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How to Keep Balance between Interaction and Automation? Toward User Overall Positive Experience of IoT-Based Smart Home Design

Huayuan Xu, Hyemin Lee, Weijie Ling and Younghwan Pan *

Department of Smart Experience Design, Graduate School of Techno Design, Kookmin University, Seoul 02707, Republic of Korea; 13256044989@163.com (H.X.)
* Correspondence: peterpan@kookmin.ac.kr; Tel.: +82-10-3305-1011

Abstract: Advances in Internet of Things (IoT) technologies have had a profound impact on the experiential tasks of the smart home, particularly automated tasks supported by sensors, embedded systems, and communication devices that are capable of autonomously performing a range of tasks previously performed by humans. However, the improvement in the level of smart home automation has not necessarily promoted more meaningful, relaxing, and positive experiences for users. This is largely due to the fact that it often overlooks the meaningful involvement of humans in the process. This paper proposes a conceptual design model for a smart home through two studies that aim to maintain the benefits of automation while ensuring positive experiences with user engagement tasks. Study 1 involved qualitative data using semi-structured interviews to understand what tasks lead to positive user experiences (P-UX) during the use of the smart home and what kind of factors influence these positive experiences. Study 2, using an online questionnaire, quantitatively investigated the varying impact of these factors on positive experiences in both automation and human–machine interactions. The results of both studies show that there are nine factors that influence positive user experience in the smart home, with instrumentality, convenience, and flexibility playing an important role in the positive experience of automation, aesthetics, immersion, association, and memory, having a greater effect on the positive experience of user engagement in interactions, and customization and emotion contributing to both paradigms. In future smart home design, this model will help designers rationally allocate tasks between automation and human–machine interaction as a way to enhance the overall positive user experience.

Keywords: smart home; Internet of Things (IoT); product design; positive design; user experience; automation; interaction

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1. Introduction

The Internet of Things (IoT) connects smart devices to the internet for data sharing, intelligent identification, and management [1]. Thanks to advances in IoT technology, the smart home sector has undergone transformations [2], defined as devices and systems distributed throughout a room that use sensors and communication technology to manage indoor environments, ultimately enhancing users' lives for greater comfort and pleasure [3]. A large amount of current smart home research focuses on replacing manual labor, hazardous work, and tedious tasks through automation to improve user experience and enhance quality of life [4]. For example, advanced automation systems are proposed to monitor and control the home environment with less user involvement [5–7]. But does a higher level of automation lead to a more positive user experience? Does the quest for complete automation ignore the interactive tasks that make a product a positive experience for the user? For example, in the case of a coffee machine, regarding the task of removing the coffee beans from the bag before pouring them into the machine, users perceive that touching the texture of the beans and hearing the sound of the beans falling brings a hushed experience of enjoyment. In addition to the task of turning the knob and then using the cup to catch the coffee, along with the aroma of the coffee, the process of watching the cup being slowly filled can also bring the user a pleasurable experience. Therefore, one of the big challenges facing smart home design in the future is in the face of conflict between automated tasks and human-involved interactive tasks, how should designers realize automation while appropriately retaining meaningful interactive aspects in order to enhance the overall positive user experience [8]?

Over the past two decades, researchers have worked on enhancing user experience through IoT technology advancements. Several systems, frameworks, and approaches have been proposed to promote better application of IoT technologies in the home to enhance the comfort and ease of daily life [9–11]. Among these, innovations in automation systems play a crucial role in life by performing a range of tasks independently and autonomously [12]. This fundamentally changes the relationship between people and products, transforms the role of the user from task performer to collaborator, and finally makes them increasingly uninvolved [13]. As a result, the engagement tasks that bring a positive user experience are inevitably compromised in the process of complete automation [14]. It should be noted that our study does not deny the contribution of automation, but rather attempts to appropriately address the relationship between automation features and human–machine interactions in design to maximize the overall positive user experience and to achieve the effect of one plus one being greater than two.

Therefore, the goal of this paper is to propose a design reference model for enhancing the overall positive user experience from the perspective of rationally distributing automation tasks and human–machine interaction tasks. The research questions are:

- What factors play a role in promoting positive user experience during the use of smart home products? We are interested in learning more about the different manifestations of these factors in the smart home.
- How do these positive experience factors interact with automation and human–machine interaction tasks?

In the next section, we look at relevant work on smart homes and positive experiences, based on which two studies were operationalized. Then, the results of the two studies are used to construct a conceptual model for smart home product design. The article concludes with a discussion of the results and highlights the strengths and limitations of the model.

2. Related Works

2.1. IoT in Smart Home

The application of IoT in the field of smart homes has been an important research theme for decades, and this research mainly focuses on several aspects. Firstly, we consider the research on smart home architecture, for example, the interconnection of smart products through the construction of indoor communication networks [15], the remote control of smart home products through cell phones, computers, and other devices [16], and the realization of smart interactive terminals for smoke detection, emergency distress, gas leakage, and other security reminders [17]. Recent studies also include proposing a service-oriented smart home framework that provides better flexibility and faster response to users' changing needs [18] and proposing a new smart home interoperability framework to improve the utilization of appliances and devices [19]. Secondly, we consider research on smart home automation. Vasicek defines automation as the ability of a smart home to respond autonomously to real-time conditions, collect and analyze data through sensors, and warn users of possible defects [20]. For example, ChienYuan proposed an automation system to realize the expected requirements of power outlet control and environmental weather detection [21], Adrian designed a pneumatic door automation system for accessing control of all smart products [22], and Yu Hsiu proposed an automated energy management system [23]. Thirdly, in research on smart home security, scholars addressed security challenges through a variety of security technologies and approaches [24–28]. It is worth noting that most of these studies have been conducted from the perspective of technological innovation while few studies have focused on positive user experience. However, positive user experience should not be ignored because technological advances do not necessarily represent an increase in user happiness [29], just as an increase in the wealth of a nation does not mean a higher happiness index for its people [30]. While automation of the smart home improves performance and efficiency, it can somehow undermine the user engagement aspect, which is the source of happiness. Bainbridge suggests that full automation does not create a more positive experience for the user [14]. As Sadeghian worries, there is an inherent conflict between automation and providing control to humans, and good human–machine interaction is a looming but not fully resolved issue [8].

Currently, researchers have proposed several models and frameworks to allocate tasks between users and automation. Rouse defines three types of static allocation methods [31]:

- Comparison allocation: performance-oriented and assigned to the party that performs better on a given task.
- Leftover allocation: functions that can be automated are assigned to automation and tasks that cannot be performed by automation technology are assigned to humans.
- Economic allocation: using cost–benefit analysis, automated functions are allocated to humans if they are not cost-effective.

However, static allocation methods are not human-centered as they regard humans as machines and consider humans to have no voice, and allocation is purely based on factors such as performance and cost, which can lead to humans being assigned boring tasks and a negative user experience [8]. Therefore, Abbass proposed the intelligent adaptive concept of CoCys, where e-cookies (smart adaptive agents) act as relationship managers between humans and machines, assigning functions between humans and machines based on trust indicators [32]. Endsley provided a model that integrates key design interventions to improve human performance when interacting with autonomous systems [33]. Despite the fact that human–machine interactions have been studied for a long time, human-centered automation models still do not provide real solutions. The research in this paper explores methods that can rationalize the allocation of smart home automation tasks.

2.2. Positive User Experience

Positive experience stems from positive psychology, an applied science that reveals human strengths and promotes positive functioning [34]. Positive psychology focuses on what makes life worth living and what conditions determine human well-being [35]. The field of design has also begun to focus on those experiences that make people happy, based on positive psychology, and has developed the concept of positive experience design: "That is, the act of designing interventions in a positive way to give a person a happy, positive experience during their interaction with a product or service, an experience that not only facilitates the development of the individual, but also contributes to the prosperity of the environment or community; it is not only satisfying for a brief period of pleasure, but also has a long-term positive impact on individual development [36]."

Positive experience focuses on how to enhance users' subjective well-being, exploring design to support users' goals for a pleasurable, meaningful, and fulfilling life [37], so it is important to identify the factors that influence positive user experience. Hassenzahl proposed the concept of designing for pleasure by centering experience and subdivided the needs that influence positive user experience into autonomy, competence, relatedness, popularity, stimulation, and security [38]. Kang introduced five attributes of user experience, which are aesthetics, instrumentality, association, self-focused identification, and relationship-focused identification [39]. Michael mentioned seven factors that promote users' positive and sustainable usage behaviors, namely, product properties, durability, memories and associations, emotion, irreplaceability, performance, and use [40]. Pirker and Bernhaupt identified user experience factors as aesthetic, utility, purpose, emotions, identification and social influences [41]. Moreover, some studies focused on mapping users' positive experiences by emphasizing specific factors. For instance, in the realm of psychological factors related to emotions, Desmet suggested that products can evoke emotions, emotions affect behavior, and positive emotions lead to a better user experience [42]. Hendrik identified that memories can have a positive impact on user experience and that designers should facilitate the interaction between the product and the user [43]. Furthermore, other sources were collected and summarized [44–49], and factors with similar meanings were combined and organized, as shown in Table 1.

Table 1. Influence factors and related literature sources.

Influence Factors	Relevant Factor	Definition	Sources
Instrumentality	Reliability, Craftsmanship, Usefulness	The product has good technology and performance to perform its basic tasks well.	C, E, F, H, I
Aesthetics	Properties, Visual Attractiveness, Appearance, Beauty	The appearance of the product is attractive and has a good visual design.	C, D, E, F, G, I, J, L
Association	Relatedness, Relationship, Connectedness	Users build intimate relationships with those around them instead of feeling alone.	B, C, D, E, I, K
Identification	Self-focused identification, Self-identity	Experience is about using a product that responds to the identity, personality or uniqueness of the user.	C, E, F, H, I, K
Durability	/	Focuses on the ability of the product to last over time.	D
Memories	Nostalgia	The product forms a connection with a person, place, or event and generates memories.	D, F, J, L
Irreplaceability	Exclusivity	Involves a personal connection to a product that is considered unique and important.	D, J
Autonomy	/	User behavior stems from their own interests and values, not from external pressures.	B, L
Convenience	Easy to use, Effectiveness, Simplicity	The product is simple to operate and easy to perform tasks.	H, I, J, L
Security	Controllability	People feel in control of their lives rather than feeling uncertain and threatened.	B, I, K, L
Emotions	Stimulation, Hedonic Quality, Fun, Pleasure, Joy	Feel like you're getting tons of happy positive emotions instead of feeling bored.	A, C, E, G, H, I, K, L
Competence	Learnability, Mastery	Users are able to easily master a skill and feel empowered rather than overwhelmed.	B, J, K, L
Completeness	Purpose	The product is able to provide complete functionality and information according to the user's purpose of use.	E, I
Flexibility	/	Users can adapt the product to their individual needs and behavior.	I
Immersion	Sensorial experience	Users lose track of time due to enjoyment and immersion when use a product.	I, J
Versatility	/	The products have a wide range of features and serve a variety of purposes.	L

Originality	/	The product is designed in an interesting and unusual way.	I

Sources: A. Desmet [37]; B. Hassenzahl [38]; C. Kang [39]; D. Michael [40]; E. Pirker and Bernhaupt [41]; F. Hendrik N. J [43]; G. Schulze [44]; H. Sahar et al. [45]; I. Andreas [46]; J. Hoyng [47]; K. Sheldon [48]; L. Manuel [49].

The factors that influence users to have a positive experience vary from domain to domain. For example, the factors that influence a workspace are different from a leisure space, the factors that influence a medical product are different from a household product, and the factors that influence an educational system are different from an e-commerce system. There are certain common factors between domains that, if researched for a specific domain and taken into consideration, can be more effective in improving the overall user experience [50]. As mentioned earlier, there is a lack of research on positive user experience in the smart home, where the unique automation experience of IoT products is usually mixed with ordinary products, in addition to describing the factors and specific manifestations that influence positive user experience in the smart home. Therefore, the aim of this paper is to develop a study on how to enhance the overall positive user experience within the smart home.

3. The Conceptual Model

Based on the previous literature review and initial insights, we hypothesize that two user experience tasks, performing automation and retaining interaction, are included in smart home product design. One part of the positive user experience is related to the automation function, and the other part is felt through the human–machine interaction. Based on the above propositions, we developed an initial conceptual model to guide the development of the following two studies (see Figure 1).

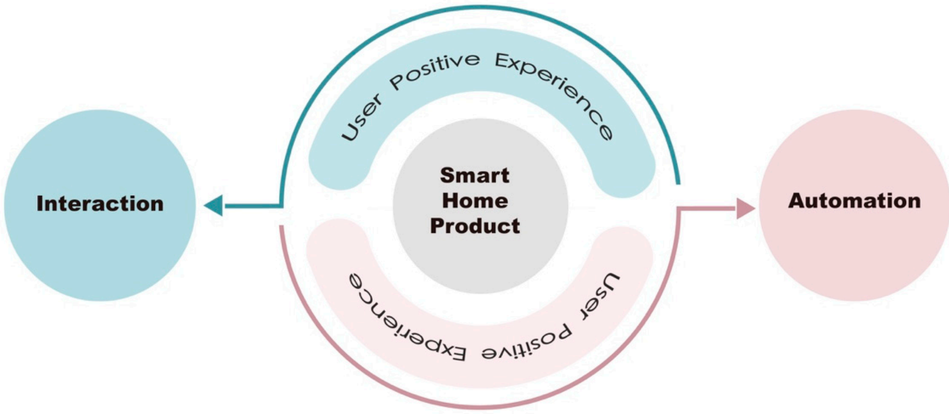

Figure 1. Smart home product design concept model.

4. Study 1: Factors of Positive Experience on Smart Home Products

Study 1 utilized semi-structured interviews and focus groups using a two-week study of users experiencing a smart home to explore the tasks that bring about a positive experience and conducted an in-depth analysis of the factors that influence them. The qualitative methodology provided rich and detailed data for this study, which helped to further explore the specific ways in which these factors manifest themselves in the smart home.

4.1. Participants

In this study, recruitment was performed by posting in a community group on online social media, and each participant was informed they would be paid for his or her contribution. Our recruitment criteria were (a) participants have at least five smart home products they use daily; (b) participants have at least one year experience with smart home products rather than ordinary products, and the IoT features should be used frequently. Despite the relatively small sample size of this study, we sought diversity in age, household type, and product type to gain insights into the process of positive user experiences with smart homes. In the end, we recruited a total of eight participants who met the criteria, ranging in age from 27 to 39 years old. The eight participants are all non-experts who have a certain level of familiarity with smart home automation. Since study 1 explores universal factors that influence positive user experiences, we researched not only the single product but the whole smart home environment. Table 2 shows each participant's basic information.

Table 2. Profiles of participants.

#	Age	Experience of Automatic System	Family Member	IoT Household Product
P1	27	3 years	Husband	Stereo, air conditioner, refrigerator, scale, washing machine, projector, pet feeder, combination lock, light
P2	33	5 years	Wife, Daughter	Table lamps, underfloor heating, floor sweepers, water heaters, washing machines, purifiers, humidifiers
P3	30	5 years	Husband, Son, Mother	Purifier, TV, curtains, sweeper, steamer, monitor, stereo
P4	26	2 years	Husband	Audio, door locks, cameras, floor sweepers, smart switches
P5	32	3 years	Wife	Smart audio, air conditioning, door locks, TV, lights
P6	36	6 years	Husband, Son	Washing machines, refrigerators, lights, speakers, curtains, cameras, purifiers
P7	28	5 years	Husband	Lamps, washing machines, stereos, cameras, doorbells, purifiers, air conditioners
P8	39	8 years	Wife、Son	Hand sanitizer, smart speaker, toothbrush, water heater, camera, air conditioner, television

4.2. Procedure

The interviews began with a brief introduction describing the purpose of the study and asked participants about basic information. The formal semi-structured interview consisted of three steps (Figure 2).

Figure 2. Methodological process of this research.

The first part was the sensitization method. In order for participants to understand the concept of positive experience, three smart home products were selected for sensitization training, and participants were asked to report which aspect of the product brought them a positive experience and what was the reason behind it. The dialog showed that participants had a good understanding of positive experiences after completing the training. For example, "During the use of an air purifier, the task of checking the air quality data would bring me a positive experience because it would inform me about the progress, and the authenticity of the data would bring me safe".

The second part was the interview. At the start, participants were required to provide the number and name of the smart products they currently use at home. In order to obtain more details about the user experience, we then conducted a hierarchical task analysis of the product use process, for example, the process of using the air purifier was divided into nine tasks: turning on the power, choosing the mode, choosing to start working, working, checking the data, adjusting the mode, turning off, opening filter, and changing filter. After that, there was no time limit for participants to express the tasks that brought them positive feelings and the reasons behind them, and researchers took notes and recorded conversations at the same time.

The third part was the discussion, in which the interviewer discussed with the participants immediately after they generated ideas about the positive experience, which could guarantee deeper data details and avoid data biases.

4.3. Data Analysis

Data analysis was completed using qualitative coding. The first author was responsible for converting the audio files into text and further analysis. The coding and analyzing methods were as follows:

A deductive approach was used. The deductive approach using the existing literature helped the researcher to accurately identify and analyze the factors that influence positive user experiences. According to the literature review section (Table 1), 17 factors were used as categorization, e.g., instrumentality, aesthetics, association, identification, etc., which we also referred to as first-level coding. It is important to note that to ensure the accuracy and consistency of the data-coding process, prior to the coding exercise, the two researchers got together to discuss the concepts of the 17 factors until they reached an agreement.

The generalization method was used. The researchers recoded the 17 categories with codes from the transcribed text data. The coding process consisted of two steps: (a) creating new subcategories: based on the text transcripts' descriptions of positive user experiences, the content was condensed and keywords were formed as secondary coding themes, for example, interconnectivity, sensor technology, and multi-mode; (b) recoding: the condensed secondary themes were coded into each of the 17 categories. We completed the analysis in a qualitative research software program (NVivo 20), which makes it easier to observe the frequency of communication factors through data coding and allows for quick review and comparison of code-to-code variability to ensure the scientific validity of the results. Ultimately, after coding each of the eight textual content, two researchers came together to discuss the compatibility of these codes.

The analysis process is described below as an example of researcher 1 processing data from participant p2:

- P2: During the use of the smart desk lamp, I can control the lamp by my cell phone while lying in bed, I don't need to move my position [Code2-Simple operation; Code1-Convenience]. The color temperature of the lamp is friendly to my eyes and I can switch modes optionally [Code2-Multi-mode; Code1-Flexibility]. When I use the sweeper, I can pre-set the working time before going to work. It can automatically finish the cleaning task and send the message of "Sweeping complete" to my phone [Code2-Save time; Code1-Convenience]. At the same time, I can view the cleaning route through the app. By the way, customizing a cleaning roadmap is also available for me [Code2-Preference setting; Code1-Customization]. In the use of the water heater, I will start the water heater in advance through the app before I get off work in the evening, so that I can take a shower directly when I get home, which saves me a lot of time [Code2-Save time; Code1-Convenience]. In addition, the water circulation function saves me some part of the energy consumption [Code2-Performance; Code1-Instrumrntallty]. The smart air purifier can react to the air quality through different color alerts, and the clear visualization makes me feel peace [Code2-Colour; Code1-Aesthetics]. Meanwhile, I can see some roundworms and dust when I change the filter of the air purifier, which makes me feel that the product is reliable [Code2-Satisfaction; Code1-Emotions]. When I go to work, I can remotely control the IoT humidifier which is able to create a more comfortable and safer living environment for my daughter [Code2-Remote access; Code1-Association]. The material of the product is transparent, and when I add water, I can clearly see the water flow, and this process makes me enjoy [Code2-Multisensory; Code1-Immersion].

4.4. Results

Through multiple iterations coded by the two researchers, nine influences were obtained that were predominantly evident in smart home products, namely instrumentality, aesthetics, immersion, emotions, flexibility, association, convenience, customization, and memories. It is important to indicate that there might be multiple influencing factors behind a positive experience [51]. For example, P7’s positive experience of using a smart speaker to control other smart products was coded by the researchers in the three factors of flexibility, convenience, and customization, which also implies that there is a certain degree of correlation between several factors. This study therefore aimed to explore a range of related but distinct factors. We then further explained the different manifestations of each factor in the smart home through condensed secondary coding themes, and we named these forms elements to increase the in-depth understanding of positive experience factors. Figure 3 below shows the 9 influencing factors and 24 manifesting elements, along with key examples from the interviews.

- Instrumentality

Instrumentality refers to the usefulness and efficiency of a product in achieving task goals, and it is closely related to usability, functionality, and utility [52]. Hassan suggests three relationships between usability and user experience [53]: (a) usability is a part of the user experience; (b) usability is a measure of the user experience; and (c) usability and user experience complement each other. Chajoong further points out in a study that instrumentality is the main reason that users are dissatisfied when using a product, which also implies that instrumentality plays a central role in positive user experience [54]. For example, users are happy when they find that the product they purchased fulfills a functional need.

The elements of the second-level coding of instrumentality are (a) IoT technology, (b) efficiency, and (c) performance. We summarized instrumentality as good technologies that help users to effectively perform basic tasks, such as lighting control, security monitoring, and temperature control. It emphasized the positive experience of the smart home in solving practical problems, enhancing work efficiency, or improving the quality of life. P1 thought that the smart refrigerator could keep fruits and vegetables fresh for a long time and even remind him of the shelf-life, a feature that brought him a pleasant experience.

- Aesthetics

The aesthetic response refers to the direct feelings triggered by the sensory system when experiencing a product [55]. In an aesthetic experience, aesthetics can bring sensory pleasure and stimulation, as well as emotional satisfaction and fulfillment with the experience [56]. Therefore, aesthetics plays a crucial role in product design. Aiqin found that high design aesthetics triggers positive emotions in users [57]. Hekkert proposed that aesthetics is the principle of pleasure in design, which facilitates users to have a positive aesthetic experience through the basic sensory functions of seeing, hearing, touching, and smelling [58].

Factors/Description	Elements	Example Quote
Instrumentality Good technology; performance; usability; functionality ; practicality	• IoT technology	P5: I would use my phone to pre-start the air conditioning, and when I arrived home the emperature was comfortable.
	• Efficiency	P3: Sweeping robots can clean according to a pre-set time, which greatly improves the efficiency of the work.
	• Performance	P1: My IoT refrigerator does a great job of keeping the fruits fresh for a long time.
Aesthetics Perceived of a product; visual; tactile; auditory; olfactory; gustatory sense	• Shape	P1: I really like the shape of my refrigerator as it decorates my home.
	• Texture	P6: I enjoyed the texture of the IoT air purifier when I touched the power supply to it with my hand.
	• Colour	P1: My IoT home products are all white, which can bring me a clean and bright feeling.
	• Sound	P5: When I use the smart speaker to play music the sound quality is very good and I can enjoy my leisure time.
Immersion Completely absorbed in the environment; lose track of time	• Multisensory	P8: When I play soothing music on my smart speaker the IoT lights get softer accordingly, making me more immersed.
	• Voice control	P6: I really enjoy talking to my smart speaker to control other IoT products.
Emotions Pleasure; well-being; positive emotions evoked by using the IoT product, or by the product itself	• Pleasure	P3: I can control the opening and closing of the IoT curtains by voice, which is very interesting to me.
	• Satisfaction	P7: When I cook the IoT air purifier detects that the air quality has gone bad and works automatically, which meets my needs.
	• Surprise	P8: I would talk to the smart speaker every morning to ask about the weather and he would surprise me with suggestions on what to wear.
Flexibility Have a wide range of functions; meet the different needs of users; applications in a variety of scenarios	• Interconnectivity	P5: I love the idea of connecting all of my home products to the smart speaker for more interesting functions.
	• Sensor technology	P8: I have set up body sensors in my home where lights, air conditioners and air purifiers. perform different tasks depending on my behavioural changes.
	• Multi-mode	P2: My IoT light has several modes to meet my different needs, such as warm light, cool light, ambient light.
Association Building intimate relationships; promotes harmonious family relationships	• Home sharing	P4: When I hear good music, I will ask my smart speaker to share it with my husband, which promotes a loving relationship between us.
	• Collaboration	P1: My husband and I will take care of our pets together and we will both use the app to confirm the status of the IoT pet feeder when we are away.
	• Remote access	P3: I can remotely open the door from my phone when seniors forget the code, so I can help my family at any time.
Convenience Simple to operate; easy to perform tasks; makes life easier and relaxing	• Simple operation	P2: I would adjust the temperature of the water in the shower through my voice, a dialogue that was easy and efficient.
	• Save time	P1: Every morning I would ask the smart speaker the time and weather status while applying my make-up to help me get to work on time.
Customization Setting up IoT products based on personal preferences and needs; personalised UX	• Preference setting	P1: I'll set the IoT water heater to work according to my schedule, creating my very own "digital companion".
	• DIY Connections	P6: I find it very interesting to set up connections between IoT products based on my needs.
Memories Products connections with people, places or events	• History Records	P7: When I hear good music I'll tell the smart speaker to bookmark it for me, and when I hear it again later I'll be reminded of the great experience I had at that time.
	• Big data	P6: Big data from IoT can analyse my daily activities, help me recall important anniversaries and significant events.

Figure 3. Smart home user positive experience factors and elements.

The elements of the second-level coding of aesthetics are (a) shape, (b) texture, (c) color, and (d) sound. The color and form of a smart product are important visual aesthetic expressive aspects. For example, P1 thought that the attractive appearance and beautiful interface of the smart refrigerator pleased her. Sound effects can also influence positive user experiences in terms of auditory aesthetics. For example, as P5 said, the high-quality sound of a smart speaker can make him enjoy the use process more.

- Immersion

Turner describes immersion as "positively correlating with the level of sensory richness evoked by the technology to promote isolation or decoupling from the real world [59]." Immersion is critical to a positive user experience, meaning that without immersive design, users may not be able to enjoy the use process [60]. Ermi subdivides immersion into three different forms: sensory immersion, challenge-based immersion, and imaginative immersion [61]. Highly immersive design has been used in a variety of fields, for example, using VR technology to create immersive learning experiences in a variety of educational environments [62]; in game design to evoke positive experiences by creating player immersion [63]; and in tourism experiences to enhance positive experiences through participatory design [64].

The elements of the second-level coding of immersion are (a) multisensory and (b) voice control. When users interact with a smart home product, they feel fully immersed in the environment they are experiencing and lose track of time due to enjoyment. In particular, IoT technology can bring about multi-sensory interactions in the same scene, making users feel like they are in a virtual or augmented environment, resulting in deep engagement and satisfaction. In addition to this, P6 believed that voice control definitely helps with immersion in the task and provides fun during use.

- Emotions

The product itself and the activities it enabled could evoke a wide range of emotions [40]. Emotions here refer in particular to the emotional experience during the usage of the product, especially emotions of pleasure rather than boredom [37]. Design can evoke positive emotions, which in turn can enhance the positive experience for the user [42]. Fronemann explored design that supports happiness for older people [65]. Ziegler explored strategies to support users' hedonistic commuting experience [66]. Gomes proposed AI techniques geared toward positive user emotions (pleasure, satisfaction, etc.) combined with artifacts for a design approach [67].

The elements of the coding of emotions are (a) pleasure, (b) satisfaction, and (c) surprise, and in the design of a smart home, designers can consciously create positive emotional connections to care for the user like a "smart companion". For example, P3 controlled the switch of the smart curtains with his voice, which was a pleasant interaction, P7 was satisfied when the air purifier detected the deterioration of the air quality and activated automatically during cooking, and P8 asked about the weather conditions through the smart speaker every morning, and usually the smart speaker will give him some suggestions on what to wear, which is a pleasant surprise for him.

- Flexibility

The current user demand for products is gradually moving toward diversification and personalization while maintaining a certain degree of cost-effectiveness, which drives the design of product flexibility [68]. Product flexibility can be defined as the degree to which the system responds to the multidimensional user needs as well as future changes in the product [69]. Smart home products based on IoT technology could supply a wide range of functionalities that can flexibly meet user needs in multiple scenarios and serve multiple purposes [50]. In other words, the flexibility of smart products could enhance positive experiences by providing more choices and control [70].

The elements of the second-level coding of flexibility are (a) interconnectivity, (b) sensor technology, and (c) multi-mode. First, smart homes provide more functionality and interoperability through the interconnection of things. For example, P5 preferred to use the smart speaker to voice control all smart home products. Second, smart home products can automatically respond by sensing users' behavioral changes. For example, P8 placed a body sensor in her home, and the air conditioner can flexibly adjust the temperature according to her behavioral changes. Finally, it can adapt to different usage scenarios and environments through multi-mode settings. For example, P2's smart light can change between cold and warm light according to different life needs, which pleases her.

- Association

Objects are often valued for their connection to memories, experiences, people, places, and values [71]. Association refers to the user's ability to develop an intimate relationship with the people, objects, or events around them [38]. Meaningful associations are also considered an important factor in product attachment promotion. Schifferstein proposed strategies for designers to promote connection by stimulating social contact and odors as a way to foster connections between people and products [72]. Tengye believes that giving smart home products a special emotional meaning and linking users' intuitive thinking habits with product design can enhance the user experience [73].

The elements of the coding of association are (a) home sharing, (b) collaboration, and (c) remote access. The association here can be understood as improving the harmony of family relationships and promoting communication among family members through the use of smart home products. Smart homes can create shared experiences. For example, music sharing, multiplayer games, and home movie watching contribute to mutual understanding among family members. Also, positive experiences can be created by facilitating collaboration among members. For example, P1 and her husband used a smart pet feeder to take care of their cat, and they checked their pet's status using an app; the collaborative status increased their interaction and brought them closer. In addition, P1 used remote control of smart home products to detect the health and safety of the elderly and provide better care and support for the elderly.

- Convenience

Convenience refers to the simplicity of operating a product or system and the ease of performing a task in order to make the user's life easier [52]. Multiple studies pointed out that convenience is an important factor affecting users' positive experiences. For example, Hsu suggested that a convenient mobile game interface design can provide players with a positive experience as well as satisfaction [74]; Berger proposed a positive experience design that focuses on enhancing passenger convenience [75]; and Rita emphasized the importance of convenience for customer satisfaction in online shopping [76].

The elements of the coding of convenience are (a) simple operation and (b) saving time. One smart home product could be a control center, which can manipulate others through simple operations. For example, P2 adjusted the temperature of the water heater by talking to the smart speaker, which made the task feel simple and efficient. In addition, the functions and automated tasks help users save time, bringing a positive experience by simplifying their lives and providing more convenience.

- Customization

Customization is a way to differentiate products with similar basic functionality, so as to enhance perceived value in the market [77]. This differentiation is at the level of the individual user rather than market-differentiated [78]. Customization has been recognized as an effective means of meeting users' needs and preferences [79]. It does so by tapping into the user's latent needs, maximizing the anticipation of individual preferences, and using the multiplicity of design to enhance the user's positive experience [80]. At the same time, customization is also the process through which designers increasingly hand over control to the user, enabling individual customization of products, experiences, and services [81]. In the smart product domain, customization enables personalized design based on the user's characteristics, personal tastes, and intrinsic needs to satisfy the individual's needs effectively and efficiently by delivering products with a positive experience [82].

The elements of the second-level coding of customization are (a) preference setting and (b) DIY connections. Participants believed that smart products could customize their functions based on personal preferences and needs, giving them some room for design. For example, P1 thought that the product after setting was like an exclusive digital companion, which enhanced the overall positive experience. P6 found it interesting to set up the connection autonomously. This involves smart home DIY functions supporting different usage scenarios. For example, work scenarios, leisure scenarios, and entertainment scenarios. It is also possible to set the connection between things according to the habits of family members to create an exclusive smart home. Similarly, smart products support users to customize the appearance and functions of the product to meet their personal preferences.

- Memories

Experiences are fleeting, and memories are what we retain from an experience [83]. The process of remembering affects the user's emotions, and Hassenzah suggests that memories can often bring us more pleasurable emotions than the experience [84]. For example, the aftermath of a pleasurable trip can be followed by a feeling of happiness from remembering the good time spent with friends. Memories can be individual or collective, and collective memory is a series of events remembered by several people [85]. The process of members creating and sharing this collective event contributes to positive emotions. Smart home products can increase empathy between family members by creating systems to receive or collect memories and create shared memories that in turn enhance positive user experiences.

The elements of the second-level coding of memories are (a) history record and (b) big data. Smart home products form connections with people, places, or events, which leads to pleasurable experiences. The most obvious element is the product history record setting, where the smart product records the user's preferences, habits, and preferences and plays them back to the user later to evoke fond memories. For example, helping users record family gatherings, birthday parties, and anniversaries. In addition, P6 felt that big data could help him recall important daily events based on his daily activities, and this recall process brought him a positive experience of peace of mind.

5. Study 2: Effects of Smart Home Positive User Experience Factors on Automation and Interaction

The purpose of Study 2 was to quantitatively validate and develop the qualitative insights derived from Study 1, including (a) exploring possible links between these factors and positive experiences from automation and human–machine interaction and (b) exploring the differences in the extent to which these positive experience factors influence both. Based on the above, the following hypotheses were formulated:

Hypothesis 1 (H1): *Several smart home positive experience factors have a greater positive influence on automation-induced positive experiences.*

Hypothesis 2 (H2): *Several smart home positive experience factors have a greater positive influence on interaction-induced positive experiences.*

Hypothesis 3 (H3): *Several positive experience factors of smart homes have a greater impact on positive experiences of both automation and interaction.*

5.1. Participants

Data collection was completed by filling out a questionnaire on the star platform. Participants were invited to the platform and those who completed the questionnaire online were entered into a lucky draw. Prizes included (1) Chinese yuan 6.6 of wechat (8.0.43) red packet; (2) Chinese yuan 8.8 of wechat red packet; (3) Thank you for joining. According to Meade and Craig's findings, if a participant's average response time was three times longer than the rest of the sample, it was likely invalid [86]. After removing the invalid sample, 505 valid questionnaires were eventually returned. The participants were between the ages of 18 and 60, and 46% of the participants were male.

5.2. Questionnaire and Variables

The design of the questionnaire followed a top-down and bottom-up approach and was developed based on previous work on positive user experiences and the factor insights generated in Study 1. The dependent variables (DVs) for this study were automation and interaction and the independent variables (IVs) were instrumentality, aesthetics, immersion, emotions, flexibility, association, convenience, customization, and memories.

This study captured data using a 7-point Likert scale ranging from 1 for strongly disagree to 7 for strongly agree. Because we set two dependent variables, automation and interaction, the questionnaire was divided into two parts. The first part concerns the investigation of the relationship between the dependent variable automation and the nine independent variables factors. Among them, the six question items concerning automation are from Balakrishnan et al. [87], Yan et al. [18], ShariqSuhail et al. [27], and Perumal et al. [19]. Among the nine independent variables, the three items related to instrumentality came from Brooke [88] and Lewis and James [89]. The three items on aesthetics came from Kang et al. [39]. The three items on immersion came from Tellegenet al. [90]. The three items on emotions came from Thompson [91]. The three projects on flexibility came from Lewis and James [89]. The three items on association came from Hassenzahl [38] and Kang [39]. The three projects related to convenience came from Brooke [88] and Lewis and James [89]. The three items on customization came from Peyton [92]. The three items on memories came from Kang et al. [38]. The second part was an investigation of the relationship between the dependent variable interaction and nine independent variable factors. Among them, the five items concerning interaction came from Arriany et al. [93], Fan et al. [94], and Woo et al. [95]. It should be noted that the nine independent variable factors here are exactly the same as in the first part of the questionnaire. In addition, in order to help users understand the questionnaire content more deeply, we provided a video of the automation function experience of the sweeper robot and a video of the interaction experience of the smart coffee maker with the user before the formal questions of the questionnaire. The list of question items and reference sources of the questionnaire are shown in Table 3.

Table 3. Results of exploratory factor analysis of the questionnaire.

Dependent Variables & Alpha				
	EFA Results for Questionnaire Items	**Factor Loading**		**Sources**
		1	**2**	
Automation α = 0.88	Complete the task according to the preset time.	0.73		[87]
	Implementation requires no involvement at all.	0.77		[18]
	It automatically detects danger.	0.76		[27]
	It adapts to changing environments.	0.76		[19]
	It can adjust the mode automatically.	0.79		[87]
Interaction α = 0.89	Voice interaction can activate the smart home.	0.78		[93]
	Touch the product texture to interact with it.	0.78		[94]
	Interesting interface interactions when in use.	0.77		[94]
	Participate in the use process as your prefer.	0.78		[95]
	The product can voice remind me.	0.76		[87]
Independent Variables & Alpha				

	EFA Results for Questionnaire Items	Factor Loading		Sources
		1	2	
Instrumentality $\alpha = 0.76$	I feel that this product is useful.	0.79	0.79	[88]
	I was able to complete my tasks efficiently.	0.76	0.78	[89]
	This product has good performance.	0.79	0.81	[89]
Aesthetics $\alpha = 0.79$	I think the product has a beautiful appearance.	0.77	0.76	[39]
	I think the product has a good tactile texture.	0.77	0.78	[39]
	Good flavors make me enjoy the experience.	0.80	0.79	[39]
Convenience $\alpha = 0.76$	I was able to complete tasks quickly.	0.78	0.80	[89]
	I thought the product was easy to use.	0.77	0.80	[88]
	It was easy to learn to use the product.	0.76	0.80	[89]
Flexibility $\alpha = 0.76$	I found the various functions in this product.	0.79	0.79	[89]
	The product can be used in a variety of situations.	0.79	0.79	[89]
	It can be easily adapted to different tasks.	0.77	0.79	[89]
Emotions $\alpha = 0.77$	I feel happy using the products.	0.80	0.80	[91]
	I enjoy using the products.	0.75	0.80	[91]
	I feel satisfied using this product.	0.76	0.81	[91]
Immersion $\alpha = 0.74$	I lose track of time when I use the product.	0.82	0.79	[90]
	Loss of awareness of surroundings when used.	0.78	0.82	[90]
	I can become completely absorbed in my use.	0.76	0.76	[90]
Association $\alpha = 0.78$	It reminds me of very important family member.	0.76	0.80	[38]
	It helps me maintain a connection with friends.	0.78	0.77	[38]
	It creates a feeling of a close relationships.	0.77	0.77	[39]
Memories $\alpha = 0.78$	The product reminds me of a previous experience.	0.76	0.79	[38]
	It reminds me of a meaningful places in my life.	0.83	0.79	[38]
	The product remind me of stories from the past.	0.81	0.79	[38]
Customization $\alpha = 0.78$	The product offers a high degree of customization.	0.80	0.80	[92]
	I can easily adapt the product to my specific needs.	0.79	0.76	[92]
	I receive personalized feedback and suggestions.	0.76	0.78	[92]

5.3. Data Analysis

To test the consistency of the hypotheses, data analysis was completed using SPSS V.27. First, because the questions of the questionnaire about the variables were derived from different literature and scales, in order to measure the consistency of the questions, we completed reliability and validity tests on the questionnaire using exploratory factor analysis (EFA) and calculation of Cronbach's alpha. Next, the composite reliability (CR), average variance extracted (AVE), and KMO were calculated. Finally, in order to assess the relationship of each factor with automation as well as an interactive positive experience, multiple linear regression analysis (Multiple regressions) was performed.

5.4. Result

5.4.1. Reliability and Validity

The results showed that the alpha values of all variables were greater than the universal level of 0.60 [96], which is a preliminary indication that the questionnaire is somewhat reliable. Next, we conducted an exploratory factor analysis (EFA) with maximum variance rotation in SPSS to confirm that all the variables in Table 3 were identified as independent, and the factors with the highest loadings for each question were tested. The results showed that five question items in each of the dependent variable's automation and interaction revealed the highest loading, and three questions in each of the nine independent variables showed the highest loadings, which meets the criterion of including at least three items to adequately represent a construct [97]. Detailed information about the factor loadings and Cronbach's coefficients for the two parts of the questionnaire are shown in Table 3. The CR, AVE, and KMO values were greater than 0.70, 0.50, and 0.70, respectively [98], which proved the internal consistency and validity of the questionnaire, and the detailed data are shown in Table 4.

Table 4. Property and correlation matrix highlighting terms.

DVs	KMO		AVE		CR	
Automation	0.713		0.581		0.874	
Interaction	0.714		0.599		0.882	
IVs	**KMO**		**AVE**		**CR**	
	1	**2**	**1**	**2**	**1**	**2**
Instrumentality	0.717	0.713	0.609	0.630	0.823	0.836
Aesthetics	0.714	0.721	0.609	0.603	0.823	0.820
Convenience	0.715	0.720	0.593	0.640	0.814	0.842
Flexibility	0.717	0.711	0.614	0.624	0.827	0.833
Emotions	0.713	0.721	0.593	0.645	0.814	0.845
Immersion	0.718	0.711	0.620	0.625	0.830	0.833
Association	0.712	0.712	0.593	0.609	0.814	0.823
Memories	0.714	0.721	0.641	0.624	0.842	0.833
Customization	0.722	0.723	0.614	0.609	0.827	0.823

5.4.2. Positive User Experience of Automation and Interplay with P-UX Factors

Relationships between factors and positive user experiences with automation and human–machine interaction were investigated using multiple linear regression. The results show that the value of VIF is less than 5, which indicates that there is no multicollinearity in the regression model [99]. There is a strong causal relationship between the individual positive experience factors and the level of positive experience of automation and interaction with varying degrees of influence in smart home use.

Regression results indicated that instrumentality ($\beta = 0.134$, $p < 0.01$), convenience ($\beta = 0.114$, $p < 0.01$), flexibility ($\beta = 0.101$, $p < 0.01$), customization ($\beta = 0.123$, $p < 0.01$), and emotions ($\beta = 0.120$, $p < 0.01$) contributed significantly to the positive experiences with automation, which supported H1. While aesthetics ($\beta = 0.084$, $p < 0.05$), immersion ($\beta = 0.085$, $p < 0.05$), and association ($\beta = 0.097$, $p < 0.05$) showed relatively moderate contributions, the other factors did not (see Table 5).

Table 5. Positive experience of automation (DV) regression analysis results.

IVs	β	SE	*p*	VIF
Instrumentality	0.134	0.040	<0.01	1.339
Aesthetics	0.084	0.040	<0.05	1.343
Convenience	0.114	0.041	<0.01	1.347
Flexibility	0.101	0.040	<0.01	1.308
Emotions	0.120	0.040	<0.01	1.343
Immersion	0.085	0.041	<0.05	1.284
Association	0.097	0.041	<0.05	1.383
Memories	0.078	0.039	0.058	1.243
Customization	0.123	0.039	<0.01	1.337

5.4.3. Positive User Experience of Interaction and Interplay with P-UX Factors

Among the positive experiences of interaction, the regression results indicated that aesthetics ($\beta = 0.155$, $p < 0.01$), immersion ($\beta = 0.101$, $p < 0.01$), association ($\beta = 0.102$, $p < 0.01$), memories ($\beta = 0.111$, $p < 0.01$), emotions ($\beta = 0.126$, $p < 0.01$), and customization ($\beta =$

0.110, $p < 0.01$) showed strong causality, which supported H2. However, convenience (β = 0.084, $p = 0.052$), instrumentality (β = 0.082, $p = 0.050$), and flexibility (β = 0.088, $p < 0.05$) contributed relatively insignificantly (see Table 6).

Table 6. Positive experience of interaction (DV) regression analysis results.

IVs	β	SE	*p*	VIF
Instrumentality	0.082	0.040	0.050	1.199
Aesthetics	0.155	0.040	<0.01	1.278
Convenience	0.084	0.041	0.052	1.243
Flexibility	0.088	0.039	<0.05	1.278
Emotions	0.126	0.039	<0.01	1.222
Immersion	0.101	0.041	<0.01	1.212
Association	0.102	0.039	<0.01	1.285
Memories	0.111	0.041	<0.01	1.262
Customization	0.110	0.041	<0.01	1.398

The overall results indicate that both emotions and customization factors have a great influence on the positive experience of both automation and interaction, which supported H3. In addition to this, instrumentality, convenience, and flexibility greatly influenced the positive experience of automation, while association, aesthetics, and immersion played a moderate role. In the positive experience of interaction, association, aesthetics, immersion, and memories exerted a great influence, while flexibility showed a moderate influence.

5.4.4. Model Development

A final conceptual model of positive experience design for smart homes was constructed based on the findings of Study 1 and Study 2, and the model includes five factors that contribute to a positive experience of automation and six factors that contribute to a positive experience of interaction (Figure 4). Automated tasks are recommended if the factors of instrumentality, convenience, and flexibility are involved. If factors of aesthetics, relevance, immersion, and memory are involved, interactive measures should be preserved. In addition, if factors of emotions and customization are involved, both automation and human–computer interaction can achieve a positive experience, and designers can vary the weight of both depending on the situation. The design process of a smart air purifier was used as the case study for further development of the model.

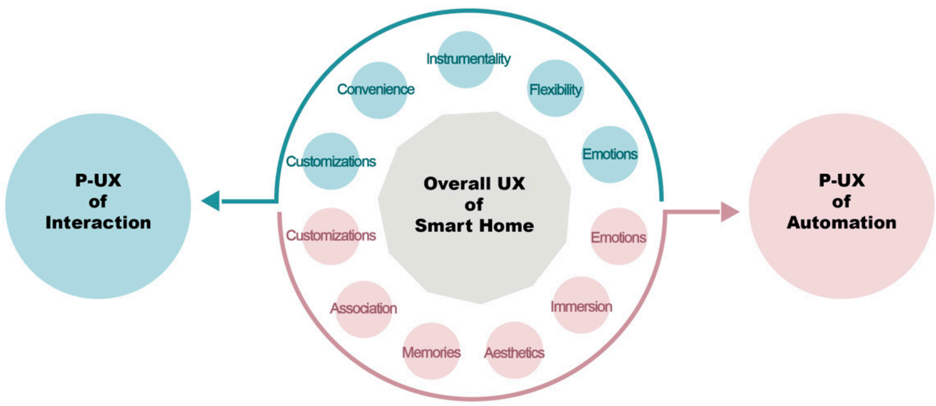

Figure 4. Smart home product design concept model.

- When starting the machine, we must consider that users want a simple and fast startup, as well as the ability to flexibly start the machine according to changes in indoor air quality, which involves the positive experience factors of convenience and flexibility. Therefore, the startup process is proposed to be automated.

- During the work, the biggest demand in this section is that the product can effectively purify the air, which is about instrumentality, and it is recommended that the work process still maintain a certain degree of automation.
- Regarding access to data information, to be able to understand the current air quality intuitively and easily, which concerns the interface design of the aesthetics factors, it is recommended to retain the user to view the data of the task. Of course, from the point of view of immersion's contribution to the positive experience of interaction, voice dialog interaction to obtain information is also a possibility.
- After a period of use, considering that the user expects the air purifier to contribute to the health of the family, it is recommended that the sharing of visualized data triggers care among family members.
- Concerning turning off the machine, like starting the machine, this is recommended to be automated.

6. Discussion

6.1. The Nine Positive User Experience Factors in Smart Home

The results show that there are nine factors that influence positive user experience in smart home use. Among them, instrumentality, convenience, and aesthetics, as the key factors affecting positive user experience in most studies, are still evident in the smart home. According to Chajoony Kim's study, these three factors correspond to the functional quality, operational quality, and sensory quality of the product experience [54]. This also shows that products oriented to new technologies are still inseparable from the issue of basic quality and that users are always concerned about whether the product meets their basic needs, is easy to use, and gives them a good perception.

Emotions also emerged as one of the positive experience factors mentioned. Interestingly, pleasure, surprise, and satisfaction were the most frequently mentioned positive emotions, and the fact that these emotions are usually felt instantly and momentarily in the smart home is likely related to the stimulation of new IoT technologies. According to Chunmao Wu's research, IoT products are largely capable of stimulating personal pleasure in the moment to enhance positive experiences [100]. From another perspective, the smart home is not only a place for individuals but also for family members, and users are equally concerned about the harmony of the family atmosphere as well as the care between members [101], which may explain why the association was mentioned.

In addition, we found that most of the specific performance of immersion, flexibility, and customization among the nine positive experience factors were related to the use of the IoT features of the product. For example, through the use of sensors and connected features, smart homes are able to flexibly respond to changing user needs. This also illustrates the critical nature of this study, and while these positive experience factors have been viewed similarly in previous related work [102], different product types will have their own unique manifestations. In other words, not all positive experience factors have an impact on the experience of any scenario, as seen in the case of the 17 factors we collected, of which only 9 were ultimately evident in the smart home. Similarly, memories benefit from the functionality of smart home history as an important factor influencing positive user experience. According to Karapanos and Hassenzahl, our experiences are understood and constructed first as a memory and later as a "positive experience" to be shared with others [103]. Overall, these nine positive experience factors are inclusive enough to fully characterize the reasons for positive user experiences in the smart home.

6.2. Relationship between Factors and Positive Experience of Automation or Interaction

The results show that aesthetics, association, immersion, and memories have important contributions to the positive experience of human–smart home interaction.

Among them, aesthetics is related to our perception of product form, color, sound, and smell, and according to JungKyoon, these perceptions are usually generated through frequent and repetitive daily interactions, which may explain why aesthetics influences the positive experience of the interaction process [104]. Immersion is also important in the process of human–machine interactions, which is mainly due to the ability of IoT. This is mainly due to the fact that IoT technology allows users to have a multi-sensory experience at the same time, and it is easy for users to ignore time and their surroundings in a near-realistic interaction experience. While association and memories both refer to associations or memories of people, events, and experiences that are awakened through the use of smart home products, we believe that these two positive experience factors are difficult to realize in an automated experience. According to Onnasch's research, a fully automated process means that the user is no longer involved in the use process, which can lead to a growing lack of perception, insight, and associative abilities [105]. Therefore, the positive experiences of relevance and memory are more likely to be gained through meaningful and reflective interactive processes.

Instrumentality, convenience, and flexibility are relatively high-impact factors in positive experiences with automation. These three positive experience factors relate to the performance, efficiency, time, and functionality of the product, which an automated approach can help to achieve from the perspective of the user's need to complete tasks with quality, quantity, and time and cost savings. As in Abbass' study, a performance-oriented human–machine automation framework is proposed that assigns most of the tasks that guarantee a performance advantage to automation [106]. This should explain the high degree to which functionality, convenience, and flexibility influence the positive experience of automation.

In addition to this, both emotions and customizations have a relatively large impact on the positive experience of automation and interaction. For example, the source of user pleasure may be voice interaction with a smart home product (Interaction) or the automatic recommendation of music genres by the product based on personal preferences (Automation). We would like to emphasize that Desmet proposes 25 positive emotions [42], and even though this study only mentions 3 (pleasure, surprise, and satisfaction) positive emotions that have an active manifestation in the smart home, the range of user feelings is very wide. Regarding the factor of customization, on the one hand, scholars propose that smart homes satisfy users' personalized needs through DIY connections and bring positive experiences by promoting users' engagement during the interaction process of setting up product connections [99]. On the other hand, smart homes can likewise be set up for customization through automation functions that are paired with sensors.

Most previous studies have emphasized the impact of different factors on positive experiences; however, there are many types of positive experiences. The significance of this study is to explore the factors that affect different types of positive experiences, which is more detailed than previous studies. We found different impact factors between the automation experience and the interactive experience. In this sense, this study provides a scientific approach to achieving an overall positive experience through an analysis of user behaviors. Since previous studies were only conducted from a technological perspective rather than a human-centered perspective, this study provides designers with a conceptual model for smart home product design from the perspective of positive user experience. The model in this study can trigger designers to think from different perspectives, and we hope to continue to optimize this model in further research.

7. Conclusions

Despite a long history of research on smart homes, there is still an unresolved question about how to effectively enhance positive user experiences in design. Especially in the face of conflict between automation technology and human–machine interaction, designers are confused about how to balance the two. Therefore, this paper conducts a qualitative and quantitative investigation to address the limitations of previous studies. Study

1 provides new insights into the factors affecting positive user experience in smart homes and study 2 shows that the positive experience of automation and interaction depends on different positive experience factors. We construct a conceptual design model for positive experience in smart homes based on the two studies, which can provide designers and professionals with deeper understanding of positive user experience and further application to the smart home development process.

8. Limitations and Future Studies

In this paper, we propose a conceptual design model for smart home products through two studies, which help to design smart products that enhance the overall positive user experience. Nonetheless, there are still two limitations of our studies: (1) not only nine factors affecting users' positive experience were obtained in study 1, but rather 24 specific performance elements. However, the feasibility and tightness of these 24 elements are yet to be explored further. In our future work, we will explore the real impact of these elements on design work through quantitative research. (2) In study 2, we found that the positive experience factors of emotion and personalization have a significant impact on both automation and interaction. There is no more specific guidance in this paper on how we should allocate automation and human–computer interaction if the user's usage task involves the influence of these two factors. Our preliminary view is that in this case, designers can further consider it based on the user's usage scenario and behavioral purpose. In future research, we will also propose more specific allocation measures for this issue to ensure the effectiveness of the designer's reference model.

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