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An Emotional Design Model for Future Smart Product Based on Grounded Theory

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Abstract: Recently, smart products have not only demonstrated more functionality and technical capabilities but have also shown a trend towards emotional expression. Emotional design plays a crucial role in smart products as it not only influences users' perception and evaluation of the product but also promotes collaborative communication between users and the product. In the future, emotional design of smart products needs to be regarded as an important comprehensive design issue, rather than simply targeting a specific element. It should consider factors such as design systems, values, business strategies, technical capabilities, design ethics, and cultural responsibilities. However, currently, there is a lack of a design model that combines these elements. Currently, there are numerous practices in emotional design for smart products from different perspectives. They provide us an opportunity to build a comprehensive design model based on a large number of design case studies. Therefore, this study employed a standardized grounded theory approach to investigate 80 smart products and conducted interviews with 12 designers to progressively code and generate a design model. Through the coding process, this research extracted 547 nodes and gradually formed 10 categories, ultimately resulting in a design model comprising 5 sequential steps. This model includes user requirements, concept definition, design ideation, design implementation, and evaluation, making it applicable to most current and future emotional design issues in smart products.

Keywords: smart product; emotional design; design model; grounded theory; design theory; intelligent product



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1. Introduction

In recent years, the progress in artificial intelligence technology has led to the increasing maturity of smart products in terms of recognition, identification, and expression. These products not only have the capability to handle a wide range of complex tasks but also possess the ability to recognize user emotions and engage in more natural communication through various modes of expression [1]. This will lead to a future where smart products provide users with richer emotional experiences, gaining increased attention from design researchers [2]. Several studies have provided evidence that smart products capable of expressing emotions are perceived as more likable and trustworthy within human teams [3,4]. This capability enhances mutual understanding and fosters trust among team members [5–7]. Early in the 20th century, research on emotional design proposed that emotions will become an integral part of machine designs in the future [8]. Nowadays, with the advancement of artificial intelligence technology, design researchers are facing a wider range of complex research opportunities within this field [9–13].

The user's emotional experience with a product is subjective and arises from product interaction. Desmet and Hekkert have established a model to explain the emotional experience: aesthetic experience, experience of meaning, and emotional experience [14].

Norman also proposed three aspects of emotional design: visceral (perceptual), behavioral (expectation), and reflective (intellectual) [15]. Lin effectively combines cultural and emotional design, supporting Norman's arguments [16]. Scherer emphasizes the connection of emotions to external or internal events, enabling the design of emotional experiences [17]. Many studies have utilized these theories to create emotional experiences in smart product design. A few examples include setting gender for voice assistants [18,19] and designing dynamically changing light colors for smart speakers [9,10,13]. Even though much research has been conducted on the emotional design of smart products, there has not yet been a design model that encompasses all of the important aspects. Furthermore, some theories that attempt to discuss emotional design systems for smart products are primarily based on the designer's perspective [8,20], and there is currently a lack of empirical research based on a large number of existing product design cases.

As discussed in this paper, as emotional design of smart products continues to evolve with increasing complexity, it should be regarded as a comprehensive and systematic issue in the future [20]. It is not just a single design issue, but also relevant and coherent with user needs, values, business strategies, technical capabilities, design ethics, and cultural responsibility [21]. Currently, it has been proven in other domains that emotional design can be summarized into systematic design models [16]. We believe that emotional design for smart products can engage in the same kind of work. Fortunately, the emotional design of smart products has been applied in a number of cases, allowing us to develop design models more objectively and effectively by qualitatively analyzing the vast amount of available information and opinions [22]. Therefore, the goal of our study is to propose a model for emotional design of future smart products based on the analysis of a large amount of data using a grounded theory approach.

2. Literature Review

2.1. Examples of Emotional Design for Smart Products

The concept of emotional design has been widely adopted in both industry and academia. A few examples of this are displaying emoticons to represent a product's emotional state [23–25], influencing a user's perception of a product through the gender of the voice [26–29], or selecting a product's emotion color based on the correlation between emotion and color [10,30,31]. Even though all of the above address emotional design in smart products, they are not considered systematically.

In recent years, some design studies have attempted to systematize smart products' emotional design. Examples include using anthropomorphism as core modules [32,33] and giving smart products their own personality as clues for design. Several more examples include the dynamic change of light to simulate product breathing [34] or the design of behavioral actions for a product [35,36]. Furthermore, there are examples of two-way interactions in which the user's behavior affects the product's emotional presentation [37,38].

The majority of these design examples focus on the emotional presentation and interaction with smart products. Few integrate other elements, such as business strategy, technical competence, and cultural awareness.

2.2. Various Perspectives on the Emotional Design for Smart Products

The emotional design of smart products is an interdisciplinary topic that can be discussed from the perspectives of different disciplines such as computer science, design, psychology, and sociology. Norman, a design psychologist, has stated that when carrying out emotional design, the challenge is not only to express emotions through design elements but to make them communicate with humans through a system that meets the needs of the machine [8]. It is critical to understand that emotion is not just a surface expression, instead, it is a central organizational structure that facilitates the integration of the product's many modules [39].

There have been a variety of perspectives presented on this topic by researchers from various disciplines. From Picard's perspective, technology capability is crucial for

products to recognize, understand, and express emotions [40]. And according to Fogg's psychology theory, products should be designed according to human social cues to be viewed as individuals with emotions [41]. Meanwhile, Chapman believes that when making emotional designs, users must become collaborators and provide ideas to the designer [2].

As a result, we suggest that all of the above points are valid and should be taken into account in a comprehensive manner when developing models for the emotional design of future smart products. As part of the process of developing a model, a variety of perspectives from different disciplines can be utilized as references to improve the reliability of our design models.

2.3. Models Related to Smart Product Design

Current research on product design models is divided into two main categories: models that focus on analysis and models that concentrate on practice. A design model that emphasizes analysis, such as design thinking models [32–44], analyzes the design from the designer's perspective. In general, these models are based on a macro design perspective and can be used to analyze almost any design problem; however, they do not provide effective and specific guidance on specific design issues. A more similar design model to this study may be the emotion-based design analysis model [8,20,45,46], which proposes to design in terms of the emotional needs of the users but fails to describe other important aspects of a product, including technology, business, and management.

Practice-focused design models can be classified into two categories: design and development practice. Design practice models [47] describe design processes for specific topics, such as creative interface designs [48], air conditioner appearance designs [49], and metric product designs [50]. Most of these models are derived from design teams' experience so they are subjective in nature. On the other hand, development practice models focus mainly on the product production cycle [51–53] and its technical realization [54] but do not consider the role design plays during this period.

This study aims to provide an objective and reliable design model for smart products' emotional design. In contrast to focusing on the designer's point of view, we formulate our model by analyzing and summarizing a wide range of product information and user interviews. Therefore, we consider non-design aspects such as technology and business in our model. As a result, the resulting model is useful both for design analysis and as a guide to emotional product design practice.

2.4. Selection and Comparison of Research Methods

In order to conduct this study, we investigated and filtered research methods. We first examined common research methodologies used in the design, such as Kansei engineering [55] and research through design [56], to generate design models based on a summary of the experiences of design teams. Second, we considered qualitative research methods for our study, such as observational methods [57], interpretive phenomenological analysis [58], or grounded theory methods [59].

According to Smith and Morrow, a theoretical model represents a reasonable assumption and simplification of data [60], so we believe that grounded theory would be a better fit for this study. Through the analysis of large amounts of raw data and the abstraction of the data in a step-by-step manner, new theories or models may be constructed. Presently, there is no complete model of emotional design for smart products, as we discussed earlier. Therefore, standardized grounded theory can be used to generate valid design models from other data when there is little similar reference information available.

Thus, this study applied grounded theory to develop a theoretical model for the emotional design of smart products. In addition to providing researchers with a reliable design process, this model will also facilitate the production, development, management, and marketing of smart products, which will incorporate emotional elements into the product lifecycle.

3. Research Methodology

The objective of this study is to develop a systematic model for the emotional design of smart products. This paper aims to integrate various perspectives through qualitative research, including the analysis of case studies and user interviews to draw reliable conclusions.

3.1. Study Design

To build an emotional design model for smart products, grounded theory [59] was chosen. Grounded theory helped us build the model without prior knowledge of existing theories [61]. We used the standardized grounded theory coding steps [62] including a series of processes such as data collection, data analysis, theory coding, and theory saturation testing, as shown in Figure 1.

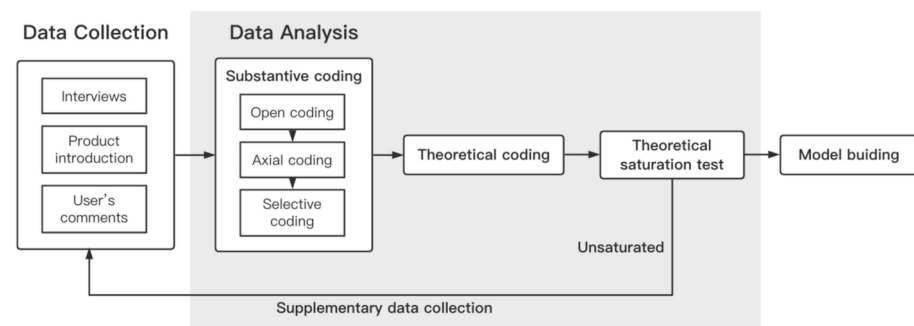


Figure 1. The standardized grounded theory coding steps [58].

3.2. Research Participants

The coding was conducted jointly by three Master of Design students, and at the end of each coding session, two other Master of Design students were invited to participate in a consistency discussion from a third perspective to reduce errors caused by subjectivity [63]. For the data collection phase, a total of five postgraduate design students were invited to collaborate on smart product data collection to avoid subjectivity.

3.3. Data Collection

In order to encompass the perspectives of both designers and users on the emotional design of smart products in the model [15], this study utilized two sources of information: first, product descriptions and user reviews; and second, semi-structured in-depth interviews. For data collection, we followed the principles of purposeful sampling [64] and used an intensity sampling approach [65] which refers to finding the sample that is most relevant and informative for the study's objectives. As intensity sampling is a subjective procedure, five students were invited to participate in the data collection process together.

3.3.1. Product Introduction and Users' Comments

We invited five design postgraduates to collect product data and user evaluations that met the following criteria: 1. The smart product possesses the capability to recognize, define, and express emotions and is explicitly described in pertinent materials such as development documents, promotional web pages, advertising videos, and others; 2. The product had been released and used by users and were not just conceptual designs; and 3. User evaluations were confirmed based on real experiences rather than hypothetical ones, which were determined through purchase details, photos, videos, and other means. After collecting data from various sources, we employed the triangulation verification method, which involves cross-referencing data from multiple perspectives to filter them [66]. For example, the team collaborated to determine their validity by comparing user evaluations with product descriptions. We collected 77 smart product profiles and user reviews from 10 different countries as initial data. Each product profile contains at least 10 valid profiles and at least 5 valid reviews.

3.3.2. Interviews

Using a semi-structured in-depth interview, we collected data on multiple meanings and perceptions of actions and events [67]. We interviewed five men and five women with experience in smart product design. Four of them were corporate employees and six were graduate design students.

Our interviews were divided into two parts, conducted face-to-face in a quiet room, and lasted 30 min. During the first part of the interview, we sought to understand the interviewees' experiences and viewpoints on smart products; in the second part, we invited participants to imagine creating a new design for an existing smart product that can understand users and express emotions.

3.4. Data Analysis

We conducted a two-part coding process using Nvivo: substantive coding and theoretical coding. Substantive coding includes open, axial, and selective coding. Theoretical coding involves analyzing and comparing coding results with existing research to generate new theories. We referred to studies on different types of affective phenomena [14,17] to conduct the encoding work. To reduce individual coder subjectivity, a consensus qualitative research (CQR) approach was chosen for the data analysis process [68]. According to the consensus principle [63], the coding was performed by three graduate students in the design field. Additionally, two other postgraduate design students were invited to discuss the results after the coding process had been completed.

3.4.1. Substantive Coding

During our substantive coding process, we began with open coding. The text was examined sentence by sentence, and keywords were identified from the original sources and coded accordingly. A total of 547 nodes were generated, including nerdy, voice gender, trustworthiness, color scheme, situational awareness, and so on. Afterward, we performed axial coding to analyze the associations between these nodes to produce 85 core elements. These elements included design philosophy, appearance, personality, and anthropomorphic behavior, among others. Finally, selective coding was conducted to integrate these core elements, including 10 core emotional design categories such as user emotional needs and product persona concepts.

3.4.2. Theoretical Coding

We developed an emotional design model for smart products by comparing substantive coding categories with existing research. In comparing the Double Diamond Model [42], IDEO's Design Process Model [69], and Stanford University's Design Thinking Model [43], we can discover clues for theoretical coding.

According to the Design Thinking Model, four substantive coding categories, such as "Design Elements", can be grouped into design practices related to the Prototype stage. Similarly, "Role Construction" and "Personality and Behavior" can be classified as "Emotional Elements of Smart Products", according to the Ideate session [70]. Additionally, it is possible to group the other core categories into the stages of Empathy, Define, and Test in order to formulate a complete design model framework.

3.4.3. Theoretical Saturation Test

As a saturation test, we added two interviews and three product cases. Both interviewees are male employees with experience in designing smart products. It was found that no new concepts or categories were generated, indicating that our emotional design model for smart products had largely reached saturation [71]. Additionally, we extracted 75 statements from the original data that described the emotional design thinking of smart products in order to confirm that the design thinking implied in the original data is reflected in our derived design model.

4. Results

4.1. Raw Data and Database

Data were collected from five graduate students in the field of design for substantive coding and theoretical saturation tests. As raw data, 80 product descriptions and user comments (including the original 77 cases and the 3 cases from the theoretical saturation test) on smart products were gathered from 10 different countries. We collected 971 emotional-relevant product introduction statements and 416 related user comments. Also, we interviewed 12 smart product designers (including the original 10 users and the 2 from the theoretical saturation test), ages 20–30, 6 men and 6 women, 8 of whom were postgraduates in design and 4 were company employees. In total, approximately 6 h and 11 min were recorded during the interviews.

Open coding was used to summarize the above data, resulting in 547 nodes, which represent a valid abstraction of the original material. There are a number of aspects related to the emotionalization of smart products. These include “multi-modality”, “bionics”, “identity value”, “lightness”, “portability”, “minimalist appearance”, “ease of use for children”, and so on.

4.2. Coding Result

Table 1 presents the coding results. To begin with, the 547 open coding nodes were compared and generalized by 3 students independently, resulting in the generation of 63, 87, and 69 axial codes. Forty-seven of these items were essentially consistent, with the only difference being in the description. Thirty-eight remaining axial codes with large differences were confirmed following consistency discussions. As a result, the total number of axial codes is 85. These codes include “Demand Expectations”, “Design Vision”, “Occupational Role”, “Material”, “Ease of Use”, “Operation Setting”, etc. In order to ensure that the axial codes are clear and encompass all aspects of the emotional design of smart products, two external design postgraduates were invited to participate in the two-hour discussion on consistency.

Table 1. The Coding Result of Grounded Theory.

Selective Coding	Axial Coding (Opening Coding Numbers)	Sub-Total for Opening Codes
User’s Emotional Needs	Demand Expectations (4), Emotional Expectations (4), User Preference (4), Demand Adaptability (7), Scenario Adaptability (7), Group Category (4), Social Concern (5), Demand Category (6)	41
Concepts for Emotional Design	The Interaction Concept (9), Design Vision (8), Design Concept (10), Design Ethics (6), Social Value (6), Business Strategy (6), Product Value (4), Pricing (2), Goal (9)	60
Role Construction	Occupational Role (9), Interpersonal Role (9), Product Identity (5), Smart Assistant Type (7)	30
Character and Behavior	Personality (8), Social Attributes (10), Emotional Characteristics (9), Anthropomorphic Behavior (14), Anthropomorphic Design Features (11), Anthropomorphic Design Attributes (8), Anthropomorphic Interaction Design (11)	71

Table 1. Cont.

Selective Coding	Axial Coding (Opening Coding Numbers)	Sub-Total for Opening Codes
Emotionally Relevant Functions	Home Function (5), Companion Function (5), Life Function (3), Leisure Function (4), Entertainment Function (4), Office Function (4), Information Function (5), Education Function (8), Communication Function (2), Transportation Function (5), Security Function (4), Health Function (6), Content Generation Function (3), Function Ecology (7), Technology Application (12)	77
Design Elements	Hardware (6), Software (5), Digital Content (5), Appearance Features (9), Appearance Size (1), Appearance Shape (5), Appearance Style (4), Material (7), Color Style (5), Design Direction (8)	55
Technical Capabilities	Iterative Ability (3), Recognition Ability (7), Perception Ability (5), Understanding Ability (7), Motor Ability (5), Intelligence Ability (9), Data Ability (5), Product Technology (7), Interaction Technology (7)	55
Use and Configuration	Software Attribute (2), Hardware Configuration (4), Hardware Attribute (9), Multi-Terminal Collaboration (9), Operation Method (5), Operation Setting (6), Interaction Method (10), Supporting Service (6)	51
Product Evaluations	Inclusion (5), Limitation (3), Diversity (10), Ease of Use (9), Proactivity (10), Immediacy (2), Product Features (11), Emotion-Relevant Personalization (4)	54
User Emotional Experience	User Experience (15), Product Impression (Subjective) (12), Product Texture Evaluation (4), Value Evaluation (4), Anthropomorphic Experience (5), User Attitude (4), Emotional Feeling After Use (9)	53

After axial coding, we systematically analyzed and compared the codes and, at a theoretical level, identified the core categories. Selective coding followed the same workflow as axial coding, with three design students working collaboratively to produce ten core categories. The three students had the same idea for eight categories: “User Emotional Needs”, “Concepts for Emotional Design”, “Role Construction”, “Character and Behavior”, “Emotionally Relevant Functions”, “Technical Capabilities”, “Product Evaluations”, and “User Emotional Experience”. Initial disagreements regarding “Use and Configuration” and “Design Elements” were resolved after a consistent discussion. The above ten categories represent the ten most critical aspects of smart products’ emotional design.

4.3. Category Definition and Model Presentation

A comparison of existing design models led to the development of an emotional design model for smart products. We referred to IDEO’s Design Process Model [69] and Stanford University’s Design Thinking Model [43] to further group the ten core categories into five categories. These categories are “User’s Emotional Needs”, “Concepts for Emotional Design”, “Emotional Attributes of Smart Products”, “The Practice of Smart Products’ Emotional Design”, and “Experience and Evaluation”. Figure 2 illustrates how these five categories are linked in a linear relationship to produce the emotional design model for smart products.

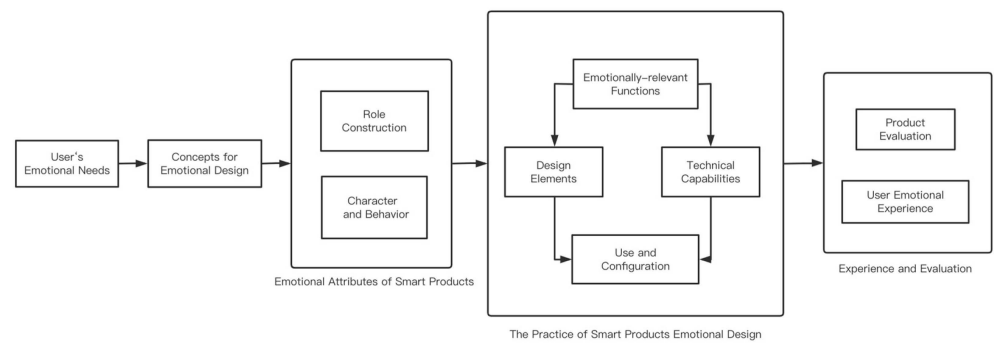


Figure 2. The theoretical coding result of grounded theory.

4.4. Theoretical Saturation Test

With the addition of two interviews and three product cases, our theoretical saturation test indicated that the current model did not continue to generate new concepts or categories. Also, we extracted 75 statements describing the emotional design thinking of smart products from the original data, enumerated their causal relationships, and represented them with Sankey diagrams using eCharts. Through this diagram in Figure 3, it is easy to see that the present model largely matches the design logic implied by the original data. As a result, our model for smart products’ emotional design is largely saturated [71].

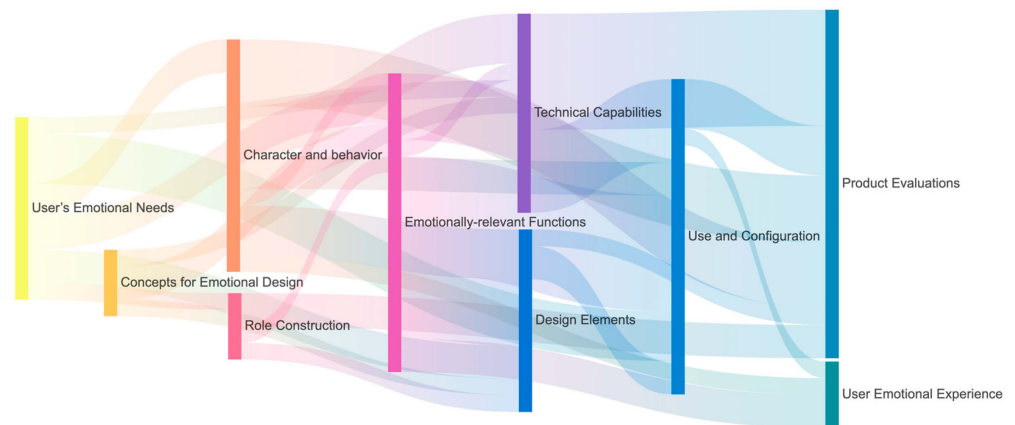


Figure 3. Cause relationships in original data in relation to emotional design.

4.5. Selective Coding Interpretation

In accordance with the standardized grounded theory coding process [62], this study summed 10 categories through selective coding, as shown in Table 2. These 10 categories represent an abstraction and summary of the full range of emotional design for future smart products.

Table 2. The Selective Coding Explanation and Original Data Reviews.

Selective Coding	Explanation	Original Data Reviews (Axial Codes)
User’s Emotional Needs	The emotional requirements or desires that a user has in relation to a product or service.	I usually just stand in front of him and stop him, just to embarrass him. Wait to see his follow-up reaction after stopping it. (Emotional Expectations) The traditional Chinese pentatonic scale is used to design the sound effect system, making Duer more suitable for Chinese families. (Social Concerns)

Table 2. Cont.

Selective Coding	Explanation	Original Data Reviews (Axial Codes)
Concepts for Emotional Design	The principles or ideas that form the basis of smart product's emotional design.	Through the minimalist animal-like design and colorful color matching, it awakens people's imagination of freedom. (Design Concept) My grandfather is in a nursing home. I hope Tombot brings him solace, because he looks so much like the only Pomeranian he remembers: Stewie. (Social Value)
Role Construction	The role of a smart product in human society.	An artificial intelligence singer based on AI deep learning algorithm to automatically generate music content. At present, there are many supernova singers such as Xiaobing, He Chang, Chen Shuiruo, Chen Ziyu, etc. (Occupational Role) MarsCat is the world's first bionic pet cat developed by Elephant Robotics, a robot pet that brings you comfort and surprise. (Interpersonal Role)
Character and Behavior	Personality traits and behaviors of a smart product.	The humorous personality that Siri was once proud of has also been overtaken by Google. (Personality) In a DIY teddy shop, there is a manual step is to put a heart in, and warm the heart before putting it in. (Anthropomorphic Design Features)
Emotionally Relevant Functions	The specific functions of a smart product that are related to the emotional experience of the user.	It can also notify family members when an elderly user encounters an emergency and assist the elderly in video calls. (Health Function) Neons can help with goal-oriented tasks and also personalize tasks that require a human touch. (Entertainment Function)
Design Elements	The physical or digital elements that can constitute the appearance, functionality, and behavior of smart products.	Romibo is also equipped with many sensors, including light sensors and acceleration sensors, which can control its trajectory so that the robot can automatically avoid obstacles in front of it. (Hardware) Among the round or square speaker shapes, Libratone's smart Bluetooth speaker has successfully attracted attention with its cute bird appearance. (Appearance Features)
Technical Capabilities	The specific skills, knowledge, or resources that are necessary to perform a task or function.	DuerOS has human language capabilities. It can understand human intentions and communicate with people in natural language. (Understanding Ability) Moxi follows orders and rules when system data reveals certain changes in patients. (Data Ability)

Table 2. Cont.

Selective Coding	Explanation	Original Data Reviews (Axial Codes)
Use and Configuration	How to use the smart product, and the process of preparing a product for use.	When you hold your iPhone close to HomePod mini, you can take immediate control without unlocking your iPhone. (Multi-terminal Collaboration) In terms of emotional interaction, the robot has set 41 types of expressions with dynamic design according to 24 emotions. (Interactive Method)
Product Evaluations	The product evaluation of smart products derived from user experiments.	This is Apple's longstanding commitment to diversity and inclusion. Products and services designed to better reflect the diversity of the world we live in. (Diversity, Inclusion) Proactively recommend the functions and information currently needed by users; proactively communicate with users to enhance understanding. (Proactivity)
User Emotional Experience	The emotional experience of a user while interacting with a smart product or service.	Very cool, but I wish they had protections against malicious remote takeover. A robot might pick up a pistol and kill you in your sleep. (User Attitude) The sound of the broadcast is not blunt or coquettish, and it is comfortable to listen to. (Use Experience)

1. User's Emotional Needs: It involves user and scenario analysis. Examples include the selection of target users and target scenarios as well as preferences derived from user research, such as emotional expectations. Moreover, there are concerns regarding special needs based on socio-cultural contexts, etc. Based on this category, real emotional needs of users are explained [72] and the core issues for emotional design are defined [47].
2. Concepts for Emotional Design: The design team identifies the core design concept by combining other information, such as cultural concepts and business strategies [73]. As an example, different design teams may propose concepts such as "emotion-relevant personalization" and "minimalism" for smart home products. It is important to define these design concepts in conjunction with social values, design ethics [74], business strategies, and design visions [75] which can be used to guide the design process in a variety of ways.
3. Role Construction: When brainstorming ideas for the emotional design of a smart product [76], designers often consider it to be a living thing, with role construction playing an important role. The concept of roles can be viewed in terms of occupational roles, interpersonal roles, and product roles, such as "doctor", "friend", "toy", etc. According to the theory of role construction in social psychology, people subconsciously presuppose each other's appearances and personalities when they interact. It is also possible to predict the behavior of others using role constructs. Therefore, defining the appropriate role for a product can help a design team in generating more specific design ideas.
4. Character and Behavior: For design teams to consider smart products as living beings for creative design, it is also important to consider their character and behavior. Designers often create personality types for smart products by imagining "behavioral habits", "social attributes", "anthropomorphic traits", etc. [7,77,78]. In conjunction with the actual functionality and technical capabilities, designers can express the personality and behavior of a product in various ways.

5. **Emotionally Relevant Functions:** Design teams often start the design from a specific functionality perspective rather than considering the experiential aspects. Two aspects determine the functionalities of a smart product: the features set by the smart product itself and the updated features derived from analysis of the emotional needs of the users. As an example, for smart speakers, the information quiz is an existing feature, whereas the child mode dialogue is a new feature designed specifically for children.
6. **Design Elements:** When faced with a specific product function, design teams should consider the selection of appropriate design elements [9,79]. “Software”, “hardware”, “appearance”, “materials”, etc., are all design elements necessary to achieve product function. Additionally, it is essential to consider the “shape”, “color”, “digital content”, “size”, etc. of these design elements.
7. **Technical Capabilities:** Technical capabilities are equally significant as design elements since the emotionality of smart products is enhanced by artificial intelligence technologies [80], such as “context awareness”, “emotion recognition”, “motion control” [81], etc. To ensure that the emotion of the smart product can be successfully expressed by the product and experienced by the user, the design team should consider the technical capabilities required to implement the function.
8. **Use and Configuration:** The design team must decide how users interact with the product after defining design elements and technical capabilities [82,83]. An interaction between the user and the smart product can be defined by concepts such as “interaction methods”, “operation methods”, “hardware and software configurations”, “multi-end collaboration”, and “supporting services”, which enable the user to interact with the smart product and have an experience [11].
9. **Product Evaluation:** A product evaluation can be identified after a product or prototype has been released and tested by real users [84], such as “ease of use”, “proactivity”, “inclusiveness” [85], etc. The design team can reflect on and further improve the product based on the objective evaluations derived from the experiments after the smart product has been developed.
10. **User Emotional Experience:** In addition to objective evaluations, users also have subjective emotional experiences with smart products [78,86]. For example, users may develop a certain level of attachment and closeness to the product or have anthropomorphic interpretations of the product. Most of these emotional experiences can be used as a useful reference for improving product design in terms of emotion-relevant personalization and emotion-relevant customization.

4.6. Explanation of Theoretical Sampling

The above ten categories are further subdivided into five classes, namely “User’s Emotional Needs”, “Concepts for Emotional Design”, “Emotional Attributes of Smart Products”, “The Practice of Smart Products’ Emotional Design”, and “Experience and Evaluation”. The five classes can be interpreted in light of the Double Diamond Model [42] and can also be compared to Stanford University’s Design Thinking Model [43], which includes stages such as “Empathy”, “Define”, “Ideate”, “Prototype”, and “Test”.

4.6.1. “User’s Emotional Needs” to “Concepts for Emotional Design”

Design teams often use empathy methods to identify user needs, such as observation and engagement [87]. Understanding users’ needs may allow design teams to identify what users expect from a product in terms of emotions, as well as dissatisfactions and barriers to emotions that may exist with smart products [43].

On the basis of the emotional needs of the user and the context in which they are used, a number of emotional design concepts are presented. These concepts provide the framework for the subsequent design and serve as the basis for developing a successful solution [73].

Here is an example based on the following initial data. A user is dissatisfied with the appearance of an existing smart product and requests a redesign that incorporates abstract design elements. This results in an emotional design concept, such as “minimalist design”.

“If the product looks like a real animal, it would be a bit creepy, and I’d like the appearance to be more abstract than realistic”.

4.6.2. Emotional Attributes of Smart Products

Emotional attributes of smart products are the result of divergent thinking from its design concepts, with the purpose of exploring a wide range of ideas about emotional design. In light of the designer’s intention to create an intelligent object, this phase consists of three factors: role, personality, and behavior [88]. These psychologically relevant attributes [89] are inextricably linked to the emotional experience of the user and can serve as a basis for motivating creative design.

For example, in the product description below, the smart product is described as a “friend” and given the character of “loyal”. In order to fulfill this emotional expectation, the design team designed a “regular update of the user’s desired content” function.

“For many years, it’s been your loyal friend and is constantly updated with interesting content you need”.

4.6.3. The Practice of Smart Products Emotional Design

The practice of smart products’ emotional design is the process of bringing ideas out of the mind and into the world. We begin this process by selecting specific product functions, either existing product functions that need to be improved or new product functions based on emotional needs. Following this, the design team considers how to implement this functionality and meet both technical and emotional requirements [9,79]. To meet these needs, it is necessary to take into account hardware, software, appearance, colors, materials, etc., as well as develop intelligent technological capabilities [80]. The final step is to define how the product may be used and configured so that its emotional design can be experienced by the user.

For example, as explained below, the design team proposed that a touch-sensitive function be developed for the robot Ollie’s animal-like features. Therefore, to fulfill this emotional function, it was necessary to equip it with a touch sensor and develop sensory capabilities.

“The haptic sensor gives Ollie the ability to ‘sense contact’ and respond to touch”.

4.6.4. Experience and Evaluation

To evaluate a product and gather feedback on the solution [11], user experiments should be conducted after the product has been released. Evaluation results of a smart product’s emotional design, including objective descriptions derived from experiments as well as subjective user experiences. As the final step in emotional design, this process not only allows us to review the design but also provides a reliable direction for iterative improvement.

Here’s an example of a robot designed to have consistent behavior, so that the user can anticipate it and feel comfortable communicating with it. This type of positive user experience can be used in subsequent design iterations.

“QTrobot acts in a consistent and predictable way to prevent children from feeling overwhelmed”.

5. Discussion

5.1. Comparison with Existing Models

By comparing the Double Diamond Model [42] and the Design Thinking Model [43], this study performs a theoretical coding step. These two models can explain most design issues from a macro perspective, while our model focuses on a single design issue: the emotional design of future smart products. For example, in the Design Thinking Model, the

Ideate stage primarily emphasizes team-based divergent thinking. In contrast, our model provides a more specific description of divergent thinking in terms of roles, personalities, and behaviors. Therefore, it is more useful as a reference for designers regarding this topic. Furthermore, this model differs from other theoretical models of emotional design, such as the Analytical Model of Emotional Design [8,45] and the Creative Interface Design Process Model [48]. They focus their work on analyzing user emotions and presenting specific design elements from the designer's perspective. However, they fail to take into account numerous factors, including user needs, business strategies, social values, core functions, technical capabilities, etc.

It is important to note that when designing smart products, other factors may affect the development of the product, so taking a single perspective can lead to a failed outcome [90]. Consequently, the model proposed in this study encompasses all aspects of user research, conceptual design, technology development, production, and testing. These enable design teams to look at all aspects of the process. A number of similar models have been developed, including the product development process cycle management model [51–53] and the product development practice model [54]. Typically, they are developed from the perspective of product management and product development, while very few are interpreted from a design perspective, and even fewer are interpreted from an emotional perspective. While our design model encompasses the entire process of product design and production, its core theme is not production management but rather emotional design. Further, we propose to integrate psychological elements such as role, personality, and behavior into the emotional design process of smart products, thereby developing a new design model.

5.2. How to Apply This Model in Smart Product Design

The model presented in this study can be a valuable reference for the emotional design of smart products. However, it is recommended that design teams consider making suitable adjustments based on specific circumstances, taking into account other relevant models or theories. Design teams can use the model to analyze the emotional aspects of smart products. In addition to analyzing and improving existing products, it can also be used to design new smart products. An innovative design team has the potential to make meaningful improvements to an existing smart product by following each step in the process. It should be noted that this design model does not require strict adherence. Depending on the design issues at hand, it is possible to skip certain steps or categories. However, we do not recommend reversing the order. For instance, it is acceptable to bypass the "Concepts for Emotional Design" category and propose "Role Construction" directly from "User's Emotional Needs". However, it would be challenging to draw meaningful conclusions by considering "User's Emotional Needs" from "Role Construction" in reverse. If a design problem is identified in the final category, users can revisit the beginning of the model to reassess the problem and redesign accordingly.

For the design of new smart products, this model should not be used alone but in conjunction with other smart product design process models. As this model focuses primarily on the emotional design of smart products, it cannot fully address non-emotional factors such as solution, productivity, and management. When used alone, it may overlook other essential features of a smart product.

6. Conclusions

The concept of emotional design for smart products is currently under heavy research, but it has not yet reached its full potential. In this area, existing design theories are too fragmented and subjective to provide guidance. Our belief is that a design model of this problem is needed to provide design teams with reliable theoretical guidance on the emotional design of future smart products. It is feasible to construct a reliable, objective, and systematic model by synthesizing fragmented design cases, design perspectives, and

design theories. As a result, this study collected data through user interviews and case studies and developed a design model based on grounded theory.

As shown in Figure 2, the central contribution of this paper is the model of emotional design for future smart products. Using the grounded theory approach, we derived this design model from a large amount of data. The model aims to describe the emotional design of smart products as a reproducible and iterative process. Design teams can use it as a guide to incorporate emotional design into the development of smart products. Our goal is to expand emotional design from being a single design issue to becoming a comprehensive design system by integrating multiple aspects. Our expectation is that future design researchers will develop new tools and methods based on this model.

Another unique aspect of this study is the use of grounded theory in the modeling process. Often, this type of design analysis and design process-related modeling is constructed through case studies and observation. It is, however, difficult to develop emotional design models of smart products due to a lack of design theory and prototyping difficulty. According to our findings, grounded theory can be used to develop theoretical models efficiently and fairly objectively in the absence of complete information.

This study also has certain limitations. Firstly, the model is currently in the theoretical stage and has not been tested in practice. Additionally, the 10 categories derived from the coding have not been thoroughly explored yet. Adjustments may be necessary during the implementation process. Second, all of our interviewees were Chinese. Although the product cases were collected from 10 different countries, they may still be biased due to cultural differences and social values. Third, this study covers a wide range of scenarios and product types, including healthcare, home, campus, etc., as well as physical and digital products. There was no consideration of whether the different types of products differ in theory. All three of the mentioned issues will be important areas for future work.

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