Factor Model for Passenger Experience in the Aircraft Cabin Design

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Abstract. As the rapid growth of the economy, people have improved the standard of living and quality of life, paying more attention to how they feel towards the world. Thus, user experience becomes an important consideration in the aircraft cabin design. A systematical understanding of aircraft cabin design from the perspective of user experience is challenging but worth exploring. In this paper, we first modeled relevant influencing factors. Specifically, we studied passenger behaviors and related touch points in the cabin by analyzing the general flight process. After dividing aircraft cabins into several system areas, such as the front service area, seats and passenger service unit, we identified the product components and their attributes in each area to form our model. Based on the factor model, further research was carried out on these influence factors. Relevant investigations and interviews were conducted with aircraft interior designers, user experience researchers and passengers. Finally, we reached to a conclusion and categorized key factors which would impact passenger experience in the aircraft cabin.

Keywords: Passenger experience · Aircraft cabin design · Factor model

1 Introduction

User experience is becoming increasingly important as demand for air travel rises [1]. The riding experience of an aircraft is directly related to the choice of the consumer and becomes a key future economic driver [1]. As a result, mastering knowledge of passenger experience in the aircraft cabin could be a competitive advantage in the airline industry. However, different from ordinary products such as chairs and mobile phones, aircraft cabin contains have complicated structures since they contain various aspects such as product, space and human-machine interaction. Besides, a variety of passenger behaviors could happen in the aircraft such as resting, eating, walking, reading, etc., which would create a lot of user touch points. Each time a touch point is changed, user's overall experience is affected.

A large number of cabin elements need to be considered in the design process in order to achieve a better passenger experience. So far, a number of studies [2, 3] have found some key elements that affect passenger experience in the aircraft cabin, such as legroom and cabin space. But these factors don't create a systematic cognition of the cabin. Other studies [4, 5] provide some basic models on passenger experience, such as the thematic structure of passenger comfort experience, and a new model of key factors which influence aircraft passengers' comfort. These models are difficult to apply to

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specific design processes by designers and stakeholders since they are too general and broad. To have a systematic and practical understanding of factors that influence passenger experience in the aircraft cabin, we conducted a study from the aspect of cabin design and constructed a key factor model on passenger experience.

In this paper, we utilized the example of studying passenger experience under the general situation in a single-channel plane cabin. Rather than airline services, this paper focuses on the design of plane cabin. First, we studied on user behavior and product system. A factor model was presented which includes three systems, eight subsystems, several high-level factors and underlying factors. Then, investigations and literature review were conducted, which led to the conclusion of our key influence factors. The research framework is shown below (see Fig. 1). The result of this study can be used to help aircraft cabin designers and other stakeholders in the aviation industry understand the key factors and priorities of aircraft cabin design with regard to passenger experience. Meanwhile, the model provides a new way to quantitatively evaluate the passenger experience in terms of aircraft cabin design and lays a solid foundation in this area.

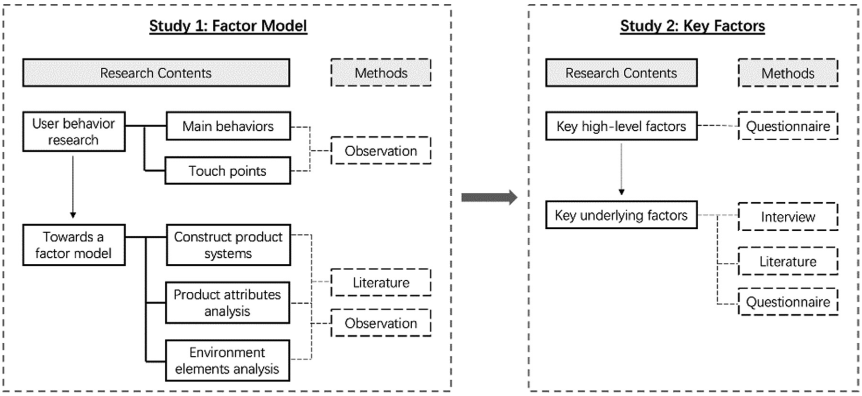

Fig. 1. The research framework.

The rest of this paper is organized as follows. Section 2 focuses on existing related work in academic and industry fields. Sections 3 and 4 contain two research studies. The first study is based on factor model to introduce approaches employed in the user behavior research and modeling of influence factors. The second study includes employed approaches, data collection, analysis and discussion on the influence level of high-level and underlying factors. Section 5 dwells on discussion, limitation and further research. Conclusion is presented in Sect. 6.

2 Related Work

Airlines and aircraft manufacturers have made a lot of effort to provide better passenger experience. For example, a small table that can be folded two times in the United Arab Emirates and large legroom in Cathay Pacific is praised by many people [6]. China

Eastern Airlines began to provide WIFI services on board since January 18, 2018 [7], enabling users to communicate with the outside world rather than spend a boring time. The Airbus divided concept air cabins into different activity zones, such as entertainment, relaxation and working zones, to meet specific needs [8]. In recent years, Commercial Aircraft Corporation of China Ltd (COMAC) has independently developed a large civil aircraft C919. Its industrial design department also attaches great importance to the study of user experience. For example, Ai summed up the evaluation factors of the comfort of the civil aircraft [9], and Lening studied the application of the user experience research in the interior design of civil aircraft [10].

Some academic research has been carried out on influence factors for passenger experience in the aircraft cabin. These studies can be categorized by two types.

The first type of research identified some key factors that have a significant impact on passenger experience. For example, Budd [11] presented airline passengers' perceptions of space, time, distance, and speed of mobility would affect their experience. The study by Vink [2] showed clear relationships between comfort and legroom, hygiene, crew attention and seat/ personal space. Similarly, in separate empirical studies, by analyzing the result of face-to-face questionnaires, Greghi et al. [3] found major discomforts during air travel are related to seat and cabin space. These studies do identify a number of influencing factors, but still lack a systematic understanding of aircraft passenger experience influential elements.

The second type of research built a system of relevant elements affecting passenger experience. A large number of related studies have been carried out by Naseem Ahmadpour. He presented eight themes and outline their particular eliciting features in one of his studies. The eight themes are physical well-being, peace of mind, satisfaction, pleasure, proxemics, aesthetics, association and social [4]. In a later study, researchers verified the eight themes by using Principal Component Analysis with varimax rotation [12]. Ahmadpour et al. [13] also presented a model identified four emotion groups that are closely related to comfort. In addition, Patel and D'Cruz [5] presented a new model of key factors which influence aircraft passengers' comfort. The factors are individual characteristics, personal travel context, the pre-flight and in-flight environments, interaction with others, activities, current state, current needs and adaptive behaviors, perceived control. These studies tried to construct models related to the passenger experience. However, since they carried out studies from the perspective of experience itself or passenger emotion, the meaning of these factors is usually very board.

Besides, there are some other relevant studies. These studies focus on the relationship between one or some specific elements and passenger experience. Brindisi and Concilio [14] modeled passengers' perceptions of aircraft cabin comfort regarding a characterization of an environment considering temperature, relative humidity, and noise level. The study by Kremser et al. [15] showed, there is a maximum overall well-being at a seat pitch of 34 inches to 40 inches, depending on the passengers' anthropometry. Pennig et al. [16] presented aircraft interior noise could be optimised reducing passengers' noise perception as 'bright' and 'shrill' as well as 'irregular' and 'varied'. In his study of *Aircraft Interior Comfort and Design*, Vink and Brauer [17, p. 47] specifically summarized the factors associated with the level of seat comfort, such as the curve of the backrest, adjustable button and so on. Although these studies can't form a comprehensive consideration of the factors in the cabin, they provide an important reference for our research.

In general, research on systematic and practical understanding of factors that influence passenger experience in the aircraft cabin is still limited. We aim to construct a key factor model from the perspective of cabin design to benefit the design processes and experience evaluation.

3 Study 1: Factor Model

This study aims at uncovering the influence factors of aircraft cabin that affect passenger experience and the relation between them. Although an experience is essentially subjective, the passenger behavior and the design content of the aircraft cabin are relatively clear and fixed. Qualitative investigations were conducted based on a real flight and cabin design. By analyzing the content of collected data and related literature, a factor model for passenger experience in the aircraft cabin design was constructed.

3.1 User Behavior and Touch Point Research

Methods. To clear passengers' general behavior, a survey was carried out in a real flight. Six researchers observed and recorded passengers' behavior from entering the cabin to leaving the cabin during a three-hour flight. We recorded activities related to the products provided in the cabin design, regardless of activities related to the products that were carried in by passengers themselves. After the flight, passenger's main behaviors were extracted based on observation record. Then, the corresponding touch points for each behavior were clear.

Results. A flight can be divided into four phases: take-off, cruise, approach, and landing [24]. Accordingly, the passenger behaviors inside the aircraft cabin are divided into five stages. The main behaviors of passengers are shown by stage as follows. Note that a passenger may only have some of these behaviors in a flight.

1. Before Take-off. Passengers enter the cabin through boarding bridge and look around for seats. After finding their seats, they put carry-on baggage in overhead bin and sit in their seats.
2. Take-off. Passengers fasten their seat belts, put their tray table and seat in the upright position, and keep window shade open.
3. Cruise. Passenger behaviors during this stage include two types. The first type is various activities that involve their own arrangements over time, including going to the lavatory, resting, eating, working, and using the entertainment system. The second type is adjustment of surrounding environment, including adjusting their seat, airflow knob, reading light and window shade.
4. Approach and Landing. Passengers fasten their seat belts, put their tray table and seat in the upright position, and keep window shade open.
5. After Landing. Passengers leave their seats, take out their baggage from overhead bin and leave the cabin through aisles.

When the above behaviors occur, passengers touch the product on the plane. As a result, different product components act as touch points that affect passenger experience in the aircraft cabin. Since similar products have different characteristics, the differences between product components are also seen as factors that influence passenger experience. We consulted the relevant product components and their characteristics according to the above behaviors (see Fig. 2).

Stage	Mian Behaviors	Product Components	Product Characteristics
Before Take-off	Enter the cabin through the boarding bridge	Welcoming placard	Color, Slogan content
	Look around for seat	Sign of seat number	Position, Recognition degree
	Put the carry-on baggage in the overhead compartment	Overhead bin cover	Open mode
	Sit in the seat	Backrest, Seat cushion	Width, Firmness
Take-off	Fasten the seat belt	Seat belt	Length, Switch mode
	Lock the tray table in place	Tray table	Storage mode
	Put the seat in the upright position	Adjustment button	Position, Instructions
	Keep window shade open	Window shade	Adjustment mode
Cruise	Go to the lavatory	Toilet, Trash bin, Water tap	Cleanliness, Open mode
	Rest	Backrest, Seat cushion	Width, Firmness
	Eat	Tray table	Dimensions
	Work	Tray table	Dimensions, Position after putting down
	Use the entertainment system	HD display	Size, Fluency
	Adjust the seat	Adjustment button	Position, Instructions
	Adjust the airflow knob	Individual vent	Switch position
	Adjust the reading lamp	Individual reading light	Switch position
	Adjust the window shade	Window shade	Adjustment mode
Approach and Landing	Fasten the seat belt	Seat belt	Length, Switch mode
	Lock the tray table in place	Tray table	Storage mode
	Put the seat in the upright position	Adjustment button	Position, Instructions
	Keep window shade open	Window shade	Adjustment mode
After Landing	Leave the seat	Legroom	Seat pitch
	Take out the baggage from the overhead compartment	Overhead bin cover	Open mode
	Leave the cabin through the aisles	Aisle	Width

Fig. 2. Passengers' general behavior and related touch points.

3.2 Towards a Model of Influence Factors

Though a preliminary analysis of passenger behaviors and experience, we found that the product components in the cabin and their attributes can be considered as passenger experience influential factors. Thus, a factor model was built from the view of cabin products.

An aircraft cabin can be divided into three relatively closed areas from the perspective of space, including the front service area, the main cabin and lavatories (see Fig. 3). The front service area refers to the area between the boarding gate and the bulkhead. Generally, there are welcome slogans and flight attendants. The main cabin is the main activity area for passenger on the plane. It can be divided into seven subsystem areas, including seats, passenger service unit (PSU), overhead bins, portholes, inflight entertainment (IFE) system, interior trim panels. There are a number of product components under each subsystem. In a plane, there are more than one lavatory, which have similar product components inside, such as a toilet, a hand basin and so on.

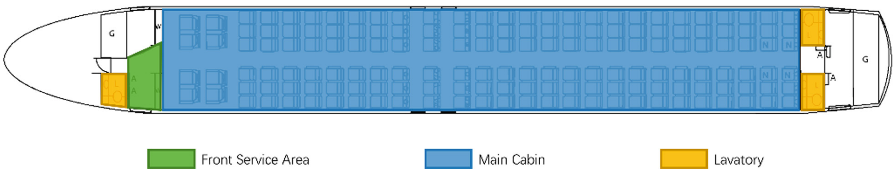

Fig. 3. An aircraft cabin can be divided into three relatively closed areas.

Then we built the model, in which we identified three systems: front service area, main cabin and lavatory. And the main cabin is divided into service subsystems, including seats, PSU, overhead bins, portholes, IFE system, interior trim panels and signs. Moreover, there are two levels of influence factors in the model. The product components in front service area, lavatory and all subsystems are defined as the high-level factors. And the attributes of these product components are considered as the underlying factors (see Fig. 4).

In order to clarify high-level factors and underlying factors, we conducted literature review and field research. In field research, researchers personally experienced the use of product components in an airplane cabin prototype. Products features were recorded in detail through photos and text. We take the analysis of underlying factors related to individual vent in PSU as an example to show detailed research process.

Literature Review. Xu presented that it's necessary to ensure that passengers corresponding to each PSU can easily use the function buttons of individual vent when design air conditioning personal ventilation module [18]. In other words, the location of function buttons on individual vents has an impact on the passenger experience.

Field Research. The functions of individual vent are air supply, air volume adjustment, air flow direction adjustment. Therefore, the related attributes that affect experience are air flow form, air temperature, wind regulation mode, and whether the wind direction is adjustable. Besides, the shape of individual vent affects the passenger's visual experience and becomes one of underlying factors.

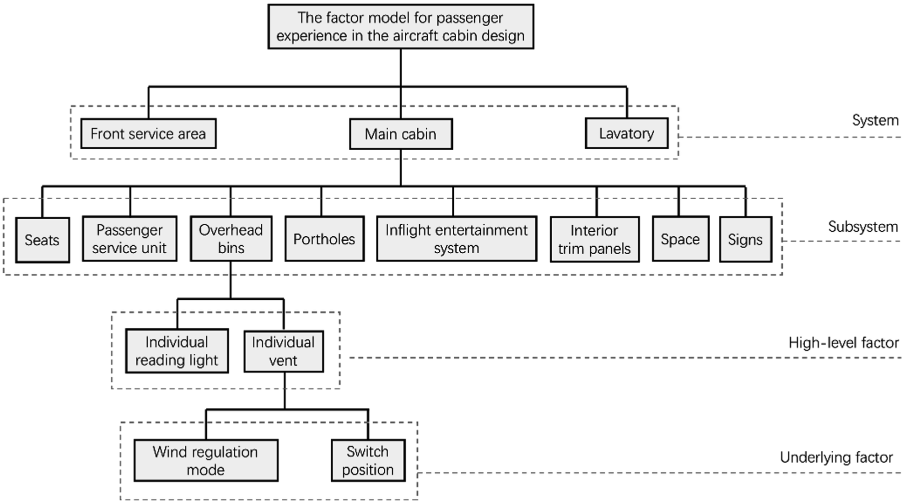

Fig. 4. The framework of factor model.

To sum up, underlying factors related to individual vent include switch position, air flow form, air temperature, wind regulation mode, shape, and whether the wind direction is adjustable.

We clarified most factors in accordance with this idea. But the passenger experience is influenced not only by product components. The pre-flight and in-flight environments are important factors which influence aircraft passengers' comfort [5]. And a lot of studies [16, 19] on the relationship between passenger experience and environment elements such as sound and thermal have been carried out. As a result, environmental impact factors were added to the three systems. For example, "sound" is added as a high-level factor. The related underlying factors are volume, type and the frequency of occurrence.

Afterwards we asked aircraft cabin designers of COMAC for comments on this model. We adjusted the model according to their suggestions and gained their approval in the end. The final model divides the influencing factors into three product systems: front service area, main cabin and lavatory. And the main cabin is divided into eight subsystems: seats, passenger service unit, overhead bins, portholes, inflight entertainment system, interior trim panels, space and signs. There are a number of high-level factors affecting the passenger experience under front service area, lavatory and each subsystem of the main cabin. And there are also several related key underlying factors under each key high-level factor (see Fig. 5).

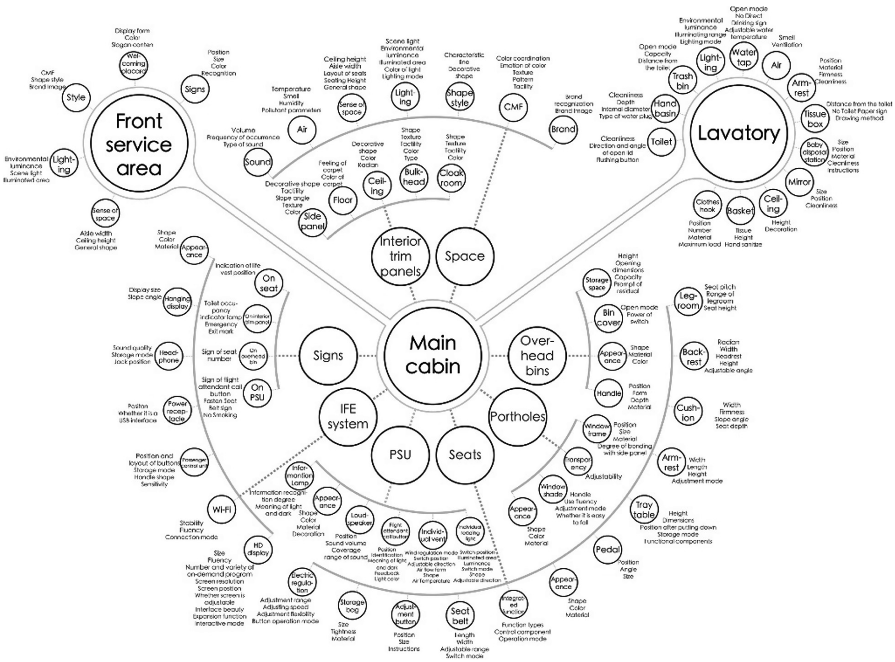

Fig. 5. Factor model for passenger experience in aircraft cabin design.

4 Study 2: Key Factors

As shown above, there are many high-level and underlying factors in aircraft cabin design related to passenger experience. Various surveys were carried out in order to find out the priority indexes.

4.1 Key High-Level Factors

Methods. In order to find out the influence level of each high-level factor on passenger experience, a questionnaire survey was carried out. Total 67 high-level factors in our model were included in the questionnaire, shown as following.

- The front service area: sense of space, lighting, style, welcoming placard, signs.
- The main cabin:
  - Interior trim panels: side pane, floor, ceiling, bulkhead, cloakroom.
  - Space: sound, air, sense of space, lighting, shape style, CMF (color, material and furnish), brand.
  - Overhead bins: storage space, bin cover, appearance, handle.
  - Portholes: window frame, transparency, window shade, appearance.
  - Seats: legroom, backrest, seat cushion, armrest, tray table, pedal, appearance, integrated function, seat belt, adjustment button, storage bag, electric regulation.

  - PSU: individual reading light, individual vent, flight attendant call button, loudspeaker, appearance, information lamp.
  - IFE system: HD display, Wi-Fi, passenger control unit, power receptacle, headphone, hanging display, appearance.
  - Signs: sign on PSU, sign on overhead bin, sign on interior trim panel, sign on seat.
- The lavatory: toilet, hand basin, trash bin, lighting, water tap, air, armrest, tissue box, baby disposal station, mirror, ceiling, basket, clothes hook.

The participants were asked to evaluate the importance of each high-level factor according to their experience. The influence is divided into three levels in the evaluation, including general influence (score = 1), important influence (score = 2), key influence (score = 3).

Participants. Total 16 participants attended the experiment. Their ages ranged from 21 to 45 years old. Their career experiences ranged from 2 to 25 years. Ten of them were aircraft interior design experts from COMAC, the other six were postgraduate students majoring in design from Shanghai Jiao Tong University who have certain knowledge and experience in this research area. The investigation scene is shown in Fig. 6.

Fig. 6. Investigation scene of questionnaire survey.

Data Analysis. After the survey, the mean value, mode and standard deviations were calculated for each factor. In order to judge the influence of high-level factors, a hypothesis about the standard of influence division is put forward. Define the mean of influence as X.

The null standard: When $1 \leq X < 1.67$, the factor is a general factor. When $1.67 \leq X < 2.33$, the factor is an important factor. When $2.33 \leq X3 \leq 3$, the factor is a key factor.

The result of factor influence level based on this standard was contrasted with the result according to the mode. If both results were consistent, the standard will be accepted. A data of 38 randomly selected factors scored by 10 experts were used to test this hypothesis. Results are presented in Table 1. Overall, both outcomes of the 34 items are the same.

Table 1. Mean score, mode score and standard deviation of some high-level factors.

System	Subsystem	High-level factor	Avg	Mode	Std. dev.
Front service area	-	Sense of space	1.89	2.00	0.78
		Lighting	2.11	2.00	0.78
		Style	1.89	2.00	0.78
Main cabin	Space	Sense of space	2.50	3.00	0.85
		Lighting	2.40	3.00	0.70
		Sound	2.70	3.00	0.67
		Air	2.60	3.00	0.52
	PSU	Individual reading light	2.50	3.00	0.85
		Individual vent	2.10	2.00	0.74
		Flight attendant call button	2.10	2.00	0.74
		Information lamp	1.80	1.00, 2.00	0.79
		Loudspeaker	2.00	2.00	0.82
	Overhead bins	Storage space	2.63	3.00	0.52
		Handle	1.50	1.00	0.76
		Appearance	1.75	2.00	0.71
	Portholes	Transparency	2.00	2.00	0.87
		Window shade	2.00	2.00	0.71
	IFE system	HD display	2.88	3.00	0.35
		Wi-Fi	2.11	2.00	0.60
		Power receptacle	2.20	2.00, 3.00	0.79
		Headphone	1.67	2.00	0.50
	Seats	Backrest	2.78	3.00	0.44
		Seat cushion	2.67	3.00	0.71
		Armrest	2.20	2.00, 3.00	0.79
		Tray table	2.10	3.00	0.88
		Adjustment button	1.56	1.00	0.73
		Storage bag	1.44	1.00	0.53
		Seat belt	2.11	2.00	0.78
Lavatory	-	Toilet	2.44	3.00	0.73
		Hand basin	2.00	2.00	0.87
		Trash bin	1.89	2.00	0.78
		Water tap	1.89	2.00	0.78
		Tissue box	1.33	1.00	0.50
		Armrest	1.78	2.00	0.67
		Baby disposal station	1.44	1.00	0.88
		Mirror	1.38	1.00	0.52
		Basket	1.33	1.00	0.50
		Clothes hook	1.11	1.00	0.33

After analyzing the other four factors, we can conclude that both results of the three factors are relatively consistent. The three factors are information lamp, power receptacle and armrest. Scores of these factors have more than one mode. And the result of factor influence level based on our standard was contrasted with the result according to one of the mode. Take power receptacle as an example. The mode of this factor is 2.00 and 3.00, which means the factor is an important factor or a key factor. The mean of this factor is 2.20, which means the factor is an important factor according to our standard. Therefore, the two results can be considered relatively consistent.

On the whole, the consensus rate of both results is as high as 97.37%, which means our standard of influence division can be accepted.

Result. Based on our standard of influence division, the influence level of all high-level factors was identified. There are 27 key factors, 24 important factors and 16 general factors. All key factors are listed below.

- The front service area: sense of space, lighting.
- The main cabin:
  – Interior trim panels: side pane.
  – Space: sound, air, sense of space, lighting.
  – Overhead bins: storage space, bin cover.
  – Portholes: window frame, transparency.
  – Seats: legroom, backrest, seat cushion.
  – PSU: individual reading light, individual vent.
  – IFE system: HD display, Wi-Fi, passenger control unit.
  – Signs: sign on PSU, sign on overhead bin.
- The lavatory: toilet, hand basin, trash bin, lighting, water tap, air.

4.2 Key Underlying Factors

Following the results from Sect. 4.1, all key high-level factors were presented. Three different surveys were conducted to identify key underlying factors related to the 27 key-level factors above.

Methods. Literature review was conducted first to count the number and importance of each underlying factor. We searched with different terms of each key high-level factor name and related terms such as “design”, “experience”, and “evaluate” with the aid of Google Scholar. Besides, we focused only on English and Chinese articles for comprehension. Next, fact-to-face interviews was carried out to gather aircraft cabin designers’ opinion. Six designers (3 male, 25–45 years of age) were asked to assess the importance of underlying factors relevant to their areas of expertise and select the most critical 1–3 factors. The interview scene is shown in Fig. 7. Finally, using a questionnaire, six user researchers (3 male, 22–35 years of age, 3–8 flights a year) were asked to independently indicate the importance of each underlying factor according to their experience. The influence is divided into two levels, including critical influence (score = 1), non-critical influence (score = 0).

Fig. 7. Investigation scene of face-to-face interview survey.

Analysis. By considering the three surveys above, key underlying factors were clarified. We take the analysis of underlying factors related to sound in space as an example to present detailed process. As mentioned in Sect. 3.2, the underlying factors of "sound" include volume, type and frequency of occurrence.

In literature review, a total of 4 related articles were found. Zhang et al. [20] found that noise volume (loudness) is most important, followed by sharpness, pitch, roughness and other parameters. Public transport hygiene requirements standard provides that cabin noise needs to be lower than 80 dB [21]. And Chen and Xia [22] emphasized that efforts should be made to adopt various sound insulation, sound absorption and noise reduction measures to improve the relative layout of aircraft sound sources, reduce cabin noise level and create a good working environment. In addition, Lei and Jiang [23] presented that cabin noise should be as low as possible to ensure the comfort of occupants and passengers.

On the whole, the "volume" factor is mentioned in all of the four studies. Moreover, one article pointed out that the volume of sound is most important. The "frequency of occurrence" factor is mentioned in two papers. The "type of sound" factor is only mentioned in one of them. Therefore, from the perspective of literature review, the "volume" is a key factor and the rest are non-critical.

Interview records show that three designers did assessment on this high-level factor. Their opinions are presented below.

Designer 01: The "volume" and "frequency of occurrence" are important.
Designer 02: The "volume" seriously affects passenger experience.
Designer 03: The "volume" is the most important factor, followed by the "frequency of occurrence".

From the above opinions, the "volume" factor is considered as a key factor by all designers. Some designers think the "frequency of occurrence" is important. The "type of sound" factor was almost never mentioned. Therefore, from the perspective of designers, the "volume" is a key factor, followed by the "frequency of occurrence".

The results of questionnaire survey are presented in Table 2. All six user experience researchers agreed the "volume" is a key factor. People who believe that the "frequency of occurrence" or "type of sound" is critical were respectively no more than half. Therefore, from the perspective of user researchers, the "volume" is a key factor.

Table 2. Underlying factors of "sound" and the numbers of researchers who considered it as a key factor (N = 6).

Underlying factor	Volume	Frequency of occurrence	Type of sound
Number of votes	6	2	0

We come to a conclusion after comprehensively considering the result of literature review and the opinions of designers and researchers. The "volume" is a key factor, and the "frequency of occurrence" and "type of sound" are non-key factors.

Results. All 27 key high-level factors were studied based on the same thought of analysis. As a result, there are 41 relevant underlying factors that have key impact on passenger experience. All key underlying factors are listed below (see Table 3).

Table 3. Key underlying factors of key high-level factors.

System	Subsystem	KEY high-level factor	KEY underlying factor
Front service area	-	Sense of space	Aisle width
		Lighting	Environmental luminance
Main cabin	PSU	Individual vent	Wind regulation mode, Switch position
		Individual reading light	Switch position, illuminated area, Luminance
	Signs	Sign on PSU	Sign of flight attendant call button
		Sign on overhead bin	Sign of seat number
	Overhead bins	Storage space	Height
		Overhead bin cover	Open mode
	Space	Sense of space	Ceiling height, aisle width
		Air	Temperature, smell
		Sound	Volume
		Lighting	Scene light, environmental luminance
	Interior trim panels	Side panel	Decorative shape, tactility
	Portholes	Window frame	Position, size
		Transparency	Adjustability

(*continued*)

Table 3. (*continued*)

System	Subsystem	KEY high-level factor	KEY underlying factor
	IFE system	Passenger control unit	Position and layout of buttons
		HD display	Size, fluency, number and variety of on-demand program
		Wi-Fi	Stability, fluency
	Seats	Legroom	Seat pitch, range of legroom
		Backrest	Radian (fit to body curve), width
		Seat cushion	Width, firmness
Lavatory	-	Toilet	Cleanliness
		Hand basin	Cleanliness
		Trash bin	Open mode
		Lighting	Environmental luminance
		Water tap	Open mode
		Air	Smell

The results of Study 1 and Study 2 are combined and presented in the following image (see Fig. 8).

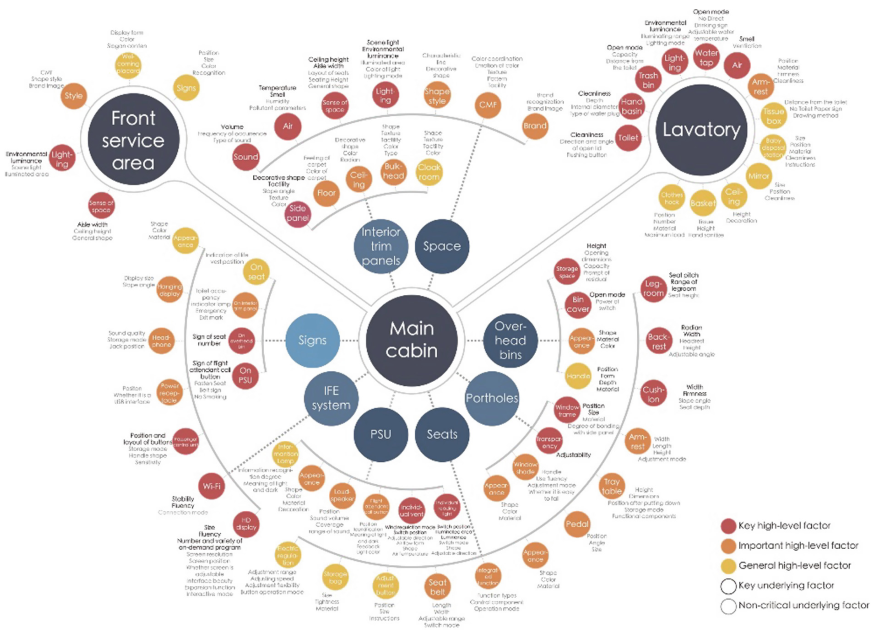

Fig. 8. The factor model with information of factor influence level.

5 Discussion

The aircraft cabin interior design is complicated. It's challenging to systematically understand it from the perspective of user experience. We focused on factors within cabin body and presented a key factor model for passenger experience in the aircraft cabin design.

In our study of the high-level factors' influence level in Sect. 4.2, we used the mean of scores as the indicator. Common statistical value that can reflect the trend of data concentration are the mean and the mode. For a certain set of data, there may be more than one mode value. But they can only have one mean value. If the mode was used as the indicator, the influence level of some factors couldn't be determined. Therefore, we chose the mean value as the indicator of influence level and used the mode to test whether the division standard of influence level is acceptable.

In study 2, the methods we used to find out key underlying factors are different from the methods used in the study of key high-level factors. Only questionnaire survey was conducted when we tried to find out key high-level factors. But when it came to key underlying factors, we also carried out the literature review and face-to-face interviews except for questionnaires. The differences between these methods are mainly due to the limitation of participants and rich language connotation. Most aircraft designers can correctly understand the meaning of each high-level factor and assess their influence level. However, since underlying factors are too detail-oriented, it is difficult for most designers to be familiar with them. Therefore, designers were only required to rate underlying factors in their area of expertise. Additionally, names of underlying factors were determined by us, so others may not be able to accurately understand the meaning. Through face-to-face interviews, we can be aware of whether respondents correctly understand the meaning of the factors. If not, we clarify the meaning of these factors on the spot. So, we used the face-to-fact interview to gather the opinions of expert designers. Meanwhile, literature review and questionnaire survey of user researchers were also conducted to get a more accurate and convincing result.

Limitations. When building the model, we regarded the factors as relatively independent. Thus, interactions between factors are not evaluated in our study. On one hand, each factor is defined based on cabin body and can be considered as a relatively independent entity. On the other hand, it is more convenient for us to clear up the structure of a large number of factors by ignoring the correlation among factors of the same level. But we still have to acknowledge and clarify possible correlations to build a more accurate model.

Also, sample size of our surveys was small in statistical terms. Although the participants were carefully selected to enhance the validity of research results, small sample size may still cause the problem of generality of results. More representative populations could be required to achieve a more convincing conclusion.

Further Research. This paper focuses on factors that affect the passenger experience. However, flight attendants and aircraft maintenance personnel are also users of aircraft cabins. Different users have different behaviors. Factors that affect other users' experience may differ from the factor model in this paper. It is advised to build factor models for other users' experience and compare their similarities and differences.

The model is based on the products in the aircraft cabin interior. An in-depth quantitative study of the relationship between aircraft cabin interior and passenger experience can be carried out based on this model. Future research could address to create a mapping system between passenger experience and these factors by studying the relationship between factors and the relationship between factors and passenger experience.

6 Conclusion

Passenger experience is an important issue in the design and development of civil aircraft. In this paper, we aimed to get a systematic and practical understanding of factors that influence passenger experience in the aircraft cabin. A factor model was built to give an image of all factors and priorities with regard to aircraft cabin design. It includes three systems, eight subsystems, 67 high-level factors and several underlying factors. All high-level factors are divided into key factors (27 factors), important factors (24 factors) and general factors (16 factors). And there are 41 key underlying factors relate to key high-level factors, the rest are non-critical. This research provides a new practical guideline to improve the passenger experience in the aircraft cabin design.

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