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Examining Emotional Factors of Smart Toilets Design for China's New Elderly

Qiuyi Li[1], Rosalam Che Me[2*], Mohd Faiz Yahaya[3]

[1-2]Department of Industrial Design, Faculty of Design and Architecture, Universiti Putra Malaysia, Serdang 43400, Malaysia
[3]Malaysian Research Institute on Ageing (MyAgeing), Universiti Putra Malaysia, Serdang 43300, Malaysia

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Corresponding Author:
Rosalam Che Me
rosalam@upm.edu.my
https://orcid.org/0000-0001-9507-6056

ABSTRACT

The emergence of a "new elderly" group in China with unique emotional needs has highlighted the importance of smart toilet design. This study explores the emotional needs of the new elderly and the potential benefits of specialized sanitary products in addressing their emotional well-being. The study developed a framework based on Norman's theory on the Three Levels of Emotional Design (NTLTED) and Maslow's Hierarchy of Needs Theory (MHNT), which are widely used in emotional design. A quantitative method was employed, and a questionnaire survey was conducted to collect the data by using cluster sampling from the high-tech zone in Chengdu, Sichuan, China. A total number of 501 respondents participated, among which 394 were new elderly and 108 were traditional elderly. The findings from a case study involving 501 elderly participants emphasize the significance of emotional factors in product design for the new elderly, specifically in the context of intelligent toilets in China. High-quality materials, personalized safety features, and cognitive enhancement improves user satisfaction. Lastly, identified pain points underscore the need for privacy and safety measures, clear instructions, and sensory comfort. Manoeuvrability enhancement addresses limited deftness and instruction readability, while adaptability focuses on tactile and visual cues. Respect, belonging, and progression considerations are pivotal in ensuring user satisfaction and well-being. This study develops a framework based on Norman's theory and Maslow's Hierarchy of emotional design in smart toilets for China's new elderly and highlights the importance of personalized features for user satisfaction and well-being.

Keywords: Elderly; Smart Toilet; Emotional Design; Maslow's Hierarchy of Needs Theory (MHNT); Norman's theory on Three Levels of Emotional Design (NTLTED)

1. INTRODUCTION

The ageing population in China is expected to double by 2050 (Lobanov-Rostovsky et al., 2023), as the study highlights and therefore implies the importance of addressing older adults' physical and emotional needs. One critical need is the establishment of smart toilets, which can improve the physical and mental well-being of the aged person (Han et al., 2020). Integrating technologies into useable products can support and sustain an individual's healthy behaviour and enhance self-awareness and health literacy (Meyer et al., 2016). Smart toilets are particularly beneficial for addressing toileting issues, which often affect the emotional well-being of older adults (Balaceanu et al., 2019).

Prioritizing the specific needs of the elderly in product design, especially in the growing market for smart toilets in China (Gong et al., 2020), is essential for promoting overall well-being. Research on product design for the elderly in China, specifically smart toilets, highlights the importance of balancing functionality with emotional appeal. Studies by Teng and Shen (2018) and Wang and Liu (2020) emphasize the need for tailored designs, while Mao et al. (2022) suggested a balance between functionality and emotional appeal. However, comprehensive guidelines are lacking, and specific emotional factors relevant to the new elderly remain unexplored. This study aims to identify emotional factors in product design for the new elderly in China, focusing on smart toilets.

The term "New Elderly" originated in Italy, describing the elderly who have reached the official retirement age yet choose to continue working or actively participate in social activities (Ma, 2010). In China, due to societal advancements and improved living standards, a new cohort of elderly has emerged. The new elderly are open-minded, energetic, receptive to new experiences, eager for social engagement, and value social interaction and communication (Teng & Shen, 2018). The elderly experience vulnerabilities in skin healing, bone density, muscle mass, cognition, vision, and hearing. It is essential to design products that cater to the specific needs of older adults by incorporating ergonomic features, adjustable settings, and intuitive interface. Promoting physical activity and training through specialized equipment can enhance muscle strength, balance, and mobility. Additionally, addressing sensory impairments with design features like high-contrast displays can improve the user experience.

Emotions play a crucial role in the well-being of older adults, with positive emotions contributing to a fulfilling life and negative emotions often requiring adjustment. Elderly individuals may experience negative emotions such as fear of loneliness and low self-esteem, which can be mitigated through product design; however, enhancing the design of sanitary products like bathtubs, shower rooms, bathroom cabinets, toilets, and sinks to meet the emotional needs of older adults can contribute to their positive mood and overall satisfaction. By considering and addressing the emotional needs of the new elderly in product design, we can create solutions that support their well-being and enhance their quality of life. This study intends to explore the emotional product needs of the new elderly, necessitating an initial examination of this group's physical and psychological attributes.

2. LITERATURE REVIEW

2.1. Characteristics of the New Elderly

The relationship between mental and physical health is essential. Ohrnberger et al. (2017) found that health policies should consider the indirect effects between mental and physical health. Investing in health and promoting social interaction can improve the overall well-being of older adults. Additionally, regular physical exercise has been associated with improved mental health outcomes, such as reduced symptoms of depression, anxiety, and cognitive decline (Arent et al., 2000; Chen et al., 2022; Erickson et al., 2015). Research suggests that maintaining good physical health can positively impact psychological well-being in older adults. Regular physical activity improves cognitive function, reduces depression risk, and enhances mental well-being (Gordon et al., 2018; Mandolesi et al., 2018). Conversely, physical ailments like chronic pain or limited mobility contribute to psychological distress and lower quality of life (Gatchel et al., 2007). The new elderly group, a subset of the elderly population, also experiences the effects of ageing on their bodies.

Tortora and Derrickson (2019) categorize the eleven principal systems of the human body based on their functions and contributions to overall well-being. These systems include protection and movement, control and coordination, and sustenance and reproduction. Despite limited research on the physical characteristics of the new elderly, existing literature provides qualitative descriptions of their traits, lacking quantitative measurement studies. Previous studies (Mao et al., 2022; Teng & Shen, 2018; Wang & Liu, 2020) suggest that the new elderly exhibit higher levels of physical health, energy, and vitality compared to traditional elderly individuals. Through advancements in science, technology, and healthcare, they actively engage in exercise and healthcare practices, leading to improved physical fitness. While physiological functions may decline with age, the proportion of healthy and relatively healthy new elderly individuals has increased.

Table 1. Physical Characteristics of the New Elderly and Traditional Elderly

Physical Factors		**Traditional elderly**	**The new elderly**
Protection and Movement	The Skeletal, Muscular and Integumentary systems	Accessible to injuries and have decreased balance	Slowly aging
Control and Coordination	The Nervous and Endocrine Systems	Hearing, vision, reflexes, and Memory deteriorate, and the endocrine system changes.	Healthier
Sustenance and Reproduction	The Cardiovascular, lymphatic, respiratory, digestive, urinary and reproductive systems	The functions decrease	Healthier

Table 1 shows an individual's age; their physical, cognitive, and sensory abilities undergo changes that can affect their daily lives. The elderly experience vulnerabilities in skin healing, bone density, muscle mass, cognition, vision, and hearing. It is essential to design products that cater to the specific needs of older adults by incorporating ergonomic features, adjustable settings, and intuitive interfaces. Promoting physical activity and training through specialized equipment can enhance muscle strength, balance, and mobility. Additionally, addressing sensory impairments with design features like high-contrast displays can improve the user experience.

Table 2. Psychological Characteristics of the New Elderly and Traditional Elderly

Psychological Factors		**Traditional elderly**	**The new elderly**
Autonomy needs	Interest	More traditional	Gravitate towards things that are enjoyable and pursue trends
	Independence	More dependent on family	Not confined by traditional notions, possessing their way of thinking
Competence needs	Learning	Not very open to new things	More willing to acquire new things and skills
	Self-challenge	Less willing to put effort into challenging themselves	More willing to challenge themselves

Relevance needs	Relationships	Less relationship-building	Engage in meaningful and supportive connections
	Activities	Less involved in social activities	More adept at socializing

Wang (2021) found that the psychological needs of the new elderly are based on the self-determination theory, as labelled in Table 2. The autonomy needs of the new elderly include interest and independence, as they are drawn to enjoyable activities and tend to embrace new trends without being constrained by traditional norms. Competence needs to involve learning and self-challenge, with the new elderly seeking to acquire new skills and engage in tasks that push their capabilities. Relatedness needs to focus on relationships and activities, with the new elderly fostering meaningful interactions with family and friends and participating in group activities to enhance their sense of belonging and connection.

2.2. Smart Toilets for the Elderly

Smart toilets are technologically advanced systems with automated flushing, seat sanitization, and efficient water management (Gong et al., 2020). They utilize sensors and information and communication technology (ICT) for optimal functionality and data collection, offering health and hygiene (Tasoglu, 2022; Zakaria et al., 2018). There is a significant untapped market potential for intelligent toilets in China, emphasizing the need to explore their evolution in the country (Gong et al., 2020). The functions of intelligent toilets, such as health monitoring, personal hygiene, and comfort, can improve the toilet experience for the elderly, providing health advice and cleaning assistance (Wang & Camilleri, 2020). Smart toilets have a significant emotional impact on the elderly, categorized into intergenerational relationships, independence, comfort, and purchase intention. Health monitoring and emergency alerts may foster collaboration with the elderly's children, enhancing emotional dependence. The functionality of smart toilets can boost dignity and independence, especially for those with mobility impairments (Balaceanu et al., 2019). Additionally, smart toilets offer intelligent safety services, aiding in disease detection among the elderly (Fong et al., 2023). The emotional experience with these products influences the elderly's purchasing decisions, with perceived value in health care, technology, and usability being key factors (Esmaeilzadeh., 2023).

2.3. Theoretical Framework Construction

The introduction of an intelligent toilet and its emotional relationship with the elderly could be testified by theories related to emotional design and the needs of the new elderly. Mainly, Norman's Three-level theory of Emotional Design (NTTED) (Norman, 2007) is widely used in the field of emotional design, and Maslow's Hierarchy of Needs Theory (MHNT) by Abraham Maslow (1943) has also been widely used and proved. These two theories are suitable for this study to explore the factors of emotional needs of the elderly. NTTED includes three levels: visceral, behavioural, and reflective level. At the visceral level of emotional design, users have instinctive responses to a design based on sensory experiences and aesthetics. For the elderly, especially those with visual impairments, designs must use clear fonts, contrasting colours, and intuitive icons to be easily understandable (Fang et al., 2016). The behavioural level focuses on usability and functionality, ensuring user-friendly products align with users' goals. It is crucial to elicit positive emotional responses and a sense of control, considering the potential physical limitations of the elderly. Designs should also incorporate the elderly's physical and mental health to influence their well-being (Elderkin-Thompson et al., 2008).

The reflective level of emotional design aims to create meaningful experiences that align with users' values, aspirations, and identities. This level can evoke deeper emotions and personal connections, especially vital for the elderly with rich experiences and memories linked to various products and services (Martínez-López et al., 2021). By considering the visceral, behavioural, and reflective levels of emotional design, designers can create products and services that cater to the physical and cognitive abilities of the elderly, enhancing their quality of life.

Maslow's Hierarchy of Needs provides a framework for understanding the progression of fundamental human needs towards self-actualization. For the elderly, technology can assist in meeting physiological and safety needs (Kang & Lee, 2015), while ICT-based welfare services can address social and esteem needs (Chen & Schulz, 2016). Home automation and positive social support can enhance self-esteem, leading to self-actualization through leisure and cultural activities (Pal et al., 2018). Designing products that align with these needs can enhance the quality of life for the elderly. The study's rationale, as emphasized in the prior literature review, is that the physical and psychological dimensions of the ageing population are closely interconnected. Understanding the complexities of this demographic's emotional needs and thoroughly examining their behaviours from every conceivable angle. Thus, MHNT can address the extensive needs of the elderly, encompassing both physical and psychological aspects. NTLTED, the core theory of emotional design, can provide more targeted emotional design recommendations when combined with MHNT.

Figure 1 shows the correlation between NTLTED and NHNT that Motivates Identifying the Emotional Variables for designing for the New Elderly.

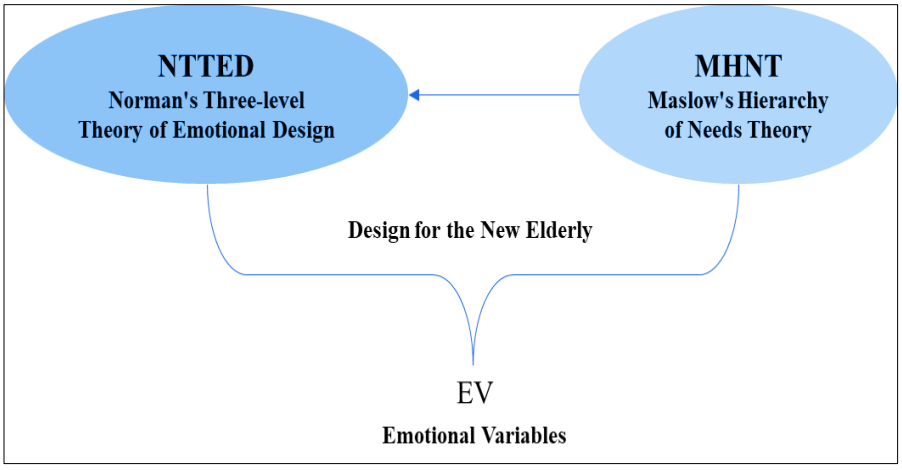

Figure 1. The Correlation between NTLTED and NHNT

Figure 1 illustrates the correlation between NTLTED and NHNT, aiding in identifying emotional variables (EVs) for designing products for the new elderly. NTLTED, serving as the central pillar of this study, offers a comprehensive perspective for understanding the emotional aspects of design when combined with MHNT. This correlation aims to distil and delineate the EVs for the new elderly, which is crucial for designing the research. This synergistic approach not only facilitates a deeper understanding of the emotional components concerning the new elderly but also lays the groundwork for practical applications and interventions to improve their well-being and quality of life.

2.4 Construction and Analysis of the Theoretical Framework

This study proposes a theoretical framework, as shown in Figure 2, that illustrates the process of identifying emotional factors in designing products for the new elderly. Firstly, the study analyzes the physical characteristics of the elderly (Protection and Movement, Control and Coordination, and Sustenance and Reproduction), as well as their psychological characteristics (Autonomy needs, Competence needs, and Relevance needs), pinpointing critical points within each aspect. Subsequently, researchers employ the correlation between NTLTED as the core theory and MHNT to determine the EVs of the elderly, categorized primarily into three aspects: visceral, behavioural, and reflective.

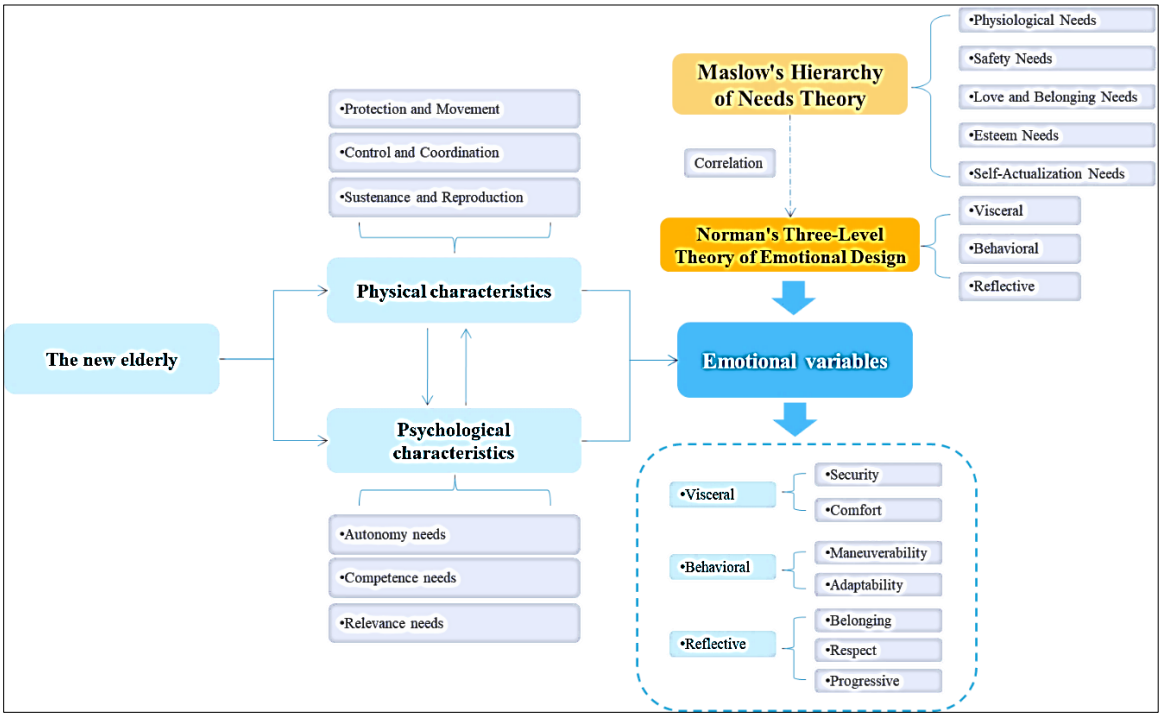

Figure 2. Theoretical Framework

The visceral level includes security and comfort, and security means products should provide a sense of safety to the new elderly groups, which is reflected in the product's function and appearance. Comfort refers to the new elderly's direct and indirect perception of a product's comfort level. When designing products, it is essential to fully consider their physical and psychological factors, such as their decline. The behavioural level encompasses manoeuvrability and adaptability. Manoeuvrability refers to the product's operation aligning with the physiological and psychological characteristics of the new elderly. For instance, considering the functional decline of the elderly, complicated operations should be minimized. Adaptability implies that the product can adjust to the physiological and psychological changes of the new elderly. The reflective level includes belonging, respect, and progressiveness. Belonging signifies the elderly's longing for connections with others, items, or trust in someone or something. Respect denotes their desire to be treated equally and respected by others, much like younger people. Despite their advanced age, they strive to learn and integrate into society. Progressiveness reflects their willingness to accept and learn about world changes and adapt themselves to society's development.

3. METHODOLOGY

This study employs a quantitative method, and a questionnaire was conducted to collect the data. This study investigates the emotional needs of the new elderly groups in China for intelligent toilets as a product, focusing on the representative sample of the regional elderly population. Cluster sampling is utilized as the method for this study. The research location chosen is the high-tech zone in Chengdu, Sichuan, China, representing the average level of developed cities in China. The population of the Chengdu high-tech zone is approximately 1,257,500, with the elderly accounting for 12.05%. The minimum sample size for this survey is 384, based on a population of 151,528, a 5% margin of error, and a 95% confidence level. An additional 10% of the minimum sample is necessary to account for potential errors, equating to 423 respondents. The questionnaire is structured into three sections to address research objectives. These sections include Demography and Screening (Section A), Emotional Demands for Smart Products (Section B), and Emotional Improvements in Smart Toilets for the New Elderly (Section C). Additionally, the questionnaire was in both Chinese and English. All participants provided informed consent, and the study was conducted following the Declaration of Helsinki guidelines, approved by the Ethics Committee for Research Involving Human Subjects at Universiti Putra Malaysia
(Ref. no: UPM/TNCPI/RMC/JKEUPM/1.4.18.2 (JKEUPM).

Table 3. Questions for Categorizing the New Elderly Population

Questions	Options	Score
Are you willing to accept and learn new things and technologies?	Yes	2
Are you eager to participate in social activities? (Including online and offline)	No	0
Are you willing to spend time on your hobbies?	Maybe	1

This study introduces three questions for screening the new elderly, as outlined in Table 3. Respondents who answer 'Yes' receive two points, 'No' earns zero points, and 'Maybe' results in one point. Those who accumulate four points or more are categorized as part of the new elderly group. Questionnaires are distributed via the online survey platform (www.wjx.cn). To ensure the precision of the target demographic, respondents' internet protocol (IP) addresses are restricted, allowing only individuals aged 60 and above to participate. This measure ensures that the data accurately reflects the elderly population. After discarding invalid questionnaires, researchers employ specific codes to align the data within SPSS, moving forward to the subsequent data analysis stage. After collecting and excluding invalid responses, 501 valid samples are available for analysis.

Table 4. KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.813
Bartlett's Test of Sphericity	Approx. Chi-Square	2383.017
	Df	1081
	Sig.	.000

Table 4 presents the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity for the survey. The KMO value is 0.813, indicating that the sample is suitable for factor analysis. Bartlett's test of sphericity shows an approximate chi-square value of 2383.017 with 1081 degrees of freedom and a significance level (p-value) of 0.000, confirming that the correlations between items are sufficiently significant for factor analysis.

4. RESULTS AND DISCUSSION

4.1 Analysis of Demography and Screening

Table 5 covers the demographic analysis and shows that about 59.28% are male respondents, 40.70% are female respondents, and most are between 60 and 64 years old. Their occupational distribution is relatively balanced across various professions. The overall educational background is concentrated at a moderate level. The majority falls within the income range of 2000-5000 CNY (Chinese Yuan), and living alone is less common, with most elderly individuals residing with their families.

Table 5. Demographic Information of New Elderly and Traditional Elderly

Cross-tabulation (Chi-square) analysis results						
Questions	Demographic	Elderly type (%)		Total	$\chi 2$	p
		Traditional elderly	New elderly			
Gender	Male	68(62.96)	229 (58.27)	297(59.28)	0.73	0.379
	Female	40(37.03)	164(41.73)	204(40.71)		
Age	60-64 years	40(37.03)	237(60.30)	277(55.28)	24.35	0.000**
	65-69 years	26(24.07)	84(21.37)	110(21.95)		
	70-74 years	23(21.29)	44(11.19)	67(13.37)		
	75 and above	19(17.59)	28(7.12)	47(9.38)		
Occupation	Government or public sector employee	17(15.74)	69(17.57)	86(17.66)	3.88	0.58
	General employee in a company or organization	24(22.22)	67(17.04)	91(18.64)		
	Self-employed/ Entrepreneur	17(15.74)	54(13.74)	71(14.72)		
	Unemployed	19(17.59)	66(16.79)	85(16.96)		
	Retire	20(18.51)	73(18.57)	93(18.53)		
	Other	11(10.18)	64(16.28)	75(14.70)		
Highest level of Education	Elementary school diploma or below	22(20.37)	49(12.46)	71(14.72)	27.16	0.000**
	Junior high/ Senior high/ Secondary	46(42.59)	89(22.64)	135(26.96)		

	technical school diploma					
	College/ Bachelor's degree	36(33.33)	236(60.01)	272(54.21)		
	Master's degree or above	4(3.70)	19(4.85)	23(4.51)		
Income per month?	2000 CNY and below	22(20.70)	62(15.76)	84(16.76)	28.21	0.000**
	2000~5000 CNY	60(55.56)	127(32.36)	187(37.25)		
	5000~8000 CNY	18(16.67)	110(27.90)	128(25.49)		
	8000 CNY and above	8(7.47)	94 (24.01)	102(20.59)		
Who do you live With?	Living alone	20(18.59)	1(0.25)	21(4.12)	165.98	0.000**
	With a spouse	30(27.78)	240(61.09)	270(53.92)		
	With children	32(29.30)	149(37.93)	181(36.18)		
	With others	26(24.74)	3(0.76)	29(5.78)		
Have you experienced any Major life changes recently that have affected your emotional well - being?	Yes, and it has been positive	43(39.15)	131(33.33)	174(34.71)	5.49	0.06
	Yes, and it has been negative	13(12.07)	28(7.15)	41(8.18)		
	No, I have not experienced any major life changes recently	52(48.18)	234(59.52)	286(57.08)		
Do you have access to Resources or support systems that help you manage your emotions?	No, I do not have access to resources and support systems	24(22.22)	104(26.43)	128(25.59)	0.801	0.371
	Yes, I have access to resources and support systems	84(77.78)	289(73.57)	373(74.51)		
Have you experienced any physical health issues that have affected your Emotional well -being?	Yes	78(72.22)	279(70.992)	357(71.27)	0.063	0.802
	No	30(27.78)	114(29.08)	144(28.73)		
Total		108	393	501		
*** p<0.05 ** p<0.01**						

For screening purpose, these three questions elicit that the total number of new elderly is 393, while the number of traditional elderly is 108. Table 6 shows that about 42.31% of new elderly respondents answered that they are willing to accept and learn new technologies, and about 48.30% stated that they may be, which could also be considered yes. However, only 9.38% of respondents were willing to learn new technologies. Most respondents were willing to participate in social activities in the follow-up question. About 50.90% of new elderly respondents said they love to spend time with their hobbies.

In general, the differences between the new elderly and the traditional elderly are summarized as the new elderly population represents a significant segment among the younger elderly individuals, indicating an emerging trend in this demographic change. Regarding education and income, the new elderly tend to possess higher education and income levels than the traditional elderly, highlighting potential socioeconomic advantages for this group. The new elderly are less likely to live alone and more likely to live with their spouse and children, emphasizing a higher level of family cohabitation and support. Both new elderly and traditional elderly acknowledge the impact of health issues on their psychological state, suggesting a shared understanding of the interplay between physical and mental health.

Table 6. Questions to Screen the New Elderly

Frequency analysis results			
Questions	Options	Frequency	Percent (%)
Are you willing to accept and learn new things and technologies?	No	47	9.381
	Maybe	242	48.303
	Yes	212	42.315
Are you eager to participate in social activities (Including online and offline)?	No	54	10.778
	Maybe	233	46.507
	Yes	214	42.715
Are you willing to spend time on your hobbies?	No	42	8.383
	Maybe	255	50.898
	Yes	204	40.719
Elderly type	Traditional elderly	108	21.557
	New elderly	393	78.443
Total		501	100.0

4.2Analysis of the Psychological State Differences between New Elderly and Traditional Elderly

Table 7 shows that a significant proportion of the elderly have not experienced major life changes, while those who have experienced such changes tend to have a more positive outlook. A considerable portion of the elderly believe that health issues can impact their mood. Overall, the happiness index is relatively high among the elderly population. In addition, most of the elderly in this sample express a desire for social interaction, a sense of life purpose, and a relatively high level of happiness. They also tend to be satisfied with their current lives.

Table 7. Psychological State Data of the New Elderly and Traditional Elderly

Independent sample t-test				
Questions	Elderly type (Mean±Std. Deviation)		t	p
	The Traditional elderly (n=108)	The new elderly (n=393)		
How important is it for you to have someone to talk to regularly?	2.722±0.994	3.013±0.771	-2.814	0.006**
Do you feel like you have a sense of purpose or meaning in your life right now?	2.546±1.241	3.064±0.838	-4.084	0.000**

How often do you feel sad or down?	2.435±1.007	1.751±0.658	6.683	0.000**
How important is it for you to have activities to look forward to?	3.000±1.085	3.349±0.922	-3.345	0.001**
How satisfied are you with your current living situation?	3.204±1.083	3.489±0.907	-2.503	0.013*
How often do you feel happy or content?	2.481±1.009	2.710±0.837	-2.157	0.033*

* p<0.05 ** p<0.01

4.3 Analysis of Emotional Demands of the New Elderly for Smart Products

Figure 3 shows that "New elderly" use about 34% of smartphones, followed by 29% of smart TVs, 19% of intelligent toilets, 13% of smart speaker devices, and 9% of other smart devices. The leading intelligent products used by the new elderly are smartphones and smart TVs. Additionally, the prevalence rate of smart toilets indicates a significant demand for intelligent toilets among the new elderly in China.

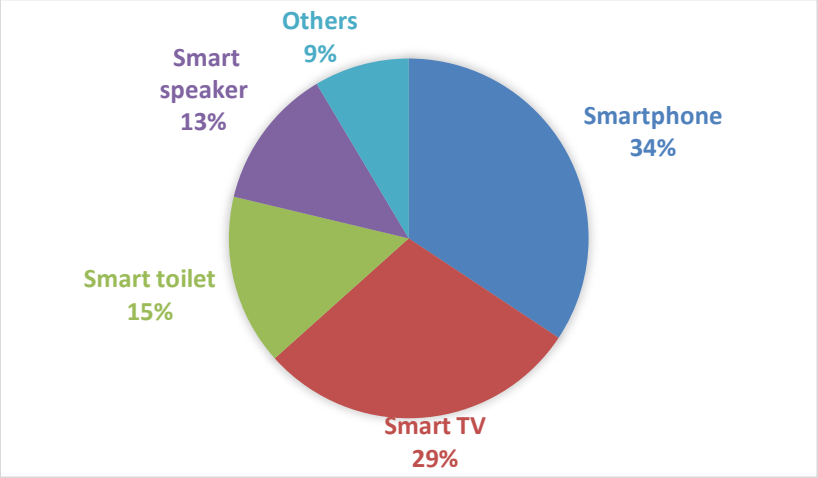

Figure 3. Categories of Innovative Products Used by New Elderly

In Table 8, the elderly were asked two questions, and it shows that the majority of the new elderly can quickly grasp the basic operations of smart devices, and most of the new elderly seek help from family members to learn how to use intelligent products. About 55.73% of participants claimed they would learn about new smart devices within an hour, and 65% claimed they would get help from family and friends to learn new innovative technology. In the follow-up questions, respondents were asked about the functions of the intelligent product. 27.57% of respondents claimed software issues or hardware problems could cause frustration.

Table 8. Maneuverability Data of Inconveniences When Using Smart Products

Response and popularity rate			
Categories of "What inconveniences did you encounter when using smart products"	Response		
	N	Response Rate	Popularity
Complex operation steps	186	24.538%	47.328%

Confusion caused by too many features	186	24.538%	47.328%
The interface doesn't match your physical decline (such as vision, hearing, and haptics)	176	23.219%	44.784%
Software glitches or hardware malfunctions can make you frustrated or confused.	209	27.573%	53.181%
Others	1	0.132%	0.254%
Total	758	100%	192.875%
Goodness of fit: $\chi 2$=190.879 p=0.000			

Table 9 highlights the product's security data. About product's security attributes, the intelligent product's too many features or complex operation steps would confuse the user and add up to the frustration. Therefore, users showed preference for simple interface, and in terms of the security data of product appearance, respondents ranked "some basic warning colours," "stable structure," and "harmless materials" as significantly necessary. As for the security data of interactive experience, the response rates and prevalence rates of the options "Biometric authentication (such as face recognition and fingerprint reader)" and "Information security" are significantly high.

Table 9. Security Data

Response and popularity rate			
Options of "What kind of smart product appearance can make you feel safe"	Response		
	N	Response rate	Popularity Rate
Some basic warning colours	269	23.07%	68.45%
Stable structure	302	25.90%	76.85%
Human-machine size	193	16.55%	49.11%
Harmless materials	267	22.90%	67.94%
Others	135	11.58%	34.35%
Total	1166	100%	296.69%
Goodness of fit: $\chi 2$=78.974 p=0.000			
Biometric authentication (such as face recognition and fingerprint reader)	255	22.16%	64.89%
Appropriate voice prompts	209	18.16%	53.18%
Real-time alerts and notifications	230	19.98%	58.52%
Information security	323	28.06%	82.19%
Others	134	11.64%	34.10%
Total	1151	100%	292.88%
Goodness of fit: $\chi 2$=82.236 p=0.000			

Table 10 shows the comfortability of the products related to color matching, 'Harmony' is the most important consideration, followed by 'Warmth'. When considering materials, 'Safe material' is prioritized, followed by "Durability" and "Comfortable touch".

Understanding how to use the product is crucial for elderly users, with ‘Leading you to know how to use the product’ ranking first. Nostalgic styles are preferred, with ‘Related to nostalgic feelings’ being the most popular. Finally, for interface comfort, ‘Icons guiding interface operations’ are preferred, followed by ‘Concise content’.

Table 10. Comfortability of the Product

How do you want the colours of intelligent products to make you feel?	**Mean**	**Std. Deviation**
Reliability	4.064	0.844
Harmony	4.135	0.814
Warm	4.092	0.828
Luxury	3.359	0.904
Elegance	3.774	1.004
Clean	3.636	1.051
the colours of intelligent products	3.843	0.581
What material can give you a good experience while using intelligent products?	**Mean**	**Std. Deviation**
Comfortable touch	3.837	1.015
Safe	4.112	0.819
Matching the function of the product	3.817	0.949
Durable	3.855	0.94
kind of material	3.905	0.687
What kind of patterns on intelligent products can make you feel pleasant?	**Mean**	**Std. Deviation**
Related to your personal preference	3.751	1.01
It can lead you to know how to use the product	4.092	0.962
Related to the shape of intelligent product	3.748	0.982
Fashionable	3.695	1.044
Traditional	3.735	1.043
kind of patterns	3.804	0.796
What kind of intelligent product shape do you prefer?	**Mean**	**Std. Deviation**
Related to your personal preference	3.718	1.057
Related to your beliefs	3.697	1.029
Related to your nostalgic feelings	4.094	0.829
Fashionable	3.725	1.04
Traditional	3.695	1.056
product shape	3.786	0.783
What interface operations can make you feel comfortable?	**Mean**	**Std. Deviation**
Concise content	3.738	1.015
Appropriately sized icons	3.641	1.084
Icons that fit your aesthetic	3.692	1.017
Icons can guide you to operate	3.997	0.896
Interface operations	3.767	0.77

Table 11 shows the average value of product feedback, and the range of adaptability that the product offers. The adaptability data highlights that ‘practical guidance which can quickly improve the new elderly's user experience when using intelligent products’ ranks first as being user-friendly. And ‘quick tips in case of emergency’ ranking second, ‘to adapt to your functional decline and customize an operation plan’ is number three on the list, and ‘clear feedback on whether the product is working correctly’ comes fourth. It also shows the value of innovative product interaction methods. The acceptance of the intelligent product interaction method through ‘voice interaction’ is the highest ranking, and ‘touch interaction’ranks second.

Furthermore, 'Motion interaction' ranked as third, and 'augmented reality' (AR) and 'virtual reality' (VR) interaction ranked fourth.

Table 11. Adaptability Data

What kind of product feedback can enhance your user experience when using intelligent products?	**Mean**	**Std. Deviation**
Provide effective guidance	4.02	0.909
Adapt to your functional decline and customize an operation plan	3.705	1.007
Clear feedback on whether the product is working properly	3.631	1.052
Quick tips in case of emergency	3.812	0.94
Product feedback	3.792	0.772
How willing are you to try different methods of interacting with intelligent products?	**Mean**	**Std. Deviation**
Voice interaction	4.069	0.899
Touch interaction	3.72	1.002
Augmented Reality (AR) and Virtual Reality (VR) interaction	3.565	1.011
Motion interaction	3.674	1.107
intelligent product interaction methods	3.757	0.8

Table 12 clearly shows that individuals place a high value on the sense of respect, belonging and progressiveness that well-designed smart products offer. When it comes to belonging, reliable performance and personalized features are of key importance, followed by safety and a unique appearance or function. It exhibits that high-quality, emotionally resonant, interactive, personalized, and intelligent products are the most respected. Regarding self-improvement, high-quality products are seen as the most stimulating, followed by products that stimulate imagination, improve creativity, and enhance a sense of responsibility. These findings suggest that individuals value innovative products that function well and cater to their emotional and self-improvement needs.

Table 12. Data of Belonging & Respect & Progressive

What kind of feeling can an excellent innovative product bring to you?	**Mean**	**Std. Deviation**
A sense of belonging	3.743	1.004
Be Respected	4.127	0.848
A feeling of satisfaction	3.684	1.006
kind of feeling	3.852	0.77
What kind of product features can bring you a sense of belonging?	**Mean**	**Std. Deviation**
A unique appearance or function	3.595	1.055
Personalized	3.735	1.031
Reliable performance	4.211	0.826
Safety	3.733	1.014
kind of product features	3.819	0.786
Which features of an intelligent product can make you feel respected?	**Mean**	**Std. Deviation**

High-quality	4.003	0.944
Personalized	3.893	0.963
Interactive	3.964	0.992
Emotional resonance	3.99	0.939
Which features of an intelligent product can make you feel respected?	3.962	0.798
Which features of an intelligent product can give you a sense of self-improvement?	**Mean**	**Std. Deviation**
Stimulating your imagination	3.908	0.879
Improving your cognition	4.099	0.807
Improving your creativity	3.885	0.878
Improving your sense of responsibility	3.875	0.822
Which features of an intelligent product can give you a sense of self-improvement?	3.942	0.652

4.4 Analysis of Emotional Improvements of Smart Toilet Designed for the New Elderly

Table 13 shows that most individuals prioritize privacy when using intelligent toilets. Safety features such as Grab bars, non-slip flooring, and an 'Emergency call button' are considered necessary by nearly half of the users, with the emergency call button ranking second. 'Natural lighting', 'Soft colours', and 'Decorative plants' contribute to a comfortable and relaxed environment, with 'All of the above' being the most preferred option. In alleviating anxiety, users believe all listed features can help, with 'Voice-guided instructions' ranking second, 'Aromatherapy dispensers' third, and 'Built-in speakers to play calming music' fourth. Moreover, as for features to alleviate anxiety when using a smart toilet, nearly half of people consider that all of the above features can ease the anxiety by using smart toilets. Besides, ‘Voice-guided instructions’ ranks second, ‘Aromatherapy dispensers’ is third, and ‘Built-in speakers’ to play calming music' is fourth.

Table 13. Visceral Level Factors of Smart Toilet

Questions	Options	N	Percent (%)
How important is privacy to you？	Not important	6	1.527
	Somewhat important	12	3.053
	Very important	128	32.570
	Extremely important	247	62.850
What safety features do you think are necessary for a smart toilet?	Non-slip flooring	57	14.504
	Grab bars	69	17.557
	Emergency call button	84	21.374
	All of the above	183	46.565
What type of design can help create a comfortable and relaxing environment?	Natural lighting	96	24.427
	Soft colours	77	19.593
	Decorative plants	43	10.941
	All of the above	177	45.038
Which of the following features can help alleviate anxiety?	Built-in speakers to play calming music	34	8.651

	Voice-guided instructions	97	24.682
	Aromatherapy dispensers	85	21.628
	All of the above	177	45.038
Total		393	100.0

As shown in Table 14, to exercise various operations poses 'difficulty with fine motor skills or have limited dexterity' is the most annoying feature, which is the number one trouble, 'Confused caused by how to choose functions' ranks second, 'Difficult to read small text or locate the controls on the smart toilet operation' ranked third, 'Challenging to remember how to operate' is fourth, and 'Others' is fifth.

Table 14. Maneuverability Factors of Smart Toilet (N=393)

Response and popularity rate			
Options of "What operational troubles have you experienced (may you encounter) while using a smart toilet?"	Response		
	N	Response rate	Popularity rate
Confused caused by how to choose functions	246	27.182%	62.595%
Have difficulty with fine motor skills or have limited dexterity	264	29.171%	67.176%
Difficult to read small text or locate the controls on the smart toilet	200	22.099%	50.891%
Challenging to remember how to operate	146	16.133%	37.150%
Others	49	5.414%	12.468%
Total	905	100%	230.280%
Goodness of fit: $\chi 2$=166.431 p=0.000			

In Table 15, as for the Adaptability factors 'Tactile feedback like vibration is difficult to feel' is the most confusing. 'Visual cues are difficult to identify' is second. 'The temperature feedback of the heated seat is not clear' ranks third. 'Have difficulty understanding Maintenance Alerts' ranks fourth, while 'Others' ranks fifth.

Table 15. Adaptability Factors of Smart Toilet (N=393)

Response and popularity rate			
Options of "What kind of smart toilet feedback will trouble you?"	Response		
	N	Response rate	Popularity rate
Visual cues are difficult to identify	254	21.453%	64.631%
The temperature feedback of the heated seat is not clear	236	19.932%	60.051%
Have difficulty understanding Maintenance Alerts	198	16.723%	50.382%
Tactile feedback like vibration is difficult to feel	302	25.507%	76.845%
Others	194	16.385%	49.364%
Total	1184	100%	301.272%
Goodness of fit: $\chi 2$=33.297 p=0.000			

To identify the belonging factors, Table 16 indicates that the majority of the samples are 'Health monitoring'. Besides, 'Voice activation (Can recognize voice well for interaction)' ranks second and 'Adjustable seat height' ranks third. The fourth choice is 'Night lights'.

Table 16. Belonging Factors of Smart Toilet

Question	Options	Frequency	Percent (%)
What kind of smart toilet improvements can give you a sense of belonging?	Health monitoring	203	51.654
	Voice activation (Can recognize voice well for interaction)	104	26.463
	Adjustable seat height	44	11.196
	Night lights	38	9.669
	Others	4	1.018
Total		393	100.0

Regarding respect factors, Table 17 shows that the improvement of smart toilets with 'Privacy screens' is the optimal way to remind people of belonging, ranking first, 'A quiet flush' ranks second, 'Pleasant lighting' ranks third, and 'Warm reminder' ranks fourth. 'Others' is number five.

Table 17. Respect Factors of Smart Toilet (N=393)

Response and popularity rate			
Options of "What kind of smart toilet features can promote a sense of dignity while using the toilet?"	Response		
	N	Response rate	Popularity rate
A quiet flush	257	26.413%	65.394%
Privacy screens	292	30.010%	74.300%
Pleasant lighting	222	22.816%	56.489%
Warm reminder	183	18.808%	46.565%
Others	19	1.953%	4.835%
Total	973	100%	247.583%
Goodness of fit: $\chi 2=231.764$ p=0.000			

As for the progressive factors represented by Table 18, a sense of respect that helps you take care of yourself' ranks first, 'Feel safe when using the smart toilet' is second, 'Feel comfortable when using the smart toilet' ranks third, 'Feels happy after using the toilet' ranks fourth, and 'Others' ranked fifth.

Table 18. Progressive Factors of Smart Toilet

Response and popularity rate			
Options of " How does a good smart toilet make you feel "	Response		
	N	Response rate	Popularity rate
Feel safe when using the smart toilet	299	24.548%	76.081%
Feel comfortable when using the smart toilet	296	24.302%	75.318%
Feel happy after using the toilet	272	22.332%	69.211%
A sense of satisfaction that you can take care of yourself	311	25.534%	79.135%
Others	40	3.284%	10.178%

Total	1218 100%	309.924%
Goodness of fit: $\chi 2$=215.998 p=0.000		

4.5 Discussion

The comparison between the new elderly and traditional elderly revealed significant differences in several areas, consistent with the findings of Teng & Shen (2018). This study expands on their work by specifically focusing on the emotional factors influencing product design for the new elderly in China, particularly in the context of smart toilets. The new elderly, characterized by higher education levels, higher incomes, and a greater willingness to adopt new technologies, exhibit distinct emotional needs compared to the traditional elderly. These differences highlight the necessity for tailored product designs that cater to the unique emotional and practical needs of this demographic group.

By starting with NTTED (Norman, 2007) and incorporating NHNT (Maslow, 1943), this study highlights the significance of the seven EVs, specifically visceral (security and comfort), behavioral, and reflective (belonging, respect, and progressiveness), as shown in the survey data, and consequently leads to discussing the key factors influencing each EV. For the new elderly, security and comfort are critical visceral factors. Fang et al., (2016) suggests that for visually impaired elderly, design should use clear, large fonts, contrasting colors, and intuitive icons for better discernibility and understanding.

This study more comprehensively identifies key security elements such as information security, stable structures, basic warning information, and non-hazardous materials. Besides, as for comfort, preferences included harmonious and warm colors, nostalgic shapes, guiding patterns, and safe durable materials. These preferences emphasize the importance of designing products that evoke positive emotional responses through their physical attributes, contributing to overall user satisfaction.

Maneuverability and adaptability are crucial at the behavioral level. Elderkin-Thompson et al. (2008) emphasizes that the physical and mental well-being of the elderly should be considered in design, as their self-perceptions of energy and health are linked to prefrontal brain morphology, which can be influenced by product and service design. The new elderly often face difficulties with fine motor skills and complex operation steps. Therefore, this study recognizes that assistive functions and clear operational steps are essential. Effective guidance and customizable operation plans are also highly valued, with voice interaction being the preferred method. These features ensure that the products are user-friendly and can be easily adapted to meet individual needs, enhancing the overall user experience.

Reflective factors encompass respect, belonging, and progressiveness. Martínez-López et al. (2021) highlights the role of social support in preventing depressive symptoms among the elderly. This suggests that products and services promoting social interaction can positively influence the reflective level of emotional design for the elderly. This study suggests that the new elderly prioritizes respect, with high-quality materials, emotional resonance, and interactivity being crucial. Privacy screens and quiet flush systems were among the most valued features, reflecting the deep-seated need for dignity and privacy. Belonging factors such as reliable performance and personalized safety features were also significant. Health monitoring and voice activation features made users feel part of a caring and supportive environment. Progressiveness was reflected in the desire for self-improvement and cognitive stimulation, with features enhancing cognition and stimulating imagination being highly valued.

The function of a good smart toilet can enhance the dignity of the elderly (Balaceanu et al., 2019), for example Fong et al., (2023) underscore their role in disease detection among the elderly through IoT-driven technology and Esmaeilzadeh (2023) points out that the elderly's willingness to use smart toilets is contingent on their perceived value, which includes health care, technology, and usability benefits. Therefore, it is significant to identify the pain points that significantly impact the user experience of the new elderly.

Based on the seven emotional factors, this study identified several pain points. Firstly, privacy was of utmost importance, with features such as emergency call buttons, grab bars, and non-slip flooring being essential for safety. Comfort-enhancing features like natural lighting, soft colors, voice-guided instructions, and aromatherapy dispensers were also crucial in creating a relaxing environment. Secondly, the new elderly often experience difficulties with fine motor skills and complex operation steps. This frustration is compounded by challenges in reading small text and locating controls. Effective guidance and customizable operation plans can alleviate these issues, making the smart toilets more user-friendly. Thirdly, privacy screens and quiet flush systems promote dignity and respect. Health monitoring and voice activation features foster a sense of belonging, making users feel part of a caring and supportive environment. Features that enhance cognition and stimulate imagination support the users' desire for self-improvement and continuous learning. Therefore, integrating NTTED and NHNT in evaluating the emotional factors in product design has proven effective. The insights gained from this study can guide future designs to better cater to the evolving needs of the new elderly, ultimately enhancing their quality of life and emotional well-being. These findings underscore the importance of addressing both practical and emotional needs in product design to create fulfilling and dignified user experiences for the new elderly.

5. CONCLUSION AND RECOMMENDATIONS

Based on the data analysis, the researchers critically identified and ranked the emotional factors influencing product design for the new elderly in China, particularly in the context of intelligent toilets. Regarding the selection criteria, factors that had a minimal impact on the relevant categories were omitted, while factors with a significant influence were selected and ranked in Figure 4. Additionally, different factors may influence each other mutually. In conclusion, this study highlights the crucial factors influencing the design of smart toilets for the elderly at visceral, behavioural, and reflective levels. Visceral factors emphasize the importance of security, comfort, and aesthetic appeal. Behavioural factors focus on assistive functionalities and clear operational steps for improved manoeuvrability and adaptability. Reflective factors underline the significance of respect, belonging, and progressiveness, ensuring the elderly feel valued and supported. Based on these insights, we recommend integrating safety features like emergency call buttons and non-slip flooring, incorporating natural lighting and soft colours for comfort, and enhancing user interactions with voice-guided instructions and health monitoring systems. These recommendations aim to address the pain points of the elderly, ensuring smart toilets are secure, user-friendly, and emotionally satisfying. The study found that 42.31% of the elderly are willing to accept and learn new technologies, while 9.38% are less inclined. The elderly often live with their families, indicating a higher family cohabitation and support level. They are socially active, have vigorous life pursuits, and maintain an optimistic attitude, leading to higher satisfaction and happiness than traditional elderly respondents. Most elderly individuals can quickly learn the basics of smart devices with family assistance. Recommendations include prioritizing using safe, durable, and comfortable materials in product design. Colour harmony and warmth are essential for comfort. Voice interaction is the most preferred method,

followed by touch and motion interactions. Designers should consider the elderly's physical and mental health, incorporating features that address common difficulties such as limited dexterity and readability issues. By focusing on the visceral, behavioural, and reflective levels of emotional design, products can be tailored to meet the needs of the elderly, enhancing their quality of life. Technology should assist in meeting their physiological and safety needs, while ICT-based welfare services can address social and esteem-level needs. Home automation and positive social support can enhance self-esteem and lead to self-actualization.

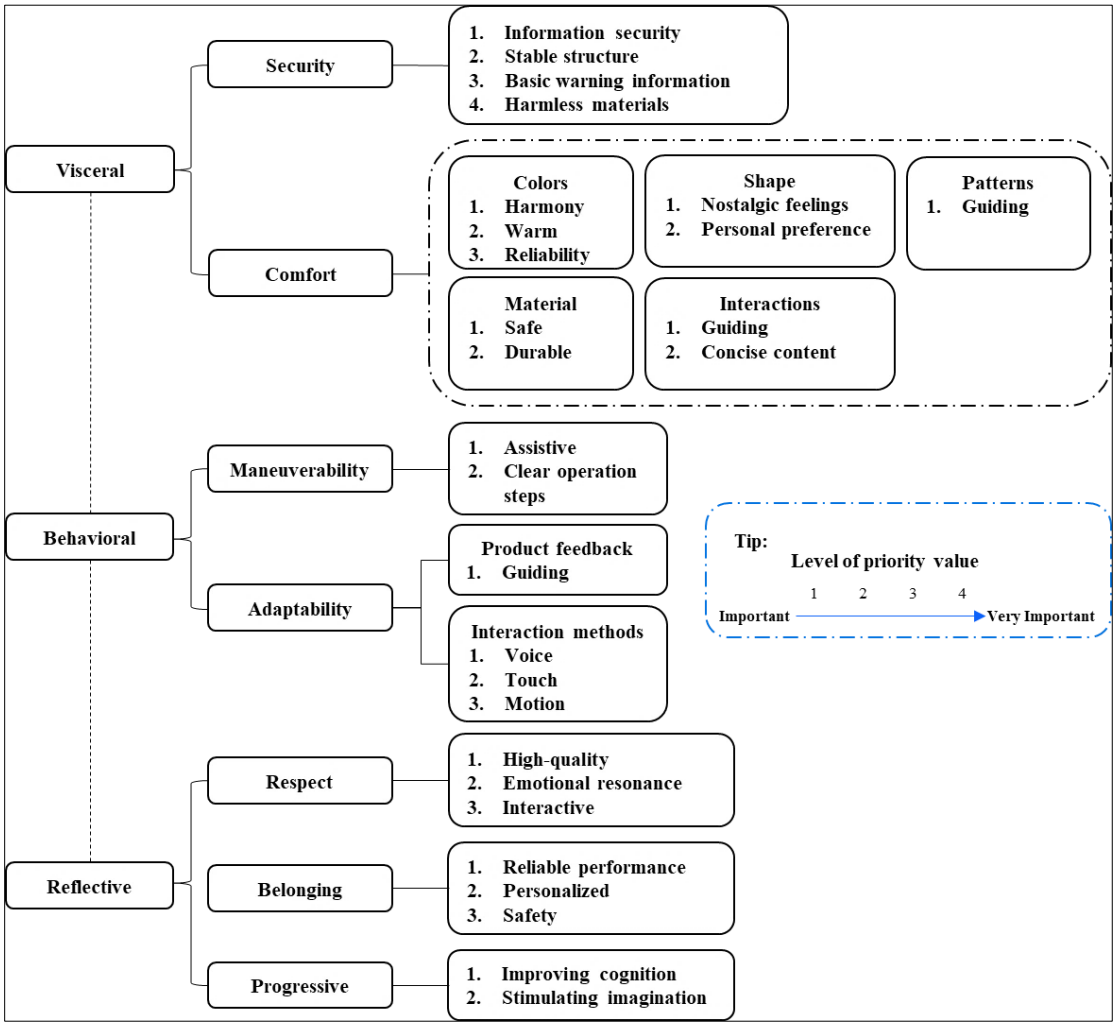

Figure 4. Emotional Factors in Product Design for the New Elderly in China

6. LIMITATIONS AND FUTURE STUDIES

The limitations of this research are threefold. Firstly, regarding the respondents, there are potential regional and cultural biases, self-reporting biases, and a limited coverage of product fields. Secondly, while the study exclusively targets the new elderly in China, engaging with new elderly groups in other regions would necessitate further research and validation. Moreover, the emotional factors suggested additional validation. Although the study provides general emotional factors, more detailed and specific emotional factors would require further research.

This research refines our understanding of the characteristics of the new elderly group in China. However, due to a current scarcity of quantitative research on the physical characteristics of this group in China, the study offers only a broad description based on existing literature. It is recommended that future product designs for the new elderly involve detailed measurements of this demographic's physical data to better accommodate their physical needs. Additionally, while this study focuses on the new elderly in representative regions of China, it may not account for varying factors from different regions, such as religious and cultural influences. Therefore, designing products for the new elderly in diverse cultural regions of China should incorporate additional emotional need factors. Nevertheless, the emotional factors from this study are generally applicable. Moreover, the theoretical framework devised in this study centered on the emotional needs of the new elderly towards products, which consequently may require further investigation and validation if applied to other groups. Furthermore, the emotional factors proposed in this study, based on the emotional needs of the new elderly in China, represents a relatively broad standard. Designers are encouraged to refine and validate their products according to the specific traits of the target group. In addition, the design suggestions for smart toilets proposed in this study, tailored to the emotional needs of the new elderly, provide a general direction for design. Detailed design elements should be more thoroughly explored and substantiated according to practical scenarios.

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