing a few changes in the particular design. Therefore, the visual impression of "Normal–Specific" is not representative for selecting interface forms for elderly residential spaces (Table 2). The acquisition of representative contrasting pairs of adjectives.

Finally, we extracted three pairs of perceptual adjective pairs: "Traditional - Modern," "Casual - Formal," and "Simplicity - Complexity." These were the most representative for the semantic preferences of Jinan seniors in their interior interface styling and are used as the evaluation criteria of affective dimensions (Kansei word) in the formal SD test for subsequent exploration of the Kansei engineering model.

2.5. Emotional evaluation and the construction of mapping relationships

An SD test was conducted with 500 older adults over 60 who were year-round residents of Jinan to identify the relationship between their residential interior interface styling and their emotion perception vocabulary. These 500 participants had good visual acuity and could easily discriminate among a relatively large number of interface designs. We used adjective word pairs (Kansei word) that passed screening for eventual use in the SD test, and the test criteria randomized the images of the test samples for the participants. We individually assessed all of the test samples using a 7-point Likert scale (ranging from −3 to 3). The data from the SD assessment were subject to analysis using SPSS software to determine whether there were significant differences between interface forms with different adjective semantics of the same type and to verify the feasibility of the model.

3. Results

We used three semantic criteria for the formal SD testing and used them to conduct SD tests on two types of interface forms (side-interface forms and top-interface forms). There were six groups in total, and the results were as follows.

As shown in Table 3, the normality test was performed on the summarized data of the six groups of semantic tests. The results for each data group were significant ($P < 0.05$), and the data groups did not obey normal distribution. For this reason, the Kruskal–Wallis test was performed on these data.

This study employed Kruskal-Wallis H test to investigate the differences in score distributions among six groups (two types of background interface forms: side-interface forms and top-interface forms) for three SD semantic test criteria. As shown in Table 4, this test is suitable for non-parametric data and aims to determine whether there are differences in the overall medians of three or more independent samples.

The test results indicate that all six groups significantly reject the null hypothesis of identical score distributions within each group, showing statistically significant differences in score distributions for all six groups. To assess the practical significance of the test results, the effect size (η^2) were further calculated for each group. Effect size is a measure of the magnitude of an effect and possesses properties such as independence from measurement units, monotonicity, and independence from sample size. Effect size can address issues where P-values fail to capture the magnitude of relationships and differences and can also mitigate “P-value manipulation" phenomenon. The effect size for the Kruskal-Wallis H test is calculated using the following Equation.

$$E_R^2 = \frac{H}{(n^2 - 1)/(n + 1)}$$

As shown in Table 4, the effect sizes for all groups are greater than 0.5, ranging from 0.581 to 0.765. These high effect size values

Table 3
Tests of normality.[a].

Adjective pairs in SD test	Interface form	Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Traditional - Modern	A1	0.155	500	0.000	0.914	500	0.000
	A2	0.227	500	0.000	0.845	500	0.000
	A3	0.308	500	0.000	0.774	500	0.000
	A4	0.183	500	0.000	0.887	500	0.000
	A5	0.294	500	0.000	0.764	500	0.000
Casual - Formal	A1	0.309	500	0.000	0.771	500	0.000
	A2	0.197	500	0.000	0.915	500	0.000
	A3	0.342	500	0.000	0.737	500	0.000
	A4	0.204	500	0.000	0.910	500	0.000
	A5	0.214	500	0.000	0.905	500	0.000
Simplicity - Complexity	A1	0.228	500	0.000	0.834	500	0.000
	A2	0.182	500	0.000	0.917	500	0.000
	A3	0.200	500	0.000	0.906	500	0.000
	A4	0.188	500	0.000	0.920	500	0.000
	A5	0.255	500	0.000	0.815	500	0.000
Traditional - Modern	B1	0.282	500	0.000	0.790	500	0.000
	B2	0.208	500	0.000	0.900	500	0.000
	B3	0.193	500	0.000	0.922	500	0.000
	B4	0.318	500	0.000	0.762	500	0.000
Casual - Formal	B1	0.193	500	0.000	0.905	500	0.000
	B2	0.296	500	0.000	0.779	500	0.000
	B3	0.200	500	0.000	0.922	500	0.000
	B4	0.250	500	0.000	0.815	500	0.000
Simplicity - Complexity	B1	0.204	500	0.000	0.861	500	0.000
	B2	0.200	500	0.000	0.911	500	0.000
	B3	0.211	500	0.000	0.914	500	0.000
	B4	0.224	500	0.000	0.855	500	0.000

[a] . Lilliefors Significance Correction.

Table 4
Test statistics.[a].

Grouping Variable	A(Traditional - Modern)	A(Casual - Formal)	A(Simplicity - Complexity)	B(Traditional - Modern)	B(Casual - Formal)	B(Simplicity - Complexity)
Kruskal– Wallis H	1453.695	1904.656	1815.338	1438.483	1530.755	1421.708
df	4	4	4	3	3	3
Asymp. Sig.	0.000	0.000	0.000	0.000	0.000	0.000
Effect Size	0.581	0.762	0.726	0.719	0.766	0.711

[a] Kruskal–Wallis Test.

indicate that the differences in score distributions among categories significantly contribute to the total variation.

The significance of Kruskal-Wallis H test results along with the high effect sizes collectively indicate notable differences in score distributions among categories within each group. This implies statistically distinctions in scores between different categories, and these variations have important practical implications.

As shown in Table 5 and Fig. 7, look at the median scores for each sample to compare the differences between the samples. The results for the differences in the side-interface forms under different semantic criteria are as follows: under "Traditional–Modern," the sideinterfaces are evaluated as A3 < A1 < 0 < A4 < A2 < A5; under "Casual–Formal," the corresponding evaluation results for the side interfaces are: A1 < A2 < A5 < 0 < A4 < A3; for "Simplicity–Complexity," the evaluation results for the side interfaces are: A1 < A2 < A4 < 0 < A3 < A5.The results for the differences in top-interface forms under different semantic criteria are as follows: under "Traditional–Modern," the evaluation results for the top-interface are: B1 < 0 < B3 < B2 < B4; under "Casual–Formal," the evaluation results of the top-interface are: B2 < B1 < 0 < B3 < B4; under "Simplicity–Complexity," the evaluation results of the top-interface are: B1 < B2 < 0 < B3 < B4.

These above results indicate a mapping of the linguistic meaning of the adjective-adjective pairs between the various interfaces and sensual needs.

1. The most Traditional side-interface and top-interface forms are A3, A1, and B1. Correspondingly, the forms identified as Modern side-interface forms and top-interface forms are A5, A2; A4; B4, B2; B4, B4; B4; B4; B4; B2; B4, A4; B4, B2, B3.
2. Casual side-interface forms, and top-interface forms are recognized as A1, A2, A5; B2, B1. Correspondingly, the most Formal form are side-interface forms; the top Formal interface forms are A3, A4, B4, and B3.
3. The side interfaces and top interfaces with the most Simplicity are: A1, A2, A4; B1, B2. Corresponding to this, the side interfaces and top interfaces with the most Complexity are A5, A3, and B4, B3, respectively.

Table 5
Percentiles.

Kansei word in SD test	Interface form	Percentiles						
		5	10	25	50	75	90	95
Traditional - Modern	A1	−3.00	−3.00	−2.00	−1.00	0.00	2.00	2.95
	A2	−1.00	0.00	1.00	2.00	3.00	3.00	3.00
	A3	−3.00	−3.00	−3.00	−3.00	−2.00	−1.00	−1.00
	A4	−2.00	−1.00	0.00	1.50	3.00	3.00	3.00
	A5	1.00	1.00	2.00	2.00	3.00	3.00	3.00
Casual - Formal	A1	−3.00	−3.00	−3.00	−3.00	−2.00	−1.00	−1.00
	A2	−3.00	−2.00	−2.00	−1.00	0.00	0.00	1.00
	A3	1.00	1.00	2.00	3.00	3.00	3.00	3.00
	A4	−1.00	0.00	0.00	1.00	2.00	2.00	2.00
	A5	−2.00	−2.00	−1.00	−1.00	0.00	1.00	1.00
Simplicity - Complexity	A1	−3.00	−3.00	−3.00	−2.00	−2.00	−1.00	−1.00
	A2	−3.00	−2.90	−2.00	−1.00	0.00	0.00	1.00
	A3	0.00	0.00	1.00	1.00	2.00	3.00	3.00
	A4	−2.00	−2.00	−1.00	−1.00	0.00	1.00	1.00
	A5	1.00	1.00	2.00	2.00	3.00	3.00	3.00
Traditional - Modern	B1	−3.00	−3.00	−3.00	−2.00	−2.00	−1.00	−1.00
	B2	0.00	0.00	1.00	1.00	2.00	3.00	3.00
	B3	−1.00	−1.00	0.00	1.00	1.00	2.00	2.00
	B4	1.00	1.00	2.00	3.00	3.00	3.00	3.00
Casual - Formal	B1	−3.00	−3.00	−2.00	−1.00	−1.00	0.00	0.00
	B2	−3.00	−3.00	−3.00	−2.00	−2.00	−1.00	−1.00
	B3	−1.00	−1.00	0.00	1.00	1.00	2.00	2.00
	B4	1.00	1.00	2.00	2.00	3.00	3.00	3.00
Simplicity - Complexity	B1	−3.00	−3.00	−3.00	−2.00	−1.00	−1.00	0.00
	B2	−3.00	−2.00	−2.00	−1.00	0.00	0.00	1.00
	B3	−1.00	0.00	0.00	1.00	2.00	2.00	2.95
	B4	0.00	1.00	1.00	2.00	3.00	3.00	3.00

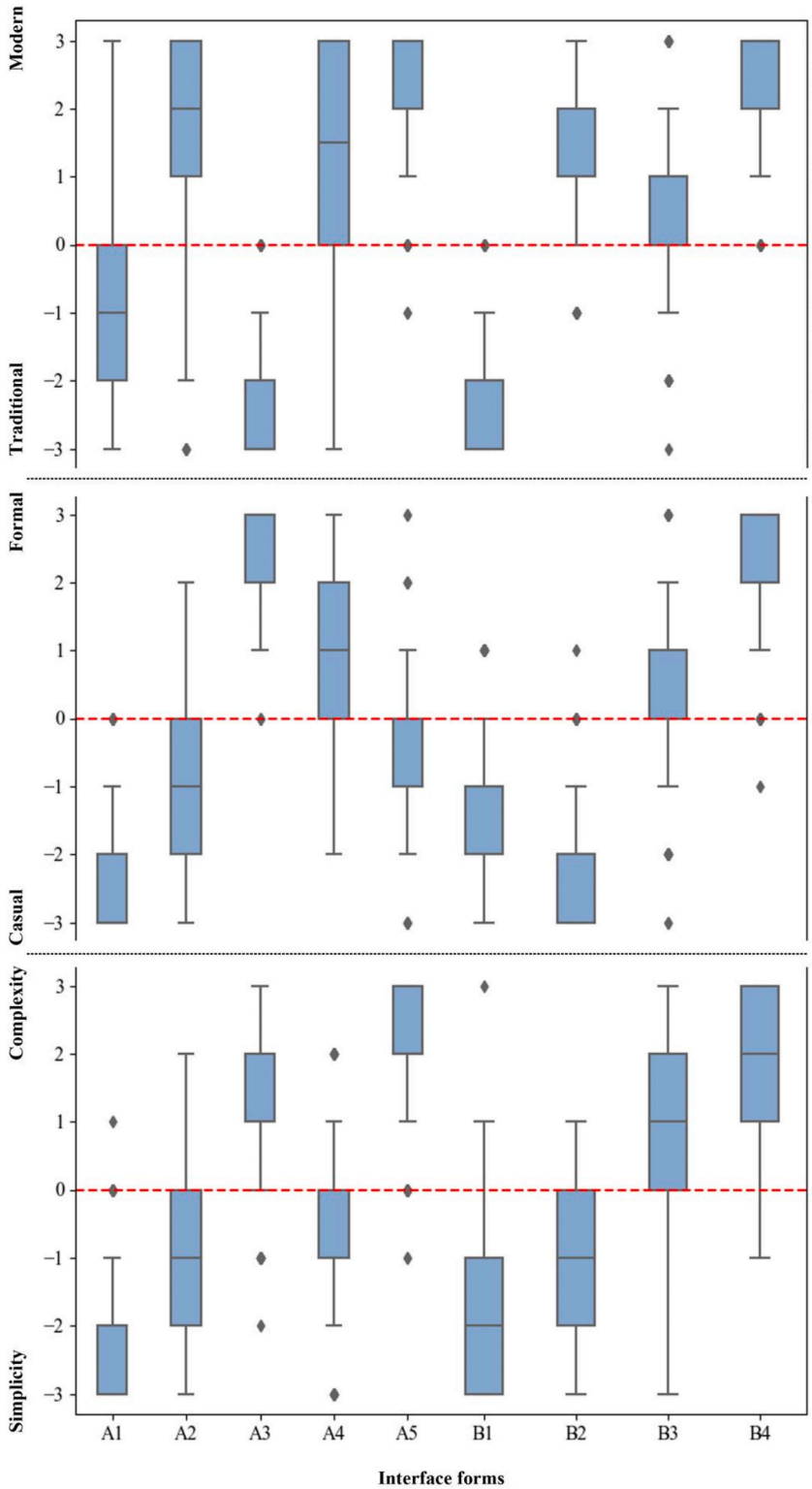


Fig. 7. Box plot of SD experiment results.

4. Discussion

Adopting a Kansei engineering approach, this study explores the interrelationship between interface forms and the emotional needs of older people in age-friendly residential spaces in the city of Jinan. First, the common side and top-interface forms of residential spaces for older people in Jinan were summarized. Following this, three sets of adjective word pairs that best represented the emotional needs of older people in Jinan regarding interface forms were screened out. This study established a transparent matching model between interface forms and the emotional needs of older people in Jinan.

Confucianism has had a far-reaching influence in China, as well as in the region more broadly. Jinan is located in Shandong Province, the home of Confucius, and it has always been focused on the inheritance and development of Confucianism. The main aesthetic idea of Confucianism is "the center is honored" [37]. This was also a long-standing consensus in ancient societies across the region and even in most of China, and the use of symmetrical interior interfaces has endured for a long time as a symbol of traditional rituals. Therefore, as shown in Fig. 8, it is logical that the symmetrical A3 side-interface form was chosen as the most "Traditional" form here. By contrast, the asymmetrical A2 side-interface was selected as "Modern." In addition, the two side interfaces, A4 and A5, which are also symmetrical, were indicated to be "Modern." This is largely because these two forms do not have a clearly defined "center" primary position.

A new finding with respect to the matching of side-interface forms to emotions is that modernist design styles promote a "Less is More" design tendency [38]. The simplest flat interface forms, consistent with modernism, are excluded from being "Modern" here. This may be related to the timing of the start of modern interior design in the region [39]. Most homes featured plain, undecorated interior interfaces in the childhood, youth, and middle age of this generation of older people. This collective memory may be at the root of why more senior people in Jinan perceive the A1 interface to favor the "Traditional" form.

A similar "collective memory" also influenced the affective matching results for the top-interface form. Traditional Chinese interiors pay close attention to the top interface [40], as the roof interface was mostly an untreated, bare original timber frame structure made with traditional timber frame construction [41]. The top-interface of modern modular housing is also largely flat and untreated [modular housing, look at the front]. The results of this study also show that only the flat B1 top-interface form is categorized as "Traditional," while the other three treated top-interface forms were compared with the "Modern."

It is nevertheless a bit surprising that, in contradiction to the results of emotional matching of the side-interface forms, the two top-interface forms of B4, which are perfectly in line with traditional Chinese aesthetics, are chosen as the most "Modern" forms. This also shows a deviation from the perception of most designers. In general, designers perceive what is "Modern" as being from the modernist school of design. Modernism centers on the importance of function, emphasizing that the form of the composition is to be subordinate to function and that the beauty of architecture is to lie in the reasonableness and logic with which the structure meets its functions and emphasizing the design point of view that "less is more." [33] Like the top interface from B4, this ceiling circle has a purely decorative role, and modernism calls for the opposite of the design concept. We identified some possible reasons for this orientation through the relevant sources of information: China's modern interior design first began in Beijing, Guangzhou, and other developed areas, under the influence of foreign hotels. It only slowly entered the homes of the general public. In the 1990s, the interior design of luxury hotels began to be imitated by individuals in their homes [31]. During this period, most of the older adults in this experimental research were middle aged. They were the backbone of society and the leading participants in interior design during this period. At the beginning of China's interior design development, some irrational phenomena inevitably appeared in interior design. Interior design during this period became an ideal substitute for identity, wealth, status, culture, and even power [31]. For example, suspended ceilings exhibiting complex forms began to appear on previously flat roof surfaces. Home interiors became a "crude" imitation of all types of design language and stacking. Reacting to commercial realities of the market, people began to consider that only ceilings were "fashionable" and "modern." These factors may play a role in the experimental results of the most complex circle of the ceiling of the B4 roof form, exceeding the asymmetrical B2 single side of the ceiling interface form, which was chosen as the most "Modern" interface form. That is, a kind of collective memory may have contributed to this slightly unexpected matching result.

As noted, Confucianism laid the ideological foundation of Chinese interior design home culture. In essence, the primary goal of Confucianism is to establish appropriate rules and order across the range of social activities [32]. The region's spatial interface design

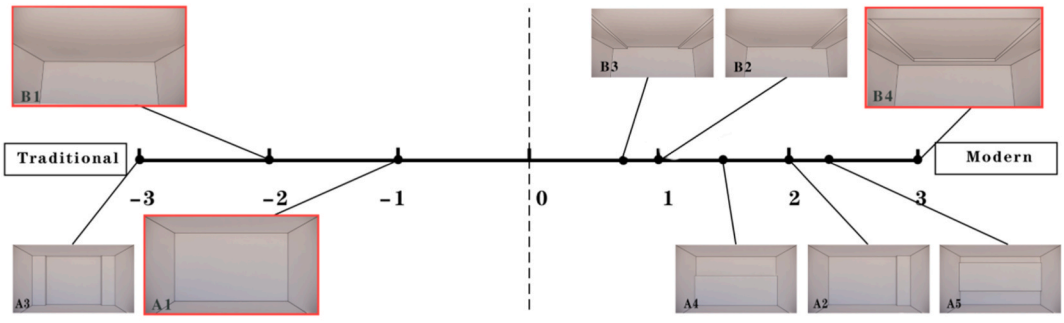


Fig. 8. SD mapping results in interface forms and "traditional and modern."

is influenced by this idea of order. To express the order of space, the layout of the interior design is in the form of axial symmetry to allow people to perceive it at a visual and psychological level. This kind of interior layout is undoubtedly the materialization of the Confucian idea of solemnity and respectfulness as the embodiment of the liturgical system. This is not only a comprehensive expression of an external art form but is also a concrete manifestation of an internal philosophy of life.

Therefore, Chinese classical spaces, which are concerned with the ritual system, usually pursue a deliberate order in their form and consider the carefully handled, symmetrical, and balanced form to be proper [42]; surfaces that seem not to be carefully managed, asymmetrical, or unbalanced are usually regarded as random. As shown in Fig. 9, the results of this experiment confirm this: the symmetrical and balanced forms of the A3 side interface, A4 side interface, B3 top interface, and B4 top interface are all "Formal"; the seemingly unprocessed and unchanged forms of the A1 side interface and the B1 top interface, the asymmetrical forms of the A2 side interface and the B2 top interface, the unbalanced forms of the A2 side interface and the B2 top interface, and the unstable forms of the A1 side-interface, the B2 top interface, and so on, are all "Formal." The seemingly unprocessed and unchanged A1 side-interface and B1 top interface, the asymmetrical A2 side-interface, the B2 top interface, and the unbalanced A5 side-interface all correspond to "Casual."

We were surprised to find that some results differed from contemporary compositional language. Modern composition language is based on vertical lines: vertical spaces are lofty, solemn, upward, and formal, while horizontal lines give people a friendly, accessible, and casual feeling [43]. By contrast with the contemporary sense of compositional language, it was found that the A4 interface, a lateral interface form dominated by horizontal lines, was categorized as "Formal." The literature indicates that in the early years of the founding of New China, this generation of older people was then in their childhood and youth. Many hospitals, local governments, schools, and other relatively official and formal organizations continued to use government buildings from the Republican period. These Republican style buildings all have a characteristic wainscoting. This is similar to the A4 side-interface, in that the lower part of the wall is divided from the upper part by horizontal lines, and the lower part is protected by wood or another color of latex paint [44]. Although this form has gradually faded out of contemporary Chinese design language with the times, the experimental results indicate that this particular interface form continues to exist in the collective memory of this generation. Unlike contemporary compositional design language, the Jinan generation perceives this form to be a "Formal" interface form. The collective memory of this form of interface, which existed in a relatively official and formal space at a particular time led this generation to view this form as a formal form of interface.

In this section, the mapping between affective cognition and interface form is clearly established. As shown in Fig. 10, a wider range of variation of interface forms produces more lines, which corresponds to more complex affective cognitions, while fewer variations of forms produce fewer lines, and this corresponds to simplicity and calmness. That is, interface forms with a number of sequences used to separate shapes less than or equal to one are considered to carry Simplicity, while others exhibit Complexity. For the same number of lines in the A5 interface form as in the A3 interface, it is possible that the slightly more complex overhanging appearance of the A5 interface form led to the recognition of A5 as exhibiting somewhat more Complexity.

As shown in Fig. 11 the model focusing on emotional resonance was employed to design the interior interface in the living spaces of older people. The emotional preferences of this demographic were identified as "Modern", "Casual", and "Simplicity". The evaluation identified two interface configurations, namely the A2 side-interface and the B2 top-interface, as the optimal solutions for addressing the emotional requirements of older people. Following a thorough assessment, these two configurations emerged as the most fitting choices, leading to the designer finalising the design based on the model's recommendations.

To verify the effectiveness of the model design, the research utilised a questionnaire to conduct an emotional resonance survey among the older population in Jinan City. Participants were asked to evaluate the design across three criteria: "Modern", "Casual", and "Simplicity", using a 5-point scale for their ratings, where "5" indicated most satisfaction and "1" denoted the opposite. Additionally, to explore whether the study's findings could extend to a broader spectrum of the older people with varied backgrounds, a diverse group of participants was chosen based on their previous occupations, which included roles such as salespersons, teachers, healthcare professionals, military staff, and civil servants. Out of 150 questionnaires distributed, 141 were returned and considered valid, resulting in an effective response rate of 94%. As shown in Fig. 12, the analysis of the feedback revealed that the final design was highly acclaimed across all evaluated aspects, suggesting that the interface recommendations derived from the emotional resonance model are well-suited to fulfill the preferences of older people for "Modern", "Casual", and "Simplicity".

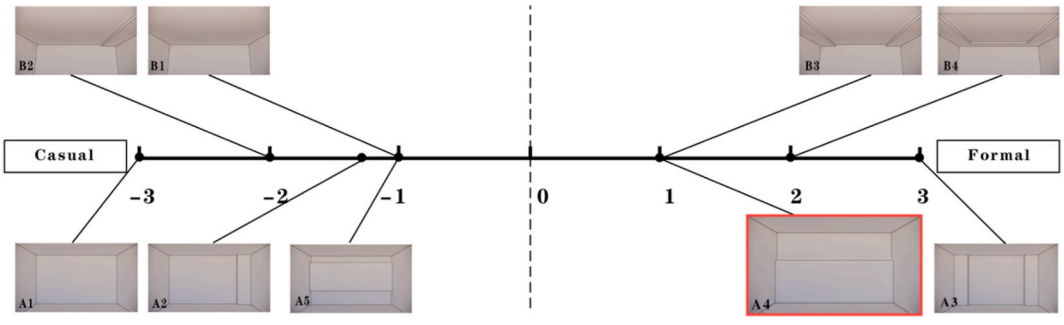


Fig. 9. SD mapping results in interface forms and "casual and formal."

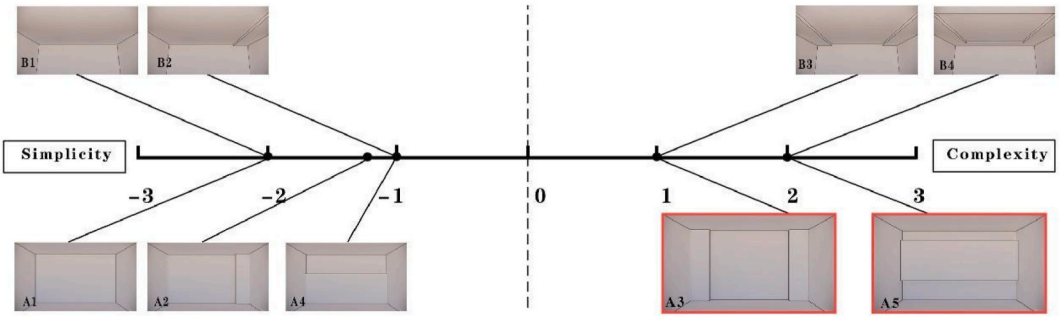


Fig. 10. SD mapping results in interface forms and "simplicity and complexity."

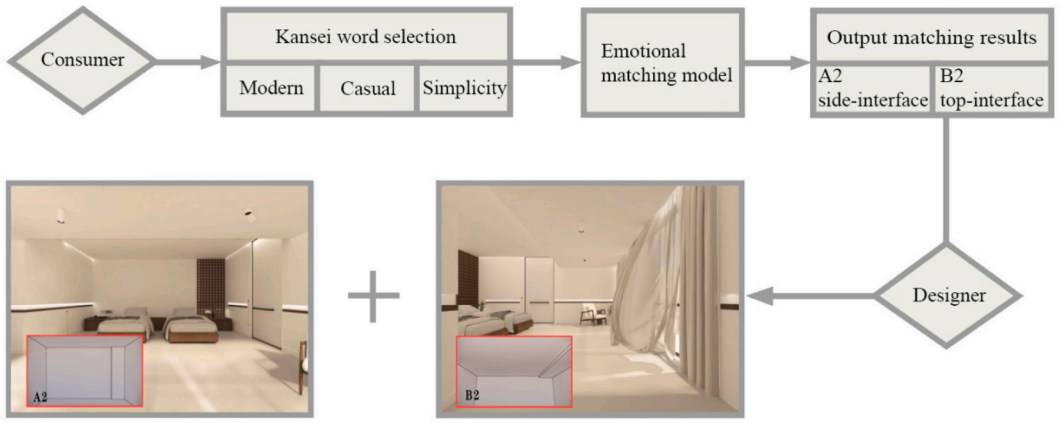


Fig. 11. Demonstration chart of emotion matching model application.

The comparison of Figs. 1 and 11 with the existing design model illustrates the efficacy of the model introduced in this research. This model is adept at minimising both the frequency and duration of communications required to relay design specifications, thereby enhancing the flow of dialogue between designers and the older people in the pre-design stage. In addition, this model's use of an emotion matching mechanism for creating interface forms lessens reliance on the personal insights of designers. This not only augments the methodological rigor in the conversion of design elements but also elevates the chances of aligning the interface's design with the emotional requirements of elderly users. Additionally, the prevalent approach to creating age-friendly spaces has largely focused on meeting functional needs. However, the model presented in this paper takes a novel approach by prioritising the emotional needs of the older people. in the domain of age-friendly space design, where the emphasis on emotional fulfilment is growing, the efficient and accurate transformation of these emotional requirements into design elements is increasingly recognized as a critical objective.

5. Limitations

First of all, space design is inherently a multifaceted creative activity, where the effect of the space is influenced not only by the interface's form but also by the close relationship of various spatial composition elements such as colour, material, and patterns. Drawing on perceptual engineering principles, this study narrows its focus to the alignment between the emotional needs of the older people and single interface designs. This scope represents the primary limitation of this study. Future studies are encouraged to explore how other spatial elements correlate with the emotional needs, broadening the research horizon.

In light of the current technological conditions, the accuracy surrounding emotional synchronisation in this research does not reach an optimum level. The analysis constructs a model that bridges emotional experiences with interface designs, catering predominantly to the emotional preferences of the elder population in Jinan. Considering the complex and variable nature of human emotions, it proves challenging to match the emotional aspects of design for senior-friendly walking spaces to each individual's needs accurately. However, as advancements in computer science, psychology, architecture, and other relevant fields progress, future studies may leverage big data analytics to broaden the scope of their samples. In addition, employing virtual reality and similar technologies could enhance the authenticity of these samples, thereby enhancing the reliability of such experimental methodologies. Moreover, adopting a multidisciplinary approach, incorporating a richer blend of methods, could improve the emotional matching model, enhancing its accuracy significantly.

Finally, In this study, the test population was specific to a particular region, and the results thus obtained cannot be directly applied

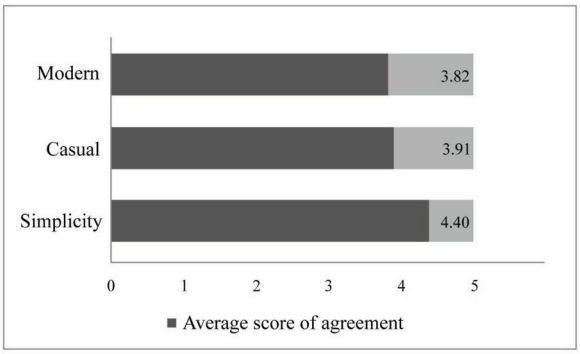


Fig. 12. Design satisfaction survey results based on emotional matching model.

to other regions or people. And the results obtained in this study are not yet generalizable. Future investigations, can expand the scope of the study area to explore whether similar results can be identified. As China has officially become an aging society, it is important to use this study as a reference for exploring indoor forms of interfaces that suit the emotional needs of older people in various regions.

6. Conclusion

This investigation explored the relationship between the emotional needs of older people in Jinan City and the interface forms in their residences. To achieve this aim, we collected and produced of interface form samples, screened of representative adjective word pairs concerning spaces that responded to the emotional needs of older people, and finally established a mapping relationship between the emotional needs of the elderly in the city of Jinan and the corresponding interface forms through the method of Kansei engineering. The results of this investigation show that the following.

1. In this study, the design interfaces of indoor spaces from 70 residences occupied by the older people in Jinan City were collected through field observations. Focus groups then organised and distilled the collected data. 2. A list of 31 adjective pairs describing the emotional resonance of spaces was compiled from a variety of channels. The indoor space interface form of elderly residences in Jinan is relatively uniform; the bottom interface keeps at a level as much as possible. Five common types of side-interface forms were found and four top-interface forms (Stimulation Test Sample Selection.)
2. Through diverse channels, 31 adjective pairs expressing the spatial emotional perceptions of the older people were amassed. These pairs were then refined and chosen employing a combination of focus group discussions and The Delphi Method. The interface forms in Jinan focuses on the following three directions (Kansei Word Selection): Traditional and Modern, Casual and Formal, and Simplicity and Complexity.
3. The study engaged elderly participants from Jinan City to partake in a survey utilizing the SD test, a common tool in Kansei engineering. A total of 500 evaluations were conducted across different Kansei criteria for various interface designs. Thereafter, extensive dataset was analysed with SPSS statistical software. The results from the Kruskal-Wallis test highlighted significant differences in the emotional responses to different design forms. A very clear relationship was found between the emotional needs of older people in Jinan and the mapping of the interface forms of their domestic dwellings. Each type of interface form exhibits a clear emotional intention. It is worth noting that, due to the influence of collective memory and other factors, Jinan's older generation exhibited emotional perceptions of interface forms that are different from the conventional ones of contemporary designers. Two sets of mappings that surprised us were, first, that the perception of the heavily decorated B4 ceiling as Modern, in spite of its absence of what is generally termed modernism, for which less is more and design should be function-oriented.58 Second, by contrast with the usual way in which contemporary compositional is expressed, where vertical lines are usually used to indicate formality and solemnity, their collective memory led older people in Jinan to select the A4 side-interface form, which is dominated by horizontal lines, as Formal.

The principal theoretical outcome of this study is its enrichment of the scope of application of the theory of Kansei engineering, indicating that this theory can provide highly operational theoretical guidance for the construction of the relationship between the mapping of emotional needs and spatial interface forms across specific regions and groups. In this research, the primary innovation lies in measuring the emotional requirements of the older people in Jinan City concerning the design of living spaces, and pairing these requirements with specific design strategies based on their emotional needs. The essence of this study, grounded in Kansei engineering, revolves around the quantification of emotions. Through a comprehensive set of methods, this work establishes a quantitative relation between the design of space interfaces and the emotional preferences of the older people, producing a model that facilitates the creation of age-friendly environments in Jinan City. This model notably streamlines the decision-making process for designers engaging in related projects, enhancing both the efficiency of design and the alignment between the results of these projects and the emotional expectations of the elderly population.

However, the design of spaces is inherently a multifaceted and creative task, where the overall ambiance is intimately connected to

various elements such as the design of interfaces, colour schemes, materials, and patterns. Considering the limitations of research methodologies and the focal points of this study, the analysis was narrowed to appraise the correlation between a single interface design and its resonance with the emotional needs of the older people. This breadth of the study marks the first limitation of this study. In the future, it would be valuable to explore how other spatial components correlate with emotional needs. Moreover, this research developed a model that aligns with the emotional experiences of a broad segment of the elderly population in Jinan City and the design of interfaces. The complexity and variability of human emotions, however, pose a challenge in achieving a accurate match for every individual's emotional needs in the context of designing spaces that are senior-friendly. This issue of accuracy signifies another research limitation. Future work should embrace an interdisciplinary approach, integrating diverse methods more comprehensively to optimize the emotional matching model and enhance its applicability. Finally, the study's focus on a specific regional demographic means the findings are not immediately transferable to other regions or demographic groups, indicating the results are not universally applicable at this stage. Future research could broaden the geographic scope to determine if the findings are replicable in different contexts.

In summary, this study applied the relevant methods of perceptual engineering theory, methodically selected the samples through interface form and Kansei analysis, and employed the SD method to explore the correspondence between these aspects. Moreover, the study identified the correlation between design elements and emotional requiremehts. Finally, a reference for the design practice of internal interface forms of residences that meet the emotional needs of older people in Jinan City and lays the foundation for further research, providing an important reference point for the design of spaces that meet the emotional needs of specific populations.

Data availability statement

Has data associated with your study been deposited into a publicly available repository?
No.
Please select why.
Data included in article/supp. material/referenced in article.

Funding

The authors received no specific funding for this work.

CRediT authorship contribution statement

Feng Wang: Writing – original draft. **Isarachai Buranaut:** Supervision. **Bo Zhang:** Project administration. **Jie Liu:** Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

PhD Program in Design, Faculty of Decorative Arts, Silpakorn University.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e29129.

References

[1] A.V. Samsonovich, Socially emotional brain-inspired cognitive architecture framework for artificial intelligence, Cognit. Syst. Res. 60 (2020) 57–76, https://doi.org/10.1016/j.cogsys.2019.12.002.
[2] E. Brunswik, The Conceptual Framework of Psychology, 1952.
[3] A. Carr, Positive Psychology: the Science of Wellbeing and Human Strengths, Routledge, 2022.
[4] E. Diener, E. Sandvik, W. Pavot, Happiness is the frequency, not the intensity, of positive versus negative affect, Social indicators research series (2009) 213–231, https://doi.org/10.1007/978-90-481-2354-4_10.
[5] P. Windley, R. Scheidt, Physical Environments and Aging: Critical Contributions of M. Powell Lawton to Theory and Practice, Routledge, 2015.
[6] L.L. Carstensen, Socioemotional selectivity theory: the role of perceived endings in human motivation, Gerontol. 61 (8) (2021) 1188–1196, https://doi.org/10.1093/geront/gnab116.
[7] L.L. Carstensen, H.E. Hershfield, Beyond stereotypes: using socioemotional selectivity theory to improve messaging to older adults, Curr. Dir. Psychol. Sci. 30 (4) (2021) 327–334, https://doi.org/10.1177/09637214211011468.
[8] L.L. Cartensen, Growing old or living Long: a new perspective on the aging brain, Public Policy & Aging Report 17 (1) (2007) 13–17, https://doi.org/10.1093/ppar/17.1.13.

[9] X. Su, K. Huang, Z.F. Zhang, Research on the visual language of interior interface design, Adv. Mater. Res. (2013), https://doi.org/10.4028/www.scientific.net/amr.739.669.
[10] A. Carlson, Aesthetics and the environment: the appreciation of nature, art and architecture. https://philpapers.org/rec/CARAAT-36, 1999.
[11] H. Leder, B. Belke, A. Oeberst, M. Augustin, A model of aesthetic appreciation and aesthetic judgments, Br. J. Psychol. 95 (4) (2004) 489–508, https://doi.org/10.1348/0007126042369811.
[12] F. Zhou, Y. Ji, R.J. Jiao, Emotional design, Handbook of Human Factors and Ergonomics (2021) 36–251. https://doi:10.1002/9781119636113.ch9.
[13] A.G. Ho, Structuring user experience design with affective concerns, Art Des. Rev. (2017), https://doi.org/10.4236/adr.2017.51006.
[14] C.N. Zabotto, S.S.L. Da, D.C. Amaral, C.J.M. Hornos, B.G. Benze, Automatic digital mood boards to connect users and designers with Kansei engineering, Int. J. Ind. Ergon. 74 (2019) 102829, https://doi.org/10.1016/j.ergon.2019.102829.
[15] M. Nagamachi, Home applications of Kansei engineering in Japan: an overview, Gerontechnology 15 (4) (2016), https://doi.org/10.4017/gt.2016.15.4.005.00.
[16] M. Nagamachi, Kansei Engineering: a new ergonomic consumer-oriented technology for product development, Int. J. Ind. Ergon. 15 (1) (1995) 3–11, https://doi.org/10.1016/0169-8141(94)00052-5.
[17] F. Guo, Q. Qu, M. Nagamachi, V.G. Duffy, 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. 76 (2020) 102940, https://doi.org/10.1016/j.ergon.2020.102940.
[18] M. Nagamachi, Kansei/Affective Engineering, CRC Press eBooks, 2016, https://doi.org/10.1201/ebk1439821336.
[19] M. Nagamachi, Perspectives and the new trend of *Kansei*/affective engineering, The Tqm Journal 20 (4) (2008) 290–298, https://doi.org/10.1108/17542730810881285.
[20] G.L. Tang, From 'take-ism' to pursuit of newness and originality: design professionals and models of creativity in contemporary China, Journal of Cultural Economy (2023) 1–18, https://doi.org/10.1080/17530350.2023.2246984.
[21] F. Wang, I. Buranaut, B. Zhang, J. Liu, Elderly-friendly indoor vertical dimensional layout method based on joint mobility, PLoS One 18 (5) (2023) e0285741, https://doi.org/10.1371/journal.pone.0285741.
[22] P.M.F. Msc, P.A. Bergland, O.A. Lund, J. Debesay, Aging and exercise: perceptions of the active lived-body, Physiother. Theory Pract. (2018) 1–12, https://doi.org/10.1080/09593985.2018.1456584.
[23] M. Afifi, B. Parke, M. Al-Hussein, Integrated approach for older adult friendly home staircase architectural design, Autom. ConStruct. 39 (2014) 117–125, https://doi.org/10.1016/j.autcon.2013.07.001.
[24] D.J. DeLoss, T. Watanabe, G.J. Andersen, Improving vision among older adults, Psychol. Sci. 26 (4) (2015) 456–466, https://doi.org/10.1177/0956797614567510.
[25] Y. Lin, An institutional and governance approach to understand large-scale social housing construction in China, Habitat Int. 78 (2018) 96–105, https://doi.org/10.1016/j.habitatint.2018.06.001.
[26] Y. Chang, C. Chen, Kansei assessment of the constituent elements and the overall interrelations in car steering wheel design, Int. J. Ind. Ergon. 56 (2016) 97–105, https://doi.org/10.1016/j.ergon.2016.09.010.
[27] P. Caratelli, M.A. Misuri, Kansei engineering methodology to define the interior design of habitats in extreme environments, in: 2020 International Conference on Environmental Systems, 2020. July.
[28] X. Lai, S. Zhang, N. Mao, J. Li, Q. Chen, Kansei engineering for new energy vehicle exterior design: an internet big data mining approach, Comput. Ind. Eng. 165 (2022) 107913, https://doi.org/10.1016/j.cie.2021.107913.
[29] J. Lenclos, D. Lenclos, Couleurs du monde: géographie de la couleur, 2003.
[30] W. Hirst, J.K. Yamashiro, A. Coman, Collective memory from a psychological perspective, Trends Cognit. Sci. 22 (5) (2018) 438–451, https://doi.org/10.1016/j.tics.2018.02.010.
[31] H. Yoon, K. Fu, J. Zhou, T. Zhou, D. Chen, Chinese sensitivity analysis for the interior design of the automobile, International Journal of Affective Engineering 14 (4) (2015) 259–268, https://doi.org/10.5057/ijae.e120613-1.
[32] D.S. Dewi, A. Rakhmawati, I.M.L. Batan, et al., Product design for post-stroke rehabilitation bicycle with Kansei engineering approach, in: Materials Science and Engineering, vol. 598, IOP Publishing, 2019 012087, 1.
[33] D. Chen, P. Cheng, The style design of professional female vest based on Kansei engineering, Int. J. Cloth. Sci. Technol. 32 (1) (2020) 5–11.
[34] X. Li, K. Liu, C. Zhu, et al., Collar style design of women's suit based on Kansei engineering, Industria Textila 73 (5) (2022) 530–536.
[35] S.H. Hsu, M.C. Chuang, C.C. Chang, A semantic differential study of designers' and users' product form perception, Int. J. Ind. Ergon. 25 (4) (2000) 375–391, https://doi.org/10.1016/s0169-8141(99)00026-8.
[36] M. Chuang, Y. Ma, Expressing the expected product images in product design of micro-electronic products, Int. J. Ind. Ergon. 27 (4) (2001) 233–245, https://doi.org/10.1016/s0169-8141(00)00053-6.
[37] M. Sato, The confucian quest for order: the origin and formation of the political thought of Xun Zi. http://ci.nii.ac.jp/ncid/BA65583892, 2003.
[38] G. Lees-Maffei, Introduction: professionalization as a focus in interior design history, J. Des. Hist. 21 (1) (2008) 1–18, https://doi.org/10.1093/jdh/epn007.
[39] A. Pitts, Y. Gao, Design of dwellings and interior family space in China: understanding the history of change and opportunities for improved sustainability practices, Buildings 4 (4) (2014) 823–848, https://doi.org/10.3390/buildings4040823.
[40] S. Abercrombie, A Philosophy of Interior Design, Routledge eBooks, 2018, https://doi.org/10.4324/9780429502668.
[41] Islom Odil Ugli Tojiboev, Chinese ARCHITECTURE. Oriental renaissance: innovative, educational, natural and social sciences 1 (8) (2021) 40–42.
[42] F. Xiang, Research on the application of Chinese traditional culture in interior design, World Scientific Research Journal 8 (4) (2022) 364–367.
[43] K. Elam, Geometry of Design: Studies in Proportion and Composition, Princeton Architectural Press, 2001.
[44] Y. Zhang, Z. Wu, Color model analysis of government office furniture and interior space in the Republican era, Journal of Forestry Engineering 2 (6) (2017) 150–156.