Interaction Design of Elderly-Friendly Smartwatches: A Kano-AHP-QFD Theoretical Approach

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Abstract. The world population is aging rapidly, and the health and care issues of the elderly are receiving increasing attention. The application of elderly smart wearable devices, represented by smartwatches, in health monitoring, is becoming more widespread. Based on the above background, a smartwatch interaction design strategy centered on elderly users is proposed to address the problem of low aging adaptability in current smartwatch design. The Kano model, hierarchical analysis method, and QFD method are integrated into the smartwatch interaction design process. Firstly, focusing on elderly users as the target, Kano was used to study user requirements, resulting in 24 user requirements classified by their attributes. Secondly, the AHP model was employed to establish the analysis matrix of the requirement indicators and determine the comprehensive weighting values of different requirement indicators. Subsequently, QFD was utilized to analyze the finalized user requirements, enabling the determination of the core design factors for smartwatch interaction design. Finally, the design scheme was conducted based on the design factors, followed by evaluation and usability testing to verify the reasonableness and feasibility of the design model and scheme.

Keywords: Smartwatch · Interaction Design · Kano Model · AHP · QFD

1 Introduction

The global demographic landscape is witnessing a rapid phenomenon of population aging, which poses the potential to surpass society's capacity to provide adequate care for the elderly [1]. Permanently entering nursing homes represents a costly means of care provision for older individuals, the majority of whom express a preference for aging in the familiarity of their own homes [2]. There is a burgeoning interest in examining the efficacy and feasibility of health monitoring and assistance delivered within the domestic sphere [3]. Several intelligent wearable devices have already integrated health monitoring functionalities, with smartwatches epitomizing aging smart wearable devices due to their convenient portability, particularly suited for elderly usage. However, smartwatches present novel concepts to elderly users, whose operational logic and design ethos significantly diverge from the functional machinery era. Factors such as limited experience, health status, income level, education, and geographic location often

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render elderly individuals challenged in adapting to new technologies. Moreover, they encounter difficulties stemming from the intricacy of emerging technologies and the absence of user-friendly services tailored to their needs [4].

Smartwatches have gained prominence within the Information and Communication Technology (ICT) industry owing to their multifaceted functionality and broad user appeal, yet empirical research on user perceptions and attitudes towards smartwatches remains at a nascent stage [5]. Recent strides in wearable sensor technology have unveiled substantial potential for enhancing the quality of life among the elderly [6]. Through wireless sensor networks, older adults can transmit real-time data on their physical condition to healthcare centers, thus garnering instantaneous feedback on vital signs such as heart rate and blood pressure, thereby facilitating real-time healthcare provisioning [7]. Present investigations into smartwatches for elderly users primarily concentrate on the functionalities of health monitoring and remote care, yet there exists a dearth of research on interaction design suitable for elderly users. Elderly users necessitate clearer operational cues when utilizing smartwatches, an aspect that current research inadequately addresses, with interface design failing to align with the needs of elderly users. Furthermore, elderly users constitute a minority within the user demographic of smart wearable devices, and the level of age-friendliness of smartwatches remains inadequate, lacking rigorous analysis and segmentation of user needs. Consequently, the interaction design of smartwatches for elderly users necessitates a user-centric approach, underpinned by a synthesis of qualitative and quantitative analyses of requirements to delineate specific and effective design strategies, thereby guiding subsequent design endeavors.

2 Research Methodology

In the developmental process of product design, user-oriented construction of design models involves methodologies such as the Kano model, Analytic Hierarchy Process (AHP), Quality Function Deployment (QFD), Axiomatic Design (AD), and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). In recent years, numerous researchers have delved into systematic design methodologies, integrating these theoretical models to formulate more scientifically sound and efficient design solutions.

The collection and analysis of user requirements constitute pivotal stages in the design and development process, thereby serving as determinants of a product's success or failure. Due to the abstract, dynamic, varied, and diverse nature of user demands, deriving precise conclusions can prove challenging [8]. The Kano model, introduced by Dr. Noriaki Kano, a professor at Tokyo Institute of Technology in the 1970s, represents a user requirement analysis model [9]. The Kano model has the potential to unearth implicit or latent human needs, satisfaction of which may enhance user contentment [10]. Nonetheless, the Kano model lacks the capability to assess the relative importance among user requirements, potentially leading to a deviation in the focus of subsequent product development endeavors.

The Analytic Hierarchy Process (AHP) is well-suited for aiding decision-making in scenarios characterized by multiple interrelated factors [11]. Employing AHP facilitates the determination of weighting coefficients for user requirements identified within the

Kano model. However, neither the Kano model nor AHP provides a definitive solution for translating final user requirements into specific design parameters.

The Quality Function Deployment (QFD) theory, proposed by Japanese scholars Yoji Akao and Shigeru Mizuno, entails a multilayered deductive analysis method aimed at satisfying quality management systems, with its core essence lying in requirement transformation [12]. QFD ensures a specific method for enhancing the quality at each stage of product development [13].

This study amalgamates the product design processes of Kano, AHP, and QFD. Grounded in user requirements, this process integrates qualitative and quantitative analytical methods. By encompassing both the emotive demands users have towards products during the design process and scientifically mapping out specific parameters for design, this approach offers heightened precision in analysis and greater efficiency in decision-making compared to traditional design methodologies.

The study is delineated into three distinct phases. In the first phase, to enhance the targeted nature of the inquiry, the research focuses on the elderly population as the primary demographic of interest. Employing a combination of interview methodologies and on-site observational techniques, explicit and implicit user requirements are elicited. Through a meticulous process, the raw descriptions provided by users are translated into unambiguous user demands. Subsequently, employing the card sorting technique, demands are categorized according to experiential elements to obtain classification indices. Utilizing the Kano model, the study delineates the classification of requirements and gauges the degree of expectation associated with user demands. Concurrently, the Analytic Hierarchy Process (AHP) is employed to construct an analysis matrix for the requirement indices, thereby ascertaining the comprehensive weighting values attributed to different requirement indicators.

In the second phase, a comparative analysis is conducted between the outcomes derived from the Kano and AHP models. The results generated by the AHP model serve to refine the user demand indices selected by the Kano model. Subsequently, employing the Quality Function Deployment (QFD) methodology, a mapping analysis of the finalized user demands onto design elements is performed. This aids in the identification of core design factors pertinent to the interaction design of smartwatches.

The third phase involves the formulation of design schemes based on the identified design factors. Subsequent to the design phase, an evaluation of the proposed design schemes is conducted to analyze their rationality and feasibility. Illustrated in Fig. 1, the research framework encapsulates the investigation and proposal evaluation of elderly-friendly interaction designs for smartwatches, predicated upon the amalgamated KANO-AHP-QFD model.

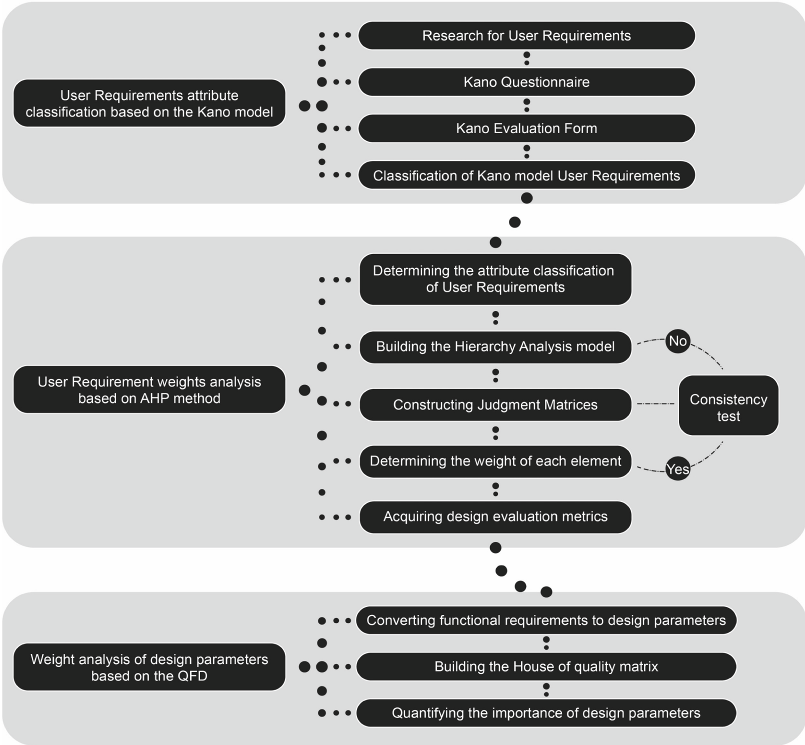

Fig. 1. KANO-AHP-QFD Hybrid Modelling Research Framework. (Self-illustrated by author.)

3 Smartwatch Interaction Design Process Based on Kano Model, AHP and QFD Methods

3.1 Kano Model-Based Requirements Extraction and Classification for Elderly Users

The observation and analysis of daily life behaviors among the elderly provide invaluable insights into their pain points and needs, thus facilitating a more nuanced understanding of their lived experiences. The target demographic for this study comprises individuals aged 60 and above, characterized by normal cognitive function and unhindered communication abilities. To ensure the relevance and specificity of the investigation, the research focuses on elderly users who have either used or been exposed to smartwatches. Adopting qualitative methodologies such as interviews and on-site observations, explicit and implicit user requirements are systematically captured. Following the collation and analysis of user research findings, a comprehensive list of 24 user demands is delineated, as presented in Table 1.

Subsequently, in adherence to the design principles outlined by the Kano questionnaire, a bifactorial approach was employed. Leveraging the elicited user requirements, a Likert 5-point scale questionnaire was meticulously crafted, as detailed in Table 1 Users were prompted to evaluate their satisfaction with each demand from both positive

Table 1. User requirements extraction.

Requirements classification	Number	Requirement Details
Functional Requirements	Q1	One-button SOS call for help
	Q2	Monitor cardiac
	Q3	Blood pressure measurement
	Q4	Medication reminder
	Q5	Monitoring of data-sharing children
	Q7	Web-based teleconsultation
	Q8	GPS positioning
	Q9	Incoming call alerts, answering calls
	Q10	Sedentary reminders
	Q11	Fall alarm
	Q12	weather alert
	Q13	Dietary records
Interaction Requirements	Q6	Simple and easy-to-understand interface
	Q20	The screen display font should be large
	Q21	The operation interface has colored ICONS
	Q22	Operation interface with animation guidance
	Q23	Can be operated by voice
	Q24	Can be operated by touch
Emotional Requirements	Q14	Beautiful appearance
Usage Requirements	Q16	Can wear on the hand
	Q17	It can be hung around your neck
	Q18	The display screen is large
	Q19	Lightweight and comfortable to wear
Economic Requirements	Q25	Moderate price (within 1000–1500 RMB)

and negative perspectives, utilizing a satisfaction scale comprising five levels: "Very Dissatisfied (1)", "Dissatisfied (2)", "Neutral (3)", "Satisfied (4)", and "Very Satisfied (5)" [14]. A total of 262 questionnaires were distributed, with the 15th question serving as an attention test item. Subsequently, 207 valid responses were obtained, which were meticulously collated and integrated. The questionnaire results were then synthesized to correspond with the Kano evaluation (see Table 1), thereby yielding insights into the relationship between user demands and product quality characteristics (Tables 2 and 3).

Taking user requirement Q1 as an illustration, 87.44% of respondents deemed the "one-key SOS emergency call" feature as a Must-be Quality (M). Consequently, this demand was categorized as a Must-be Quality (M). The Kano attributes of the other

Table 2. Kano Two-factor Fifth-order Likert questionnaire.

If available, what is your attitude?					Smartwatch requirements for designers	If not, what is your attitude?				
1	2	3	4	5		1	2	3	4	5
One-button SOS call for help										
Monitor cardiac										
Blood pressure measurement										
Medication reminder										
Monitoring of data-sharing children										
Simple and easy-to-understand interface										
……										

Table 3. Kano evaluation criteria.

Negative						
		Very Dissatisfied (1)	Dissatisfied (2)	Neutral (3)	Satisfied (4)	Very Satisfied (5)
Positive	Very Dissatisfied (1)	Q	A	A	A	O
	Dissatisfied (2)	R	I	I	I	M
	Neutral (3)	R	I	I	I	M
	Satisfied (4)	R	I	I	I	M
	Very Satisfied (5)	R	R	R	R	Q

23 user requirements were determined using the aforementioned analytical method, as depicted in Table 1.

Among the 24 user requirements delineated in Table 1, there are 6 Must-be Quality (M) attributes, 8 One-dimensional Quality (O) attributes, 4 Attractive Quality (A) attributes, and 6 Indifferent Quality (I) attributes, with no occurrences of Reverse Quality (R) or Questionable Quality (Q). Notably, GPS positioning, incoming call reminders and call answering, sedentary reminders, weather alerts, and dietary records were classified as Indifferent Quality (I). This signifies that these demands have no direct impact on enhancing user satisfaction and thus do not warrant design optimization efforts.

Must-be Quality (M) constitutes essential features of the smartwatch, where the fulfillment of such requirements does not augment user satisfaction. However, failure to meet these standards significantly diminishes user satisfaction. One-dimensional Quality

(O) represents features users expect the smartwatch to possess. Satisfaction increases when demands are met but declines relatively when they are not. Attractive Quality (A) embodies unforeseen user demands, which, if unmet, do not decrease user satisfaction; however, satisfaction experiences a substantial improvement upon fulfillment of these demands. These three Kano classifications should be duly considered throughout the smartwatch design process (Table 4).

Table 4. Kano questionnaire analysis table.

Number	Percentage (%)						Kano orientation
	A	O	M	I	R	Q	
Q1	0	0	87.44	12.56	0	0	Must-be Quality (M)
Q2	0	0	80.193	19.807	0	0	
Q3	0	0	86.957	13.043	0	0	
Q4	0	0	86.473	13.527	0	0	
Q20	0	0	79.71	20.29	0	0	
Q24	0	0	81.643	18.357	0	0	
Q5	2.899	61.353	1.932	33.816	0	0	One-dimensional Quality (O)
Q11	5.314	58.454	0.966	35.266	0	0	
Q14	1.932	54.106	12.56	31.401	0	0	
Q17	2.899	54.589	12.56	29.952	0	0	
Q19	8.213	51.208	12.077	28.502	0	0	
Q21	9.179	53.14	11.111	26.57	0	0	
Q23	3.382	55.556	8.696	32.367	0	0	
Q25	6.28	55.556	10.628	27.536	0	0	
Q6	82.609	0	0.966	16.425	0	0	Attractive Quality (A)
Q7	79.71	0	0	18.357	0	1.932	
Q18	78.744	0	0	21.256	0	0	
Q22	77.778	0	0	21.256	0	0.966	
Q8	4.831	0.966	0	94.203	0	0	Indifferent Quality (I)
Q9	8.696	0	0	91.304	0	0	
Q10	6.28	0.966	0	92.754	0	0	
Q12	6.28	0.966	0	92.754	0	0	
Q13	5.314	0	0	94.686	0	0	
Q16	11.111	0	0	88.889	0	0	

3.2 Calculation and Analysis of Elderly User Requirement Weights Based on AHP Method

Following the classification of user requirements for smartwatches, Kano does not provide a clear indication of the importance ranking of each demand. In order to elucidate the significance of individual requirements in the subsequent design process, a fusion of Kano and Analytic Hierarchy Process (AHP) methodologies is undertaken to compute the weights of various user demands. This amalgamation ensures precise identification of the pivotal user requirements that must be considered during the smartwatch design process.

Initially, based on the attribute analysis of user requirements for smartwatches according to Kano, a hierarchical analysis model is constructed utilizing fundamental concepts of AHP, as depicted in Fig. 2. The structural model is delineated into three hierarchical levels, aligning with the needs and design objectives of smartwatches for elderly users. These levels include: (1) the Target level, which represents the overarching objective of smartwatch interaction design; (2) the Baseline level, subdivided into Must-be attributes (M), Expected attributes (O), and Attractive attributes (A); and (3) the Sub-baseline level, further divided into specific attributes such as One-button SOS call for help (M1), Monitor cardiac (M2), Blood pressure measurement (M3), Medication reminder (M4), Large screen display font (M5), Touch-operable interface (M6), Data-sharing monitoring with children (O1), Fall alarm (O2), Beautiful appearance (O3), Necklace-wearable (O4), Lightweight and comfortable wear (O5), Colorful icon operation interface (O6), Voice-operable interface (O7), Moderate price (within 1000–1500 RMB) (O8), Simple and easy-to-understand interface (A1), Web-based teleconsultation (A2), Large display screen (A3), Animation-guided operation interface (A4), totaling 18 aspects.

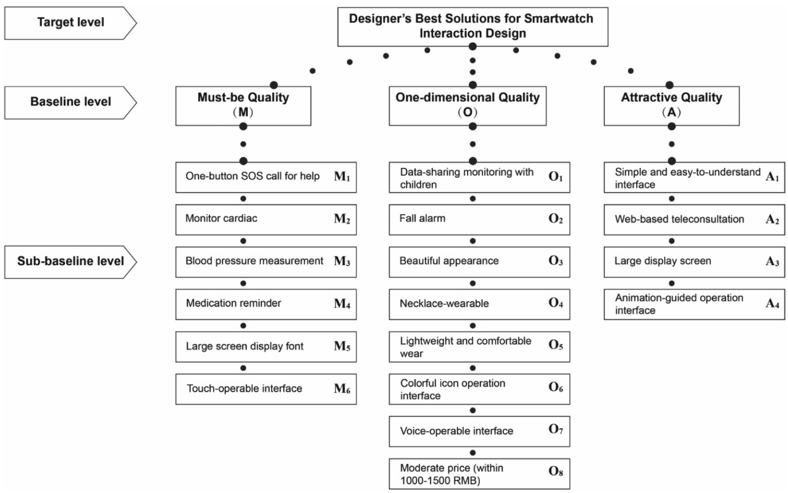

Fig. 2. Hierarchy expansion of designer demands for smartwatch. (Self-illustrated by author.)

To ensure the professionalism and applicability of the weighted results, the research opted for the AHP questionnaire design proposed by Thomas L. Saaty, employing a 9-level scale [15]. A total of 18 experts related to smartwatch interaction design were invited to fill out the matrices. This expert panel comprised 7 professionals engaged in smart wearable product design, 5 experts in the field of interaction design, 3 smartwatch interface designers, and 3 graduate students specializing in interaction design. Initially, the 18 experts were requested to evaluate the importance of each level of requirement using pairwise comparisons and ratings on a scale of 1–9. The arithmetic mean of these ratings was then computed as the basis for calculating the weights, yielding judgment matrices for each level. Subsequently, employing the geometric mean method, the weight coefficients for each level were calculated, ultimately determining the weighted values of user requirements for smartwatches. The computation process is outlined below, with results tabulated in Tables 5 and 6.

(1) Constructing a judgement matrix B:

$$B = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1j} \\ a_{21} & a_{22} & \cdots & a_{2j} \\ \vdots & \vdots & \ddots & \vdots \\ a_{i1} & a_{i2} & \cdots & a_{ij} \end{bmatrix} \tag{1}$$

$a_{ij} \cdot a_{ji} = 1, i \neq j = 1, 2, \cdots, n.$

(2) Calculate the maximum eigenvalue (λ_{max})

$$\lambda_{max} = \frac{1}{n} \sum_{i=1}^{n} \frac{B_{w_i}}{W_i} \tag{2}$$

B_{W_i} is the i component of the vector B_w. n is the order.

(3) Consistency of results test (λ_{max})

$$I_{CI} = (\lambda_{max} - n) \big/ (n - 1) \tag{3}$$

$$I_{CR} = I_{CI} \big/ I_{RI} \tag{4}$$

n is the order corresponding to the evaluation scale of the judgement matrix. I_{RI} is the average stochastic consistency index. I_{CR} is the consistency ratio.

(4) Calculate the maximum eigenvalue (M_i)

$$M_i = \prod_{j=1}^{n} b_{ij} (i, j = 1, 2, \cdots, n) \tag{5}$$

b_{ij} is the demand indicator in row i, column j. n is the quantity of the demand indicator.

(5) Determine the geometric mean of the product of the scales of each layer (a_i)

$$a_i = \sqrt[n]{M_i} (i = 1, 2, \cdots, n) \tag{6}$$

(6) Calculate relative weights (W_i)

$$W_i = a_i \Big/ \sum_{i=1}^{n} a_i \tag{7}$$

Finally, to ensure the scientific validity of the results, a consistency test is required for the calculated results. When $I_{CR} \leq 0.1$, the consistency test is passed, and vice versa.

Table 5. Primary Indicator Weight.

Primary Indicators	M	O	A	Weight Value	I_{CR}
M	1	2	3	0.5390	0.0088
O	1/2	1	2	0.2973	
A	1/3	1/2	1	0.1638	

Table 6. Secondary Indicator Weight.

Secondary Indicators	Judgement Matrix								Partial Weight	Composite Weight	I_{CR}
M_1	1	2	2	3	3	4	×	×	0.3280	0.1768	0.0184
M_2	1/2	1	1	2	2	3	×	×	0.1918	0.1034	
M_3	1/2	1	1	2	2	3	×	×	0.1918	0.1034	
M_4	1/3	1/2	1/2	1	2	3	×	×	0.1322	0.0713	
M_5	1/3	1/2	1/2	1/2	1	2	×	×	0.0964	0.0520	
M_6	1/4	1/3	1/3	1/3	1/2	1	×	×	0.0598	0.0322	
O_1	1	1/5	2	3	1/3	1/2	1/4	2	0.0855	0.0254	0.0695
O_2	5	1	2	4	4	3	2	3	0.2800	0.0832	
O_3	1/2	1/2	1	1/2	1/2	1/3	1/3	2	0.0682	0.0202	
O_4	1/3	1/4	2	1	1	1/3	1/4	1	0.0644	0.0191	
O_5	3	1/4	2	1	1	1/2	1/3	2	0.0973	0.0289	
O_6	2	1/3	3	3	2	1	1/2	2	0.1370	0.0407	
O_7	4	1/2	3	4	3	2	1	3	0.2114	0.0628	
O_8	1/2	1/3	1/2	1	1/2	1/2	1/3	1	0.0562	0.0167	
A_1	1	5	3	2	×	×	×	×	0.4742	0.0777	0.0761
A_2	1/5	1	1/3	1/2	×	×	×	×	0.0844	0.0138	
A_3	1/3	3	1	3	×	×	×	×	0.2781	0.0456	
A_4	1/2	2	1/3	1	×	×	×	×	0.1632	0.0267	

In order to ensure the scientificity of the results, the consistency test ($I_{CR} \leq 0.1$) was carried out on the results of the judgement matrix, in which the value of the criterion layer

I_{CR} was: 0.0088, and the values of the sub-criterion layer I_{CR} were: 0.0184, 0.0695, and 0.0761 respectively, all of which were less than 0.1, and conformed to the consistency test standard.

Table 7. Relative weight calculation ranking table.

No.	Composite Weight	Number	No.	Composite Weight	Number
1	0.1768	M_1	16	0.0191	O_4
3	0.1034	M_2	12	0.0289	O_5
2	0.1034	M_3	10	0.0407	O_6
6	0.0713	M_4	7	0.0628	O_7
8	0.0520	M_5	17	0.0167	O_8
11	0.0322	M_6	5	0.0777	A_1
14	0.0254	O_1	18	0.0138	A_2
4	0.0832	O_2	9	0.0456	A_3
15	0.0202	O_3	13	0.0267	A_4

The ranked results of user requirement weights presented in Table 7 reveal that the interaction design of smartwatches for the elderly must not only meet the users' indispensable attributes, such as the One-button SOS call for help (M_1), Monitor cardiac (M_2), Blood pressure measurement (M_3), Medication reminder (M_4), Large screen display font (M_5), and Touch-operable interface (M_6), but also prioritize addressing the expectations and attractive attributes that rank high in importance. These include features like Monitoring of data-sharing with children, Fall alarm, Lightweight and comfortable wear, Voice-operable interface, Simple and easy-to-understand interface, and Operation interface with animation guidance. Once these critical requirements are met, user satisfaction with the smartwatch among the elderly demographic is poised to significantly enhance.

3.3 Design Element Analysis Based on QFD Method

Upon determining the weight values and comprehensive weights of various user requirements for smartwatches using QFD (Analytic Hierarchy Process), it becomes imperative to transform the designer's requirements for the smartwatch into product design parameters through the QFD methodology (refer to Table 8), ultimately culminating in the computation of design element weights.

Establishing the House of Quality (HOQ) serves as the cornerstone of the Quality Function Deployment (QFD) process. The HOQ illustrates the relationship between user requirements and design elements matrices, elucidating the focal points of the design team in crafting the product [16]. An expert panel (comprising five interaction designers) was convened to evaluate the correlation between user requirements for the aging-friendly smartwatch and the design elements, utilizing pairwise comparisons for

Table 8. Comparison of user requirements with design parameters.

Number	User Requirement	Design Parameter
M_1	One-button SOS call for help	Health and safety DP_1
M_2	Monitor cardiac	Health and safety DP_1
M_3	Blood pressure measurement	Health and safety DP_1
M_4	Medication reminder	Health and safety DP_1
M_5	Large screen display font	Strong recognition DP_2
M_6	Touch-operable interface	Interactive mode DP_3
O_1	Data-sharing monitoring with children	Health and safety DP_1
O_2	Fall alarm	Health and safety DP_1
O_3	Beautiful appearance	Appearance modeling DP_4
O_4	Necklace-wearable	Appearance modeling DP_4
O_5	Lightweight and comfortable to wear	Comfort level DP_5
O_6	Colorful icon operation interface	Strong recognition DP_2
O_7	Voice-operable interface	Interactive mode DP_3
O_8	Moderate price (within 1000–1500 RMB)	Price DP_6
A_1	Simple and easy-to-understand interface	Strong recognition DP_2
A_2	Web-based teleconsultation	Health and safety DP_1
A_3	Large display screen	Appearance modeling DP_4
A_4	Animation-guided operation interface	Strong recognition DP_2

scoring. As depicted in Table 9, designers rated the relevance of each of the 18 requirements for the smartwatch and the 6 design elements. Each rating was quantified, with symbols denoting strong correlation (●), moderate correlation (◎), weak correlation (△), and blank indicating no correlation. Following the quantification of correlation degrees, default values were assigned as follows: ● = 5, ◎= 3, △ = 1, and blank space = 0.

The evaluation results were consolidated within the House of Quality (HOQ), where the absolute weights and relative weights of design elements' importance were computed. Subsequently, the results were imported into the HOQ's basement, and the calculation formula (8) was employed.

$$W_i = \sum_{i=1}^{q} W_i P_{ij}, \ W_k = \frac{W_j}{\sum_{i=1}^{q} X_j} \tag{8}$$

Here, W_j represents the absolute importance weight of design elements, W_i denotes the comprehensive weight of user requirements indicators, P_{ij} signifies the correlation coefficient between user requirements and design elements, and W_k represents the relative importance weight of design elements. The results of the weight calculations were then subjected to weight ranking for prioritization.

Table 9. House of Quality for design parameters in smartwatch.

UR_x / DP_x	Composite Weight	DP_1	DP_2	DP_3	DP_4	DP_5	DP_6
M_1	0.1768	●					●
M_2	0.1034	●					●
M_3	0.1034	●					●
M_4	0.0713	●					●
M_5	0.0520	△	●	△			△
M_6	0.0322	◎	△	●		△	△
O_1	0.0254	◎					◎
O_2	0.0832	●					●
O_3	0.0202		△		●		◎
O_4	0.0191	△	◎	△	●	◎	△
O_5	0.0289	△			◎	●	◎
O_6	0.0407	△	●	△			△
O_7	0.0628	◎	◎	●		◎	◎
O_8	0.0167				△	◎	●
A_1	0.0777	△	●	●		●	◎
A_2	0.0138	◎			△		◎
A_3	0.0456	△	◎	◎	●	●	
A_4	0.0267	△	●	◎		△	
SUM (Scores)		1.2589	0.5011	0.4576	0.1925	0.4055	1.2508

Upon analysis, the relative importance weight rankings of design elements, as derived from Table 9, are as follows in descending order: $DP_1 > DP_6 > DP_2 > DP_3 > DP_5 > DP_4$. These findings indicate that in the context of designing smartwatches tailored for the elderly, priority should be given to health and safety, pricing, and strong identifiability. Subsequently, attention should be directed towards interaction modalities and comfort, while considerations regarding aesthetic appeal should be addressed after fulfilling the aforementioned design elements.

4 Conceptual Design of Smartwatch Based on Kano, AHP, and QFD Models

4.1 Key Functional Requirements for Smartwatch Design in Elderly Users

The foremost functional demand of smartwatches for elderly users primarily revolves around health monitoring. This encompasses monitoring vital signs such as blood pressure, heart rate, medication reminders, and fall alerts. Given the substantial physiological, psychological differences, and distinct basic needs of the elderly compared to other consumer groups, design principles for smart wearable devices targeting the elderly should emphasize lightweight and consistency [17]. Applications on the smartwatch should retain only core functionalities, with streamlined operational procedures to avoid multitasking and complex processes. Additionally, employing standardized, universally recognizable gestures or buttons (see Fig. 3) facilitates the establishment of a unified cognitive framework among elderly users. In terms of interface design, considerations must account for potential visual impairment among elderly users. Therefore, font size significantly impacts readability and the utility of health monitoring functions. Appropriately magnifying fonts enhances user experience for the elderly, ensuring greater clarity and readability. For instance, in the smartwatch interface design by aeac (see Fig. 4), prominently sized fonts enhance readability and visibility.

Fig. 3. Apple Watch. (Source: https://osxdaily.com/2015/08/23/reduce-motion-apple-watch/)

4.2 Comfort and Affordability as Imperatives in Aging-Friendly Smartwatch Design

Comfort and pricing stand as pivotal design elements necessitating significant consideration in the design of smartwatches tailored for the elderly. Comfort is not merely confined

Fig. 4. aeac brand smartwatch. (Source: https://www.amazon.co.uk/Fitness-Monitor-Waterproof-Counter-Smartwatch-Pink/dp/B0BXLD6CJG?th=1)

to the material and weight of the smartwatch but extends to the quality of the interactive experience. Beyond conventional gesture operations, voice control holds paramount importance for elderly users, effectively mitigating usability challenges. Light weight, ease of wear, aesthetically pleasing design, and competitive pricing are all demands from elderly users beyond the essential functionalities of smartwatches, representing crucial emotional requirements within age-appropriate design considerations.

4.3 Optimizing User Satisfaction Through Aging-Friendly Smartwatch Interaction Design

The degree of age-appropriateness in smartwatch design significantly impacts elderly user satisfaction. Age-appropriate smartwatches must accommodate the behavioral patterns and cognitive levels of elderly users. Elderly individuals often prefer to rely on their past habits and experiences, gradually diminishing curiosity and interest in learning about new things, with their learning willingness typically limited to simpler and more easily memorable matters [18]. Therefore, smartwatch interaction design should prioritize the physiological and psychological characteristics of elderly users. For instance, opting for vibrant and lively colored icons in interface design (see Fig. 5) and incorporating animated guidance (see Fig. 6) in interface design facilitates clearer operational cues for elderly users during smartwatch usage.

Fig. 5. KOSPET MAX GPS Android Smartwatch. (Source: https://www.nepal.ubuy.com/en/product/3ZQUJG4AW-kospet-optimus-2-android-smartwatch-1-6-4g-lte-phone-watch-with-blood-oxygen-heart-rate-sleep-monitoring-13mp-rotatable-camera-and)

Fig. 6. Apple Watch animations. (Source: https://3sidedcube.com/apple-watch-animations/)

5 Conclusions

The burgeoning elderly population coupled with the perpetual evolution of societal dynamics has engendered increasingly discerning expectations regarding quality of life among the elderly. Smart wearable devices have emerged as facilitators of more timely, convenient, and secure personalized services for elderly users, thereby enhancing their overall quality of life. The user-driven smartwatch interaction design established through the Kano-AHP-QFD methodology epitomizes a user-centric design paradigm, effectively surmounting the inertia of conventional thinking in the design process and furnishing robust support for design decisions. The smartwatch interaction design framework constructed in this study partly alleviates the limitations of singular method designs, aiding designers in precisely identifying user requirements amidst ambiguous scenarios and facilitating informed design decisions. This framework ensures the scientific and rational progression of product development while also presenting novel research avenues for other user-driven product developments.

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