Design of Music Physiotherapy Products for Alzheimer's Disease Based on Kansei Engineering and the Kano Model

Chang Su [1, a]

[1]Qingdao University of Science and Technology

[a] scqust@163.com

Abstract. With the accelerating aging of the population, China has become the country with the largest number of Alzheimer's disease patients in the world, which will undoubtedly bring a heavy burden to the patients, caregivers, and the whole society. The purpose of this study is to design a music physiotherapy product for Alzheimer's disease patients by combining Kansei engineering and the the Kano model, to improve the quality of life of the patients. Firstly, the the Kano model is used to analyze the functional needs of Alzheimer's disease patients to improve the overall satisfaction of the products, secondly, the theoretical framework of Kansei engineering is used to analyze the perception of Alzheimer's disease patients on the appearance of the music physiotherapy products, and the results are statistically analyzed to obtain effective quantitative data, and finally, the design elements are extracted and the design of the Alzheimer's disease music physiotherapy products is carried out. Through the study, it is found that the comprehensive consideration of Kansei engineering and the the Kano model can effectively guide the design of music physiotherapy products for Alzheimer's disease to further satisfy the special needs of patients, and provide certain reference value for designers and researchers.

Keywords: Kansei engineering; the Kano model; music physiotherapy products.

1. Introduction

Alzheimer's disease is a common clinical neurodegenerative disease, which is mainly manifested as a decline in thinking and independence in daily activities[1]. The "14th Five-Year Plan" period is a critical "window period" for China to actively respond to population aging, and with the accelerating process of population aging, China has become the country with the largest number of Alzheimer's disease patients in the world. Currently, there are about 10 million Alzheimer's disease patients in China, and it is expected that the number of patients will range from 27.65 million to 91.94 million by 2050, which will undoubtedly bring a heavy burden to the patients, caregivers, and the whole society. For this reason, under the guidance of the China Center for Disease Control and Prevention Chronic Disease Center, People's Daily Online-People's Health and the Alzheimer's Disease Branch of the China Geriatrics and Healthcare Association jointly released the "Alzheimer's Disease Patient Needs Insight Report". The Report shows that Alzheimer's disease patients in China are predominantly in the elderly population, with a growing trend towards youthfulness. The pathogenesis of the disease has not yet been determined, and effective treatment is temporarily unavailable through pharmacological means, therefore, non-pharmacological interventions have gained more and more attention as a complementary therapeutic option for the management of Alzheimer's disease[2].

Music therapy has been used for many years to improve dementia symptoms and reduce cognitive impairment, and it is a safe and promising approach to cognitive rehabilitation. The use of music therapy can be beneficial for patients with Alzheimer's disease, both in the short and long term[3].It involves the use of music to satisfy the cognitive, emotional, behavioral, and social needs of patients as well as to improve their mood, memory, and executive functions[2]. The improvement of dementia symptoms can also be effective in improving the quality of life of patients and their carers[2]. For older adults, emotional design, that is Kansei engineering, is of great significance. This study will explore the design of a music physiotherapy product for Alzheimer's disease with a focus on Kansei engineering.

2. Designing the research methodology and process

2.1 the Kano model

The Kano model is a tool for classifying, analyzing, and ranking design requirements, which is a typical qualitative analysis model used to fill the gap between user requirements and product features[5] . Currently, the the Kano model is widely used in product design and healthcare for gaining insight into user needs and improving user satisfaction, and has been used to good effect[4] . It categorizes user needs into Attractive Quality (A), One-dimensional Quality (O), Mustbe Quality (M), Indifference Quality (I), and Reverse Quality (R)[5] . Using the the Kano model to quantify the factors based on user needs and user satisfaction, and then evaluating the different features of the product, and considering that emotional characteristics are the key factors to understanding the emotional needs of the users, this study will determine the needs of Alzheimer's disease patients for the music physiotherapy product based on the the Kano model to assist in the effective design of their products and to further help the designers to understand the Alzheimer's disease patients' emotional needs for this product[5] .

2.2 Kansei engineering

Kansei engineering is a representative method that allows designers to understand user needs and design products from an emotional perspective[6] , and plays an important role in the field of industrial design[8] . It can promote communication between designers and users in the process of product design, reduce the cognitive differences between designers and users, improve reliability, and enhance innovation[7] , and there is a great relationship between the user's acceptance of the product and the user's perceptual needs[6] , and Kansei engineering can quantify the human psychological emotions, to design products based on the user's preferences[7] . Kansei engineering is a design method focusing on the research process and the processing and analysis of research data[8] , specifically through the collection and collation of the product's perceptual vocabulary, survey research on users, and statistical analysis, to obtain effective quantitative data, designers can determine the user's emotional preferences for perceptual vocabulary, to create products that are more in line with the user's experience, to meet the user's perceptual needs, to improve its market competitiveness[7] .

Currently, Kansei engineering is used to guide design and research[8] for the development of attractive technical products[9] . Its main focus is on the appearance of the product's shape and color scheme, in addition to the texture and material of the product[8] . The main goal of Kansei engineering is to design emotional products to improve the quality of life of users[9] . Due to the advancement of science and technology, the development of productivity, and the increasing emotional needs of users, user perception is no longer limited to visual sensations, but rather multi-sensory resonance is triggered by product features, the focus of design has also gradually shifted from functionality to emotion[8] . Kansei engineering can also be linked to the healthcare sector, where emotional design can be used to help patients recover[6] .

2.3 Research process

The general structure of this study is as follows: (1) Alzheimer's disease patient group behavior and needs analysis, (2) Alzheimer's disease music physiotherapy product design based on Kansei engineering, and (3) Alzheimer's disease music physiotherapy product program design. In the specific process, the user needs analysis based on the the Kano model will sequentially analyze the research content, research results, and conclusions, while the product design of Alzheimer's disease music physiotherapy based on Kansei engineering will be carried out through the steps of collecting perceptual vocabularies, establishing a product sample library, questionnaire survey by semantic differential method, and data analysis, the product design will be carried out after obtaining the elements of functionality and appearance design (Fig. 1)[7] .

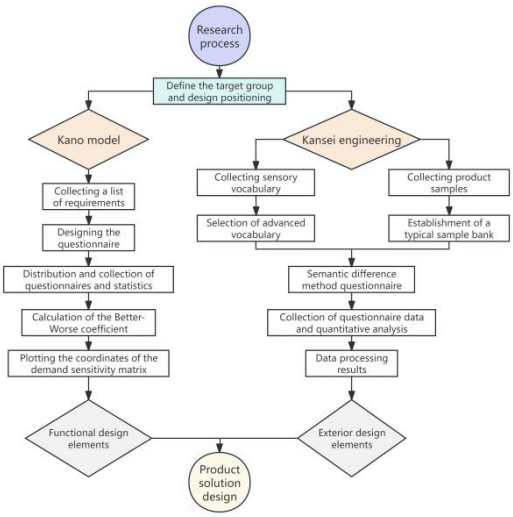

Fig. 1 Flow chart of product design research

3. Behavior and Needs Analysis of Alzheimer's Disease Population Groups

3.1 Physical and psychological characteristics of patients with Alzheimer's disease

Cognitive symptoms of Alzheimer's disease include memory loss, decreased visual-spatial ability, and executive dysfunction, and psychological symptoms include emotional apathy, depression, anxiety, agitation, and emotional control[2][3] . Patients with Alzheimer's disease are broadly divided into four stages: (1) the preclinical or presymptomatic stage, in which patients are characterized by mild memory deficits and a temporary lack of dysfunction in daily activities; (2) the mild or early stage, in which patients gradually develop a wide range of symptoms, such as memory loss, mood variability, and inattentiveness; and (3) the moderate AD(Alzheimer's disease) stage, in which patients suffer from a gradual decline in their memory, have difficulty recognizing family members and friends, are unable to control their emotions, they become repressed and fearful, and are unable to speak, read and write normally; (4) In severe or advanced AD, patients develop cognitive deficits, are unable to recognize family members and friends at all, are unable to take care of themselves, and often experience mental symptoms such as confusion, delusions, anxiety, apathy, irritability and so on.

This study will focus the target group on patients with mild to moderate Alzheimer's disease and exclude patients with other forms of dementia (e.g. mixed dementia, Lewy bodies, etc.)[2] .

3.2 Music intervention behaviours and processes

Music intervention behaviors are usually divided into active and receptive (passive) approaches[2] . Active music therapy includes singing, dancing, improvisation, clapping, playing an instrument, etc. Acceptance (passive) music therapy, which involves listening to music, creating personalized music playlists based on patient preferences or songs that motivate the patient's positive emotions, and freely selecting music, can be used to enhance situational memory in patients with mild-to-moderate Alzheimer's disease, and to improve depression, anxiety, agitation, etc. and reduce agitation, thereby improving the sense of well-being of patients with Alzheimer's disease[2][3] .

3.3 Analysis of pain points

According to the music intervention behaviors described above, the pain points mainly include: (1) individual differences: patients' responses to music vary from person to person, and different patients have different preferences for the types of music, so choosing the right music may be a challenge; (2) communication barriers: for patients who are unable to express their needs verbally, it may not be possible to ascertain their music preferences; (3) differences in cognitive levels: Some

patients may have limited understanding and response to music due to differences in their cognitive levels; (4) mood swings: patients with cognitive impairments may carry mood swings, which in turn may affect their response to music, resulting in parts of the music that may not work at certain moments. Understanding and addressing these pain points is key to designing a product solution that can effectively support and help people with Alzheimer's disease.

3.4 User requirements analysis based on the Kano model

3.4.1 Research content

Through reviewing relevant literature, conducting user research, and other methods, 14 functional keywords such as "interaction with children" and "multi-sensory interaction" were classified and sorted out, and the 14 functional keywords obtained were edited into the core content of the questionnaire, and these keywords were briefly explained. The 14 keywords were edited into the core content of the questionnaire, and these keywords were briefly explained. Using the online platform Tencent questionnaire, the array the Kano model questionnaire is designed, as the target group is generally the elderly, there may be living with their children, caregivers to watch, etc., so the elderly, their families, and chaperones must conduct a questionnaire on the demand for Alzheimer's disease music and physical therapy products, and each function point will involve positive and negative questions, and each question will be set up with five options, namely "like" "must" "don't care" "can tolerate" "hate ". After the questionnaire is entered, the background can view the data information and generate statistics in real-time. 40 questionnaires were finally recovered, of which 36 were valid and 4 were invalid.

3.4.2 Research findings

By calculating the Better-Worse coefficient, the absolute values of Worse and Better for 14 functional requirements were derived, and they were used as the horizontal and vertical coordinates, respectively, and the mean value of the Better-Worse coefficient (0.358,0.703) was used as the origin of the coordinates, and the quartile diagram of the Better-Worse coefficient analysis was plotted (Fig. 2), which was able to present a clearer present the data. From the figure, we can see that there are three attractive quality functions, namely "interaction with children", "multi-sensory interaction", "scientific color matching", and above the average value (i.e. the one-dimensional quality function), "emotional regulation", "sleep aid" and "orientation" should be considered appropriately in the design.

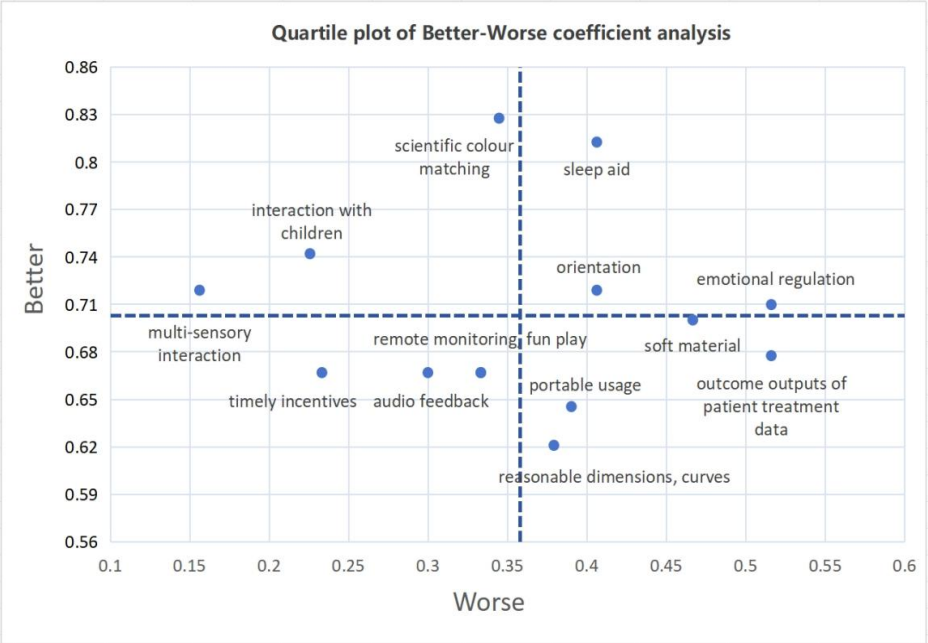

Fig. 2 Quartile plot of Better-Worse coefficient analysis

3.4.3 Analysis of conclusions

After the analysis, it is concluded that the resulting output of patients' treatment data, soft material, portable use, and reasonable size and curve are the necessary needs of the product according to the users. At the same time, mood regulation, sleep aids and positioning can meet the user's desired needs and enhance the user's experience. The attractive quality function belongs to the surprise function, striving to achieve the user's glamour demand which can largely improve the user's user experience as well as strengthen the user's good impression of the product.

4. Design of music physiotherapy products for Alzheimer's disease based on Kansei engineering

4.1 Perceptual vocabulary collection

Preliminarily select 50 appearance design perceptual vocabularies by reviewing relevant literature, network evaluation or other methods, screening and eliminating similar vocabularies, finally selecting 12 representative perceptual vocabularies, and then matching the corresponding antonymic repertoire respectively, including pluralistic-minimalist, soft-rigid, fashionable -traditional, gentle - cold, smooth - rough, humanisation - mechanisation, light - heavy, warm - cold, interactive -stand-alone, smart -traditional, bright - muted, fixed -portable.

4.2 Establishment of product sample library

Through search engines, e-commerce platforms, and other means, sample images of music physiotherapy products and their related products were collected, and 46 products were collected in total. To ensure the objectivity and comprehensiveness of the samples, the 46 products were merged and categorised, eventually retaining 10 samples with typical characteristics (Fig. 3).

Fig. 3 Product Sample Library

4.3 Semantic difference method questionnaire

Using the semantic differential method, the sample photos of 10 music physiotherapy products were numbered 1-10, and 12 groups of perceptual vocabulary together to form a Likert seven-level scale questionnaire, whose perceptual values were set to -3, -2, -1, 0, 1, 2, 3, and subjects scored the 10 samples by their perceptual perceptions. A total of 24 questionnaires were distributed and 24 questionnaires were recovered, of which 20 were valid and 4 were invalid. The perceptual semantic evaluation of a single typical sample was obtained by counting and collating the questionnaire data and calculating the mean of the 12 sets of perceptual vocabulary scores for each sample (Table 1).

Table 1. Typical sample perceptual semantic evaluation

	multivariate	soft	stylish	gentle	slick	humanisation	light	warm	interactive	intelligent	vividness	fixed
1	1.35	.55	.05	-.30	-.25	.70	-1.00	.10	.10	-.40	1.25	1.85
2	.90	-.65	-.60	-.40	-1.20	.25	-1.40	-.30	-.75	-.65	1.05	1.85
3	1.00	-.40	.05	-.55	.50	.25	-.75	-.50	.55	.85	.40	.60
4	-.10	-.40	-.90	-.50	-.70	-.70	-.30	.00	-.85	-1.15	.75	.85
5	.30	.00	-.25	-.40	-.30	-.35	.25	-.90	.05	.35	.30	.05
6	.00	-.35	-.15	-.45	-.80	-.45	-.60	-.55	.30	-.45	.20	.70
7	.40	.00	-.80	-.10	-.35	-.65	-.75	.15	-.20	-.60	.75	1.25
8	.00	.10	-.50	.25	-1.10	.15	-.80	-.45	-.40	-1.10	.45	1.55
9	-.85	.20	-.80	-.50	-.60	.50	-.05	-.05	-.45	-.90	.25	-.15
10	-.60	-.70	-.60	-.65	-.80	-.20	-.45	.20	-.55	-.40	.85	.35

4.4 Data analysis

The calculated mean values were entered into SPSS software, a data statistics and analysis software produced by IBM, and the data were processed by factor analysis and principal component analysis method of dimensionality reduction, which finally resulted in a table of the common factor variance (Table 2), a table of the total variance explained (Table 3), a gravel diagram (Fig. 4), and a table of the component matrix (Table 4). As can be seen from Table 2, the extracted values range between 0.519 and 0.984, and the results of the factor analysis show that the information of most of the variables can be effectively extracted by the common factor. The number of principal components can be seen through the total variance explained graph and the gravel graph, from Table 3, it can be seen that the initial eigenvalues of components 1, 2, 3 and 4 are all greater than 1 and the cumulative proportion reaches 86.178%, therefore, these four components are extracted as the principal components, and it can be seen in Fig. 4 that at the beginning the change in the slope is more pronounced, and the first four eigenvalues are all greater than 1 and are significantly higher than the other points, from which it can also be determined that the components 1, 2, 3, and 4 are the main components. The ranking of each perceptual vocabulary can be obtained through the component matrix Table 4, and finally, the four main perceptual vocabularies influencing the Alzheimer's disease music physiotherapy products were selected: interactive, fixed, gentle, and warm.

Table 2. Common factor variance

Communalities

	Initial	Extraction
Zscore(multivariate)	1.000	.901
Zscore(soft)	1.000	.943
Zscore(stylish)	1.000	.862
Zscore(gentle)	1.000	.877
Zscore(slick)	1.000	.801
Zscore(humanisation)	1.000	.519
Zscore(light)	1.000	.887
Zscore(warm)	1.000	.861
Zscore(interactive)	1.000	.881
Zscore(intelligent)	1.000	.928
Zscore(vividness)	1.000	.896
Zscore(fixed)	1.000	.984

Extraction Method: Principal Component Analysis.

Table 3. Total variance explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.958	32.983	32.983	3.958	32.983	32.983	3.790	31.583	31.583
2	3.461	28.841	61.824	3.461	28.841	61.824	3.198	26.653	58.236
3	1.645	13.708	75.533	1.645	13.708	75.533	1.744	14.532	72.768
4	1.277	10.646	86.178	1.277	10.646	86.178	1.609	13.410	86.178
5	.805	6.705	92.883						
6	.380	3.170	96.053						
7	.289	2.408	98.461						
8	.138	1.147	99.608						
9	.047	.392	100.000						
10	1.287E-15	1.073E-14	100.000						
11	6.803E-17	5.669E-16	100.000						
12	-1.272E-16	-1.060E-15	100.000						

Extraction Method: Principal Component Analysis.

Fig. 4 Gravel diagram

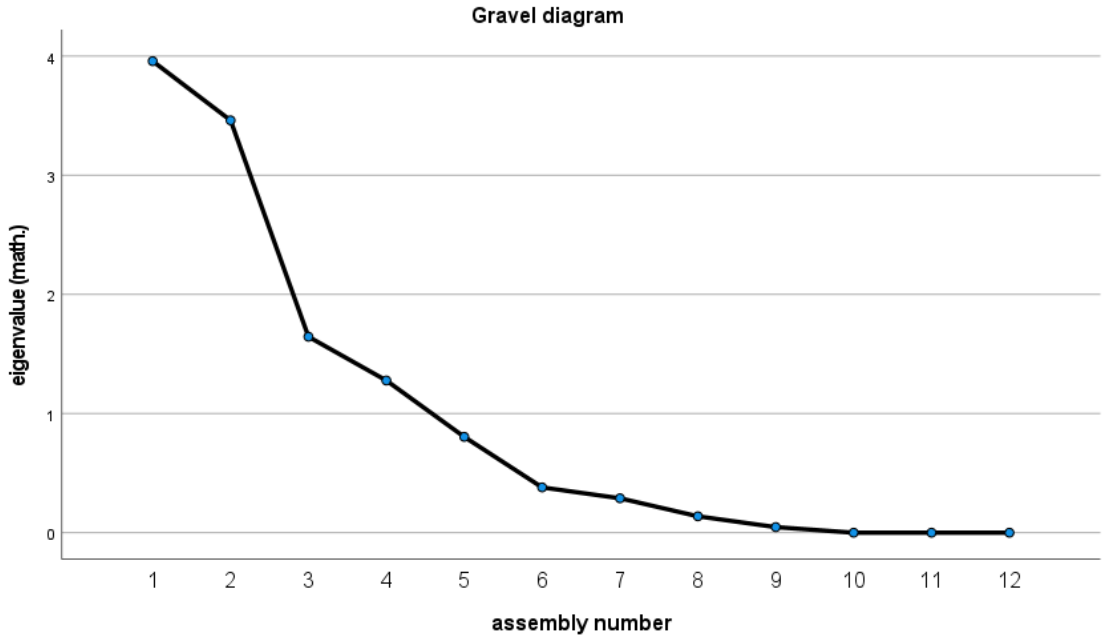

Table 4. Component matrix

Component Matrix[a]

	Component			
	1	2	3	4
Zscore(interactive)	.926		.125	
Zscore(intelligent)	.909		-.309	
Zscore(stylish)	.854	.358		
Zscore(slick)	.804		-.165	.357
Zscore(fixed)	-.263	.925		-.238
Zscore(soft)	.160	-.867	.212	.255
Zscore(multivariate)	.470	.800	-.142	-.140
Zscore(vividness)	-.351	.737	-.418	.235
Zscore(humanisation)	.222	.490	.151	.455
Zscore(gentle)	-.217	.411	.774	-.247
Zscore(soft)	.184	.268	.733	.548
Zscore(warm)	-.574	.230	-.322	.613

Extraction Method: Principal Component Analysis.

a. 4 components extracted.

5. Alzheimer's disease music physiotherapy product programme design

5.1 Functional design

According to the needs of Alzheimer's disease patients for music physiotherapy products, 14 design requirements such as remote monitoring and fun play were identified and screened out, and it was concluded by using the Better-Worse coefficient analysis of the the Kano model that the attractive quality functions of the music physiotherapy products for Alzheimer's disease were "interaction with children", "multi-sensory interaction", "scientific color matching", and the one-dimensional quality functions are "mood regulation", "sleep aid" and "orientation". According to the results of the Kano model, this design has the following main points in terms of functional positioning:

1. Interaction with children

Patients with mild to moderate Alzheimer's disease often face communication difficulties and memory loss. Using voice interaction allows patients to have simple voice dialogues with their children, which can be greetings, sharing of memories, or playing voice messages from children, to evoke patients' fond memories of their families; using Bluetooth connection to associate the music physiotherapy product and mobile phone APP, the patient in the process of using the product, the child can real-time view of the patient's treatment data results of the output and feedback; personalised music playlists and different colored key sequences are set up on the mobile app according to the patient's preferences. Music genres such as classical music can also be played randomly and the key sequence is automatically generated, with the patient pressing the corresponding colored keys according to the color sequence played on the product display. Through simple and intimate interactions, it promotes the emotional connection between patients and their children, while also helping to alleviate the stress and pain of caregivers.

2. Multi-sensory interaction

Multi-sensory stimulation can enhance the patient's perceptual experience. Combining visual, tactile, and auditory stimulation, through vision you can see the up and down of the buttons, the change of colors, patterns, and lights on the display, through touch you can press the buttons of the corresponding colors to exercise the nerves and muscles, and through listening to the music that is synchronized with the visual effect you can feel the rhythm fast and slow. The three interact to achieve the purpose of music physiotherapy, allowing the perceptual system, nervous system, and motor system to be exercised, helping to create a comprehensive and pleasurable sensory experience.

3. Scientific color matching

Considering the impact of colors on mood and cognition, scientific color matching aims to use the right colors to guide the patient's emotional state and achieve a calming and comforting experience. Brightly colored products can go some way to helping Alzheimer's patients improve their already reduced differential visual acuity, with contrasting colors such as red, yellow, grass green and blue allowing for greater flexibility in brain function. color-specific buttons are more easily recognised by the patient, thus facilitating correct operation, and changes in color on the display can be synchronised with changes in the emotion of the music, enhancing the overall effect of the therapy.

Patients with Alzheimer's disease may also face sleep disorders. Providing audio content designed specifically for sleep aids, such as soft music, natural hypnotic sounds or guided meditations, patients can adjust the product to sleep aid mode before going to bed, fall asleep with lights and music, and continue to improve their sleep quality.

5.2 Modelling design

According to SPSS data processing analysis, the appearance of music physiotherapy products should be "interactive", "fixed", "gentle", "warm", which is more in line with the perceptual perception of Alzheimer's disease patients and helps to improve the use experience and therapeutic effect. According to the results of Kansei engineering, this design has the following main points in appearance modelling:

1.Product shape

The overall shape of the music physiotherapy product resembles a half-sphere, with round operation buttons of different colors distributed on the top, conveying a warm and accommodating feeling through the rounded shape. When the patient operates the round buttons, dynamic color, pattern and light changes are presented on the display for feedback to increase the interactive fun and visual effect. At the same time, allowing the patient to interact with the product through simple voice commands or voice interactions helps to improve the accessibility of the product and makes it easier for the patient to operate the product. to make the product more stable and less likely to tip over, the bottom of the product is designed with a flat base and added non-slip material to avoid accidental sliding during use, while the upper buttons are designed as a fixed structure and take the form of an even distribution, to provide a soft and stable pressing feeling to help patients understand and operate the product.

2.Product color

The main body of the music physiotherapy product adopts light yellow, which is a warm and soft color with a certain affinity. Red represents enthusiasm and vitality, yellow represents optimism and hope, grass green represents nature, vitality and health, then blue represents tranquility and purity. By cleverly combining colors such as red, yellow, grass green and blue which are applied to the operating buttons, a warm and sunny atmosphere can be created in the overall design.

3. Product material

Choose soft, skin-friendly plush material, so that the appearance and touch of the product is more gentle, to prevent collision or friction during the use of the patient caused by adverse effects, while the plush material has a certain soothing effect, helping to reduce the patient's anxiety level and improve the overall emotional state. For patients' long time pressing operation, the surface of the silicone material button is soft and comfortable to touch, which can relieve hand fatigue, and also has a certain anti-slip property, which can avoid the finger sliding when operating the button, and provide a more stable using experience.

5.3 Design Options

After integrating the target group, product positioning and research data, the most appropriate functional and styling design elements were selected, and then "interaction with children", "multi-sensory interaction", "scientific color matching" and other design elements were integrated and applied to the design practice, resulting in the final Alzheimer's disease music physiotherapy product design program (Fig. 5).

Fig. 5 Product design program

2. Concluding remarks

This study provides insight into the need for the design of music physiotherapy products for Alzheimer's disease to take into account the theoretical guidance of Kansei engineering and the Kano model to further understand the specific needs of patients. The limited number of samples researched in the study can result in inaccurate data, and there are also regional restrictions on the users of the study, which are somewhat limiting, so there is a need to further improve the adequacy and comprehensiveness of design research. This study aims to draw the attention of researchers, designers and society to the special needs of the Alzheimer's disease patient group in terms of music physiotherapy products, and to provide some reference value for the research and design of such products in terms of theoretical approaches. Future design practice needs to be guided by continuous innovation to meet the individual needs of Alzheimer's disease patients and their families in a more comprehensive and in-depth manner, so as to enhance the treatment effects of the products and the overall quality of the users' lives. Combining design innovation with medical care to bring the effect of a warmer and more caring experience for Alzheimer's patients.

References

[1] Breijyeh Z, Karaman R. Comprehensive review on Alzheimer's disease: Causes and treatment[J]. Molecules, 2020, 25(24): 5789.

[2] Matziorinis A M, Koelsch S. The promise of music therapy for Alzheimer's disease: a review[J]. Annals of the New York Academy of Sciences, 2022, 1516(1): 11-17.

[3] Bleibel M, El Cheikh A, Sadier N S, et al. The effect of music therapy on cognitive functions in patients with Alzheimer's disease: a systematic review of randomized controlled trials[J]. Alzheimer's Research & Therapy, 2023, 15(1): 65.

[4] Materla T, Cudney E A, Antony J. The application of the Kano model in the healthcare industry: a systematic literature review[J]. Total Quality Management & Business Excellence, 2019, 30(5-6): 660-681.

[5] Jin J, Jia D, Chen K. Mining online reviews with a Kansei-integrated the Kano model for innovative product design[J]. International Journal of Production Research, 2022, 60(22): 6708-6727.

[6] López Ó, Murillo C, González A. Systematic literature reviews in kansei engineering for product design-A comparative study from 1995 to 2020[J]. Sensors, 2021, 21(19): 6532.

[7] Gong X, Guo Z, Xie Z. Using kansei engineering for the design thinking framework: Bamboo pen holder product design[J]. Sustainability, 2022, 14(17): 10556.

[8] DING Man, CHENG Yu, HUANG Xiaoguang, et al. Status and progress of kansei engineering design method[J]. Status and progress of kansei engineering design method[J]. Journal of Machine Design, 2020, 37(1): 121-127.

[9] Coronado E, Venture G, Yamanobe N. Applying kansei/affective engineering methodologies in the design of social and service robots: a systematic review[J]. International Journal of Social Robotics, 2021, 13: 1161-1171.