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In-vehicle Voice Assistants in Different Markets

Understanding region-specific user preferences

Master's thesis in Industrial Design Engineering

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Department of Industrial and Materials Science

CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

The thesis focuses on the research and conceptual design of region-specific user preference for in-vehicle voice assistants. Firstly, three research methods, such as Consumer psychology, Human-centered design and Country-specific design, are utilised to examine current user preferences and potential factors influencing them, which helps designers establish the design guidelines for IVA project. Secondly, the conceptual IVA solutions were designed to meet user needs(preferences) and stakeholder's requirements based on the design guidelines. In addition, some research methods, design approaches and design tools have been innovatively adapted based on the author' study experience and practical design experience.

Keywords: User preference, User research,Country-specific, Design Practice,Industrial Design,

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Zhicong Lu, Gothenburg, June 2023

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List of Acronyms

IVA	In-vehicle voice assistant
HCD	Human-centered design
UCD	User-centered design
ABA	Attribute-based approaches
CSD	Central screen display panel
Region-specific	Country-specific = Mainland China (excluding Hong Kong, Macau and Taiwan)

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Introduction

1.1.Purpose

In-vehicle voice assistant products have been used in smart driving for some time, but the design and technical development of these products has resulted in not fully meeting the needs of users, ultimately affecting their driving experience. According to the China Smart Driving Report, voice assistant products in the Chinese region do not fully meet the expectations of drivers. Therefore, the purpose of this project is to understand Chinese users' preferences for in-car voice assistants, to obtain better voice assistant design directions and design principles through region-specific user research, and to provide reasonable research support for future voice assistant product design to improve user satisfaction and loyalty to the brand.

1.2.Aim

The aim of the project is to identify Chinese users' preferences for visual elements of in-car voice assistants, which are not limited to shape, type, colour, material, virtual animation, etc. At the same time, the research investigates the user's needs for voice assistants in different situations, such as when driving, when parking, while driving, etc. Research on how voice assistant products can be more user-friendly through product image in terms of interaction and experience. In-depth research into Chinese user characteristics, including consumer psychology, behaviour, social environment, cultural practices, etc., any factors that influence the user's preference for a product. Finally, to develop more accurate design guidelines for users in that particular region and to design and develop in-car voice assistants to be appropriate for them.

1.3.Scope

In the case of the study of Chinese users' preferences for visual elements on in-car voice assistants, the geography of the study limits the research methodology, as the designer is based in Sweden and all research methods need to be carried out in a remote mode, and this remote research process will undoubtedly lead to limitations and uncertainties in data collection. At the same time, when exploring user preferences for visual elements in in-car voice assistant products, it was necessary to avoid deviations in the direction of the research, as there is a strong correlation between product visuals and functionality, and it is possible

that users may in many cases prioritise product functionality and believe that functionality determines the presentation layer elements of the product. Therefore, in this study, the research will focus more on the visual needs of users using the in-car voice assistant in different contexts, rather than considering the analysis of user needs from a functional perspective.

It is worth emphasising that the study of subjective factors influencing user preferences will be a major part of the project, as the study of subjective factors such as consumer psychology, emotional satisfaction, driving issues, etc. will allow for a deeper insight into the reasons for the formation of user preferences and the establishment of more fundamental design guidelines based on these reasons.

1.3.1.Stakeholders

The background of the research topic is based on Lynk&Co's project requirements. Currently, we are in contact with feedback from the market and user feedback on Lynk&Co's in-car voice assistant, most of which is negative. The client, Lynk&Co, therefore needed to incorporate a better in-car voice assistant into future vehicle development projects to improve the user driving experience and brand reputation. The client therefore set out a clear requirement:

- To explore user preferences for in-car voice assistants as a research direction.
- The research and IVA conceptual design should be data-based.
- The design was adapted to the local market

To analyse how the design of the IVA would enhance user stickiness and brand loyalty. After completing the above requirements, actual solutions will be produced to demonstrate the feasibility of the solution, including but not limited to hand-drawn sketches, 3D models, Animation, or physical models if needed.

1.4. Research Questions

Once the clear needs have been identified with the company, the customer's needs are translated into research questions.

Firstly, in order to explore user preferences for in-car voice assistants it is necessary to investigate what factors influence the user's preferences and to understand what attributes of the product will satisfy the user. It is also important to understand the cultural values, aesthetic trends and preferences of the local market in order to adapt the solution to the local market. Secondly, the user expects the designer to provide valid data to support the validity of the solution, so qualitative and quantitative research methods are important in this project. Finally, analysing the relationship between the IVA and user stickiness and brand loyalty required reference to the research findings to develop a design strategy.

Therefore, the four different needs can be divided into two research questions and these research questions will be answered in the different studies and analyses that follow. The research questions are as below:

I. What are the latest findings on user preferences for IVA products?

II. How to set up the design guidelines of In-vehicle voice assistant innovation ?

1.4.1. Current research of user preferences

Research Question I is responsible for providing current research information on the topic to Research Question II during the course of the project, which primarily requires the use of the literature review method. The main emphasis of the research questions is on the following areas:

1. *Exploring the latest research on user preferences for in-car voice interaction*

A review of previous research will enable designers to select the right research methods to move the project forward. At the same time, the latest findings and results are summarised to gather possible factors that influence user preferences and to understand the patterns of user preferences based on these factors.

1.4.2.Set up the design guidelines

After completing the study of Research Question I, Research Question II required further refinement of the research methodology to provide a holistic understanding of the research subject, looking for potential user preference patterns from multiple levels of research. The main emphasis of this research question is on the following points:

1. *Collecting the needs and preferences of users in a specific region*
2. *Analysing the relationship between potential factors and user preferences*
3. *Analysing whether the IVA design meets the needs of multiple parties*

In order to develop design guidelines for this project, the above three areas need to be researched. By using a number of different research methods to gather the needs and preferences of the target users of the IVA product in a specific region, which were then screened and validated to produce accurate user data. Next, country-specific methods were used to explore the relationship between potential influencing factors and user preferences. Next, the relationship between user data and influencing factors is analysed to verify which influencing factors are the most important user preferences.

1.5. Outline of the Thesis

The article consists of eight chapters: Introduction, Background, Research method, Research tools, Design practice, Conclusion, Discussion, Future work, all of which are based on the design process of the project. They are therefore divided into five steps: communication, research, data collection, design and validation, and conclusion. Each step has a different core task, but is interlinked to form the overall framework of the text.

Introduction, the introductory chapter, provides a short overview of the research aims, objectives, scope, customer requirements and research questions of the in-car voice assistant project.
Background, the background chapter, introduces the research topic and provides background information about in-car voice assistants in different regions. It focuses on the current development of the product, including technological development, application scenarios, product design, etc. It also summarises what problems exist in the current application and development of the product in the Chinese market.
Research methods, the theoretical chapter, introduces the design theories used in the research and design of the project. Consumer psychology is used to study the behavioural characteristics of Chinese users, their purchasing decisions and the factors that shape brand loyalty. The human-centered design theory provides a complete and detailed user-centered design framework and research steps during the user research and design phases. The country-specific design theory, on the other hand, provides a holistic theory of design based on a variety of cultural factors in a particular region/country.
Research tools, the design methods section, describes the methods used to collect and analyse user research data. Examples include literature reading, qualitative and quantitative research methods, user testing, observation, etc., and a summary of the results of each research tool.
Design practice, describes the design of the solution based on the findings in the above sections and presents the final solution and several user tests.
Conclusion, the conclusion section, addresses the research questions and highlights the findings and conclusions of the project.
Discussion, the discussion section, talks about the limitations of the study, such as the combination of methods, sample limitations, and problems found during the study.
Future work, which presents potential work that may be faced in relation to the IVA, or suggestions for changes to the prior results, etc.

2

Background

2.1.Voice interaction development in China

The development of voice interaction in China dates back to the 1980s, but at that time the technology was not good and could only simply recognise numbers and simple Chinese characters, making it difficult to meet the needs of users. But with time, in the early 21st century, China began to apply voice interaction technology to various scenarios, for example, voice services, voice search, voice recognition and so on.

In 2008, China Unicom Mobile officially launched the Shenzhouxing Voice Navigation System, a navigation system that not only enables voice input of routes, address search, voice navigation, etc., but also voice recognition to confirm identity and voice payment, greatly enhancing the driving travel experience. Since then, voice interaction technology has gradually been widely used in China and has gradually become an integral part of people's lives.

With the continuous improvement of voice interaction technology, such as deep learning, artificial intelligence and other technologies, the accuracy of voice recognition has been greatly improved, basically achieving 95% accuracy rate of voice recognition. At the same time, voice interaction scenarios are also gradually expanding. Nowadays, voice interaction technology is used in smart home, smart car, smart medical and smart service scenarios, gradually forming a technology ecosystem and bringing great improvement to the convenience of human life. Moreover, voice technology can now realise multiple language input, multiple voice commands, intelligent recognition of user needs, proactive voice interaction, emotional interaction, etc., making the interaction more natural and human-centered.

2.2.In-vehicle voice systems for car manufacturers

In-car voice systems are becoming increasingly trendy for the automotive industry nowadays, providing the ability to interact with the car without the need to use hands, greatly facilitating the driving experience. As a result, car manufacturers are constantly innovating and improving their in-car voice systems to provide a more user-friendly voice control system to control and monitor the driver and vehicle conditions. In simple terms, they install microphones in different areas of the car connected to the car's central console, allowing the

user in different areas of the car to give commands effectively. The voice system can also recognise various commands such as turning on headlights, adjusting the air conditioning temperature, changing the radio channel, navigating and so on. The in-car voice system also has a safety alert function, which immediately signals when the driver is off the proper navigation route. Furthermore, the latest in-car voice system is combined with various sensory systems to identify if the driver is tired or driving under the influence of alcohol. If the driver is detected to be driving while fatigued or under the influence of alcohol, the voice system provides an immediate warning reminder, which greatly enhances road safety. In addition to this, the voice system is also integrated with the entertainment function, which allows you to adjust entertainment items such as news, music, movies, games, etc. via voice commands.

Overall, in-car voice systems are becoming increasingly intelligent and a highlight of smart driving, and car manufacturers are increasing their brand value by humanising their systems.

2.3.Introduction of in-vehicle voice assistant

In professional terms, a "voice assistant" is a digital agent of artificial intelligence that is capable of performing tasks in response to verbal commands, requests and questions from users. This technology has been used in many human-computer interaction scenarios, such as home smart TVs, smart stereos, smartphones, etc. [3]. With the development of information technology and communication technology, the automotive industry is also increasingly adopting voice assistants to improve the driving experience. Drivers can now feel more freedom as intelligent car assistants can help them with more tasks and information [2]. In addition to functional needs, voice assistants are also seen as an important player to address the mental and emotional needs of the car's passengers [4].

On the one hand, voice assistants act as an interactive bridge between the user and the car, bringing many benefits to the user and the automotive industry. For the user, driving is an activity that involves many human resources to be managed, as well as the need to be aware of the surrounding environment. With the help of voice assistants, drivers can spend less attention, thinking and operating to handle these resources. Currently, AI voice assistants can not only respond to basic commands (send messages, play music, navigate, etc.) but can also tailor services to the user's personal preferences (recommended music, recommended restaurants, recommended temperatures, recommended parking locations, etc.). Thus, AI-based voice assistants can reduce the driver's cognitive compliance and work compliance, which improves driving safety [4]. Furthermore, many voice assistants are designed to be 'special', improving the driver's emotion and experience by enhancing the intimate relationship between the person and the product. For example, approachable, friendly images and interactions can help to stimulate positive emotions in drivers when they are faced with stressful or unpleasant scenarios [5].

On the other hand, voice assistants can act as a hub for human-vehicle interactions, enabling companies to create better built-in hub relationships (car brand and customers) to increase consumer purchase intent and brand reputation. In addition, JD power states that most car consumers prefer to buy a car with a voice assistant that knows them well[6]. Moreover, by collecting data from voice assistants, companies can more easily understand

the deeper needs and driving habits of users, and effectively translate this user information into product benefits to enhance brand competitiveness.

2.4.In-car voice assistants in the Chinese market

At present, in the Chinese market, in-car voice assistants can be categorised into two main types. The first, in-car voice assistants developed by technology companies alone, such as Tmall Genie, Baidu Xiaodu Assistant, HUAWEI, etc. The second, in-car voice assistants developed by car manufacturers, but due to the presence of many Chinese car manufacturers, more than 100 car manufacturers[8]. Typically car manufacturers name their voice assistants after the car brand, e.g. NIo-Nomi, Xiaopeng-Xiao P/Classmate P, BYD-Xiao Di/Classmate Di, etc. Thus, by researching the voice assistant brands of the major car manufacturers in the Chinese market and orienting the research towards the visual interaction of voice assistants, the table is as follows:

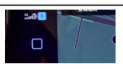
Main Car brand in CN market	VA Products	Product image/form	Anthropomorphic emoji	Customization	Proactive interaction
XPeng Motors 小鹏	Junior P		Yes	Support for Little P voice image and skill customization; no support for custom wake-up words	-
NIO 蔚来	NOMI		Yes	Support for NOMI image and wake-up words customization	Yes
Li Auto 理想	Classmate Li		Yes	No any support for customization	-
UNI长安-China Chang'an Automobile Group	Ann 小安		-	Limited support for customization	-
Lynk&Co 吉利-领克	JOJO		Yes	3D virtual assistant with image customization; customised love names, wake words and voice packs	Yes
ROEWE SAIC 上汽-荣威	Small Attendant 小跟班		-	Support for image customization	-
BMW cn宝马中国	Tmall Genie		-	Support for wake-up words and name customization	-
Volkswagen ID 大众ID	No name		-	Supoort for wake-up words customization	-

Figure 1. The main In-car voice assistants of car manufacturers

As can be seen from the table, the voice assistants of different car manufacturers are differentiated in terms of product shape, image, customisation, active interaction and so on. However, in terms of product image/form, they can be divided into two types, one physical (Nomi) and one virtual (the other rest).

3

Research Methods

The design and development of voice assistant products for users in specific regions requires the following three approaches. Understanding consumer purchasing decisions and the factors that influence them requires the use of consumer psychology to help inform product design strategies. Human-centered design methods are used to gain insight into the real needs and expectations of users. By involving the user in the design process and evaluating the effectiveness of the design, and understanding the user's human perceptions, insights and decision-making processes in complex systems (in-vehicle interactions), this can help designers to optimize the design to enhance user performance and safety in using the system/product. When designing for a specific country, a country-specific approach is used to consider the cultural values, customs, economy, etc. of a particular region to help designers create products that are more attractive to users in that region and more in line with local values. Literature review is a generic research method and is used in all of the above methods.

3.1.Literature Review

A search for the keywords "in-car voice interaction, user preference" in Google Scholar and sciencedirect literature sites did not yield valid research literature. Replacing the keywords with "voice assistant, in-car interaction, user, preference, acceptance" yielded more articles with strong relevance. The time frame was set between 2018 and 2023, and the most relevant articles were selected for browsing and filtering for key information.

3.1.1.Related works

In their study, JIng Liu, Fuchen Wang highlight that, from a practical perspective, most voice assistants are also designed to perform practical tasks, despite the desire to meet the growing social and emotional demands of interaction in the car. In other words, these in-car intelligent voice assistants are still function-oriented rather than user-centered design-oriented [33].

However, in the field of human-computer interaction, the findings of some studies do not match the current state of the function-oriented intelligent voice assistant industry. For example, Braun found that the most promising are voice assistants with empathy, compared to other interaction technologies [34]. It has also been highlighted that personalised voice assistants can have a positive impact on user acceptance, trust and workload [35]. In the field of design science, Row et al. introduced a pet morphology design approach and identified a set of dog behavioural features for in-car voice assistants [36], and they explored how these design features could be added to different driving scenarios. Ringfort-Felner used

a design fiction approach to investigate the relationship between a virtual voice assistant and the driver and to understand how it meets the user's social experience [37]. Meck et al. experimentally demonstrated the development of a set of language-based guidelines that were effectively used to rapidly design in-car voice assistants at the syntactic, grammatical and lexical levels [38]. Ji found that message type and speaker gender also influence user preferences for in-car voice assistants in in-car interaction contexts [39]. In the field of behavioural science, Wolf demonstrated that human-voiced voice assistants can facilitate purchase behaviour and reduce negative emotions [40].Liu found that user preferences for voice assistants were related to a range of design feature factors, including personality traits, voice pitch, and speech rate, among others [41].McLean and Osei-Frimpong found that by examining user preferences for home voice assistants adoption and motivation found that personal preferences for voice assistants were driven by three main benefits of voice assistants: utilitarian benefits, symbolic benefits, and social benefits [42].

Overall, in response to Research Question I, although the literature review approach explains what factors influence user preferences for intelligent voice assistants from the fields of human-computer interaction, design science, and behavioural science, these studies are largely centered on the voice assistant object to explain how a particular factor of the object influences user preferences, acceptance or attitudes, and do not provide an analysis of potential influences from the user's perspective and the user's context to analyse the potential influencing factors. Therefore, the project still requires additional research methods to gain insights into the subjective factors influencing user preferences. Therefore, methods such as consumer psychology, human-centered design, and country-specific design were introduced to explore the research question II.

3.2.Consumer Psychology

In consumer psychology, aesthetics has been used largely to describe the form of objects, people, or consumption environments [11]. Furthermore, aesthetics is a universal experience rooted in human nature, and there is no such thing as aesthetic behaviour isolated from culture [10]. Many previous studies have also shown that aesthetics, from different paths, resonates with consumers, from product design to the coordination of the sales environment [12, 13], and it has long been recognised as a point of difference between positive product attributes and brands that are used to attract and satisfy users [14]. It has also been highlighted that design elements are also likely to influence the overall product evaluation, even if they are irrelevant in the product [14], [15].

The visual appearance of a product plays an important role in consumer response and design success [43]. Consumers often judge a product largely on the basis of the elegance, functionality and social impact of its visual information [44]. Maslow's principle clearly describes that once a product's utility, safety and comfort are satisfied, consumer attention shifts towards decorative, emotional, and symbolic design attributes. However, depending on the context, the perceptual attributes of a product may be more important to consumers than the tangible attributes of the product, such as emotional feedback, experience and identity, rather than the function and image of the product [9].

In general, consumers expect a certain consistency and balance between function and form [45]. Increasingly, consumer research has focused on the balance between function and

aesthetics, finding that a product with an aesthetically pleasing form is more popular with consumers than one without, even if the former is not as well-functioning. However, an excessive focus on aesthetic form can often lead to a reduction in perceived functionality, which can also lead to product failure. It has also been shown that in some products, when assessing the importance of aesthetics and functionality, an increase in perceived aesthetic appeal does not necessarily lead to a decrease in perceived functionality [18]. Thus, when evaluating a product, consumers often make a trade-off between aesthetics and functionality, and the extent and degree of this trade-off is flexibly adjusted depending on the particular cultural context and usage scenario. At the same time, it is worth noting that the trade-off between functionality and aesthetics is not equal, but is also closely related to the characteristics of the product. For example, the functional-aesthetic trade-off between handicrafts and electronics varies considerably.

In previous research, the functionality of a product can largely be categorised as utilitarianism, while the aesthetics of a product are considered hedonistic, and consumers are heavily influenced by both of these perceptions when preferring a particular product [17]. Utilitarianism tends to give consumers a sense of satisfaction with a product or service, whereas hedonism gives consumers a sense of pleasure that exceeds perceived expectations. Therefore, it is safe to assume that consumers are more hedonistic, when the product meets a certain level of functionality. However, when the product does not reach a certain level of functionality, the positive impact of aesthetics is not sufficient to eliminate the negative consumer response [19]. The diagram below, explains the relationship between traits (functional - Must be, aesthetic - More is better) and consumer satisfaction.

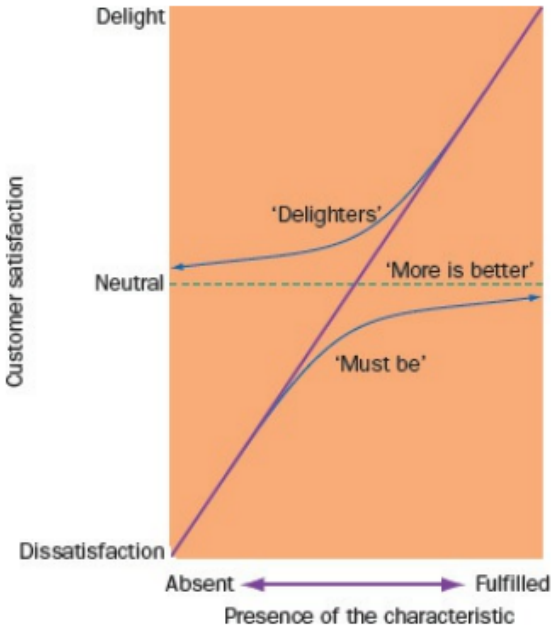


Figure 2. .Creating customer satisfaction

In more detail, consumers' evaluated (behavioural and psychological) responses to products can be divided into three categories: innate, personal, and cultural [9, 22]. Inherent response preferences (behavioural and psychological) are universal and constant, but personal and cultural diversity exists. Numerous consumer studies have investigated the influence of

personal characteristics on design preferences, presenting considerations of age, gender, experience and individual personality factors that contribute to the diversity of consumer purposes, attitudes and criteria which determine their focus on products [23]. Also, consumers' behaviour and psychology towards product evaluation is influenced by culture. Within a given cultural context, there is a perception defined as a cultural agreement, which is somewhat akin to a 'majority direction', e.g. what looks good, what is worth pursuing, what brings value, etc. Such perceptions influence how products are evaluated and accepted by the consumer market [9].

In summary, consumer psychology provides a framework of knowledge to fully understand how consumers think, react and perceive products when making purchasing decisions. Studying consumer psychology not only helps designers to understand consumers' psychological processes and experiences, but also helps designers to identify key factors and motivations in the decision-making process, to develop effective research and development strategies for product design and development, and for companies to develop products and services that are more attractive and meet consumer expectations.

Therefore, in this short section I summarise the key messages previously made about consumer psychology, mainly：

1. the positive role of visual information about the aesthetics of a product on consumer product perception,
2. that for the consumer there is a balance between functionality and visual information (external elements) and that they can influence and compensate for each other.,
3. the perceptual attributes (status, emotion, experience) provided by the product are more important than the functional and image attributes of the product, in a given context,
4. Product aesthetics - hedonistic properties that give the user a sense of pleasure beyond expectations,
5. Consumer preferences are influenced by a variety of factors, subjective (age, gender, experience, personality) and objective (cultural agreements).

However, it is worth pointing out that consumers' subjective assessments of products may differ significantly from designers' perceptions [25], mainly because their perceptions of products are based on different perspectives. For example, consumers perceive 'feminine' products as images with female gender characteristics, while designers define 'feminine 'feminine' products as products with visual elements of elegance, tenderness and sensuality [25]. This differentiation of cognitive models is a gap and a challenge for designers trying to understand consumers. Designers therefore need a bridge to connect with each other, which is human-centered design.

3.3.Human-centered Design

Today, human-centered design is based on the use of technology to communicate, interact, empathise and stimulate those involved to understand their needs, desires and experiences, often beyond what people themselves are actually aware of. As such, human-centered design differs from many traditional design practices in that the natural focus of the questions, insights and activities is on the person for whom the product, system or service is intended, rather than on the designer's personal creative process or the material and

technical basis of the artifact [26]. "The Ergonomics of Human-Centered Systems Interaction describes human-centered design as "an approach to systems design and development that aims to make interactive systems more useful by focusing on their use and applying human factors [27], using the following six characteristics:

- The adoption of multidisciplinary skills and perspectives
- Explicit understanding of users, tasks and environments
- User-centered evaluation driven/refined design
- Consideration of the whole user experience
- Involvement of users throughout design and development
- Iteration process

Although all designers incorporate human-centered or user-centered design principles into their work, very often they also use specific design frameworks and models to demonstrate these six characteristics through the construction of a rational and detailed design process. Of course, different design processes vary depending on the needs of the design project, for example, the classic double diamond model (discover, define, develop, deliver) and Stanford University's five patterns (empathize, define, ideate, prototype, test), both of which are design frameworks which encourages designers to move flexibly between phases in solving project problems in order to encourage experimental design activities. Although there are differences between the model and the nomenclature in the human-centered method, there are three core stages that are consistent. These include, 1) communicating with all stakeholders to understand and define the problem from their perspective, 2) designing innovative solutions to meet the needs of multiple stakeholders, and 3) prototyping, implementing, and evaluating the solution [46]. It is important to note that both the design framework, design model, design steps, and design process are highly similar in terms of goal-oriented, iterative, requirements analysis, creativity, and feedback mechanisms, and that these characteristics can be achieved using different design tools [32].

As the toolbox of human-centered design techniques continues to evolve, sometimes by borrowing from fields such as psychology or sociology and sometimes by defining new methods that emerge from design practice [26]. These tools can be categorised according to the intention of their use as follows: anthropometric, biomechanical, cognitive, emotional, psychophysical, psychological and sociological data and models which define the operational boundaries of the tools for the practical application of this human-centered method, basically for the presentation of basic facts or data [26].

Some human-centered design tools include methods and techniques for interacting with people to help designers examine meanings, desires and needs in a verbal or non-verbal way [26]. cognitively inspired, language-based techniques such as ethnographic interviews [28]. Questionnaires, role playing and focus groups [29]. Some methods are increasingly focused on investigating people's mental activities, such as participant observation [30], facial coding analysis [31], and many have been applied by designers and researchers in user research. Finally, a range of human-centered design tools are used to stimulate intuition, seek opportunities, reproduce possibilities for purpose, response and discussion. The diagram below, provides an overview of most of the most commonly used human-centered design tools, some of which may be named differently due to different sources of information, but are applied in a largely consistent manner.

Human Data and Models	*Capture of Needs, Desires and Meanings*	*Simulation of Possible Futures*
– Anthropometric data sets and models – Biomechanical data sets and models – Psychophysical data sets and models – Cognitive data sets and models – Emotional data sets and models – Psychological data sets and models – Sociological data sets and models – Philosophical data sets and models	Verbally based – Ethnographic interviews – Questionnaires – Day-in-the-life analysis – Activity analysis – Cognitive task analysis – The five whys – Conceptual landscape – Word-concept association – Think aloud analysis – Metaphor elicitation – Be your customer – Customer journey – Extreme users – Personas – Scenarios – Brainstorming – Contextual inquiry Non-verbally based – Game playing – Cultural probes – Visual journals – Error analysis – Fly-on-the-wall observation – Customer shadowing – Body language analysis – Facial coding analysis – Physiological measures – Electroencephalograms	– Focus groups – Lead user design – Co-design – Storyboard futures – Experience prototypes – Para-functional prototypes – Role playing – Real fictions

Figure 3. Human-centered design toolbox, provided by Joseph Giacomin

In summary, the human-centered research approach provides a very important contribution to IVA project research. It has been proven by many design studies and design practices to provide designers with an effective design approach and design framework to ensure that designs meet the needs, expectations and experiences of users. At the same time, this research approach can have a positive effect on the competitiveness of products and services, improve the efficiency and accuracy of design, and enhance brand image and credibility, among other things. The IVA project then integrates the right, effective and applicable design methods and processes to facilitate the research and design of the project step by step.

3.4.Country-specific Design

Country-specific design means that when developing a product for a specific geographic region or market (the Chinese market), due consideration should be given to the distinctive

characteristics of that region, such as ethnic culture, region, climate, language, habits, policies, education levels, economic development and so on[48].

Aryana, B's study concluded that the main approaches to the study of users and products in specific countries are:Attribute-based approaches, Empirical approaches and user-centered approaches[48].

Attribute-based approaches, which focus on the attributes of a product or service as the central basis for design decisions, often focus on the functionality, appearance and performance aspects of a product and optimize these aspects. For example, one study concluded suggested design features for shopping websites across different geographical regions by testing the relationship between the attributes of different design elements (navigation design, visual design, information design) and trust, satisfaction and loyalty in a cross-cultural context [49]. Other studies have tested the conclusions drawn from the ABA approach to information coding and found that even very small amounts of information can be important design inputs in China and India, which drive design direction. In addition, some studies have highlighted that attribute-based classification is easily integrated into the design and development process [48]. So, how can attribute-based approaches be applied to country-specific design and development?

Many studies have adopted a design approach consisting of Hofstede's cultural dimensions, cultural oriented design and product model to correlate country-specific cultural attributes with product component attributes, and then analyse the compatibility of country/cultural values with The product attributes are then analysed for compatibility with the country/cultural values in order to develop a design strategy [50, 52, 53, 55]. Among others, Röse summarises in detail the definition of Hofstede's cultural dimensions in his study of cross-cultural HMI design research [52]:

- Hofstede’s cultural dimensions
    - Power Distance Index, extent to which the weaker members of a society accept inequality in power.
        - High Power Distance: Centralized decision making, management and superiors are highly respected and have the last say in decisions.
        - Low Power Distance: Everyone expects to share in decision making; management hierarchies are flatter and more open to questioning.
    - Individualism vs. Collectivism Index, the relationship between individuals and groups.
        - High Individualism: Social ties are loose; individuals expected to look after themselves.
        - High Collectivism: Individuals are strongly incorporated into groups of family and school; government policies often favor the group over individual rights.
    - Masculinity vs. Femininity Index, the distribution of emotional roles between genders.
        - High Masculinity: Favors assertiveness with an emphasis on competition.
        - High Femininity: Focuses on quality of life with an importance placed on the well-being of relationships.
    - Uncertainty Avoidance Index, extent to which a society feels threatened with unknown situations, ambiguity, and uncertainty.
        - High Uncertainty Avoidance: Strictly defined rules of behavior and formality; things that are different or unexplained can be viewed as dangerous.
        - Low Uncertainty Avoidance: Willingness to take risks, more experimentation and/or innovative behavior.

- Long- vs. Short-Term Orientation Index, extent to which members of a cultural group are willing to accept delayed gratification of material, social, and emotional needs.
    - Long-Term Orientation: Promotes virtue and persistence, focus towards future rewards.
    - Short-Term Orientation: Emphasis is placed on the past and present, fosters a respect for tradition.

Hur.W's study of 400 Chinese users based on Hofstede's cultural dimensions in the customer-brand relationship found that although China is more pragmatic (high Masculinity) and long-term oriented, Pragmatism (high Masculinity), hedonism (Femininity) and long-term orientation also have a very strong influence on brand trust, brand loyalty and preference [47]. A summary of Hofstede's research in 2008 found that Chinese cultural values tend to be more long-term oriented, collectivist[93], high power distance, low uncertainty avoidance, and masculinity[94], as shown in the figure below.

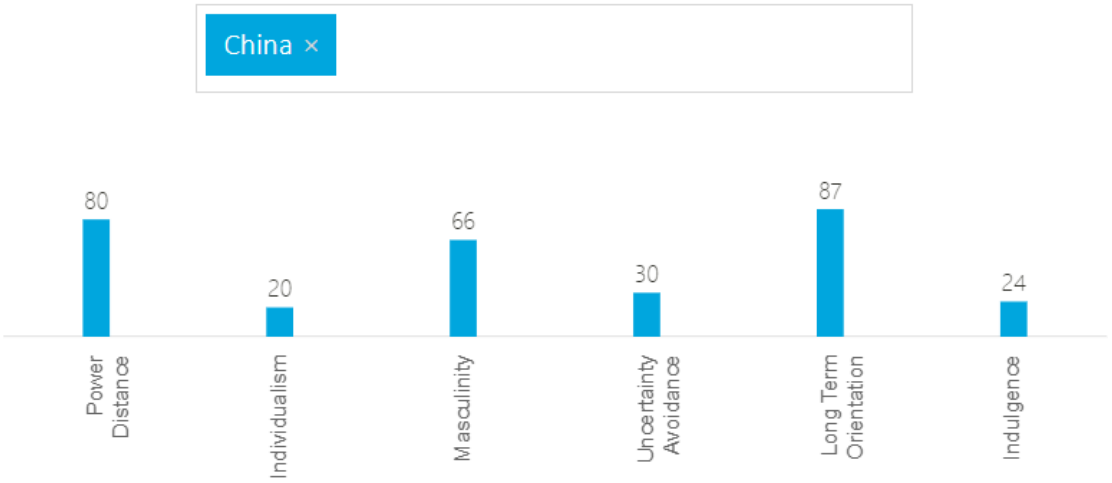


Figure 4. Chinese culture compass of Hofstede Insights

It is worth drawing attention to the fact that with his research, a new dimension of cultural values, 'Indulgence', was added. It can be seen that China scores very low on this dimension, so it is a restrained society and its cultural values are conservative and restricted, with people being oriented in such a way that their behaviour is limited by social norms and they do not make bold and innovative decisions [54].

- Object oriented product model. In his study, Aryana, B, showed that product models can show components and classifications of products, modular production and personalisation by providing customised components [56]. In his study, he split the components of smartphones according to product models to show the classification of product attributes at each level for subsequent research, for example, smartphones contain, data bearers, user interface, graphic user interface, screen, main screen. Havam also emphasises that an object-oriented paradigm is among the main perspectives for creating product models, which define the An object-oriented paradigm is among the main perspectives for creating product models, which define the product as a system structured by objects and classes [56].

However, previous research has used object oriented product models (OOPM) to analyse existing products with known industry standards to help facilitate the development or improvement of next generation products. For conceptual, and innovative design projects, no research has concluded guidelines for the use of OOPM models for such conceptual products. For example, there are no clear design guidelines or design components for the design of in-car voice interaction assistants. Therefore, it is not possible to use the OOPM model without identifying the product components of the concept.

This leads to a new concept, Concept oriented product models, where the designer first needs to adapt the Object oriented product model. This is done by first conducting a user study, summarising the results of the user study, defining the IVA concept according to user preferences and then disassembling the product components (in general) and the product hierarchy through product models. (Note: Concept oriented product models are not supported by previous research, this model is only derived from design experience and based on additional derivation of object oriented product models, its validity will be tested later in the project design), the adjustments are shown below;

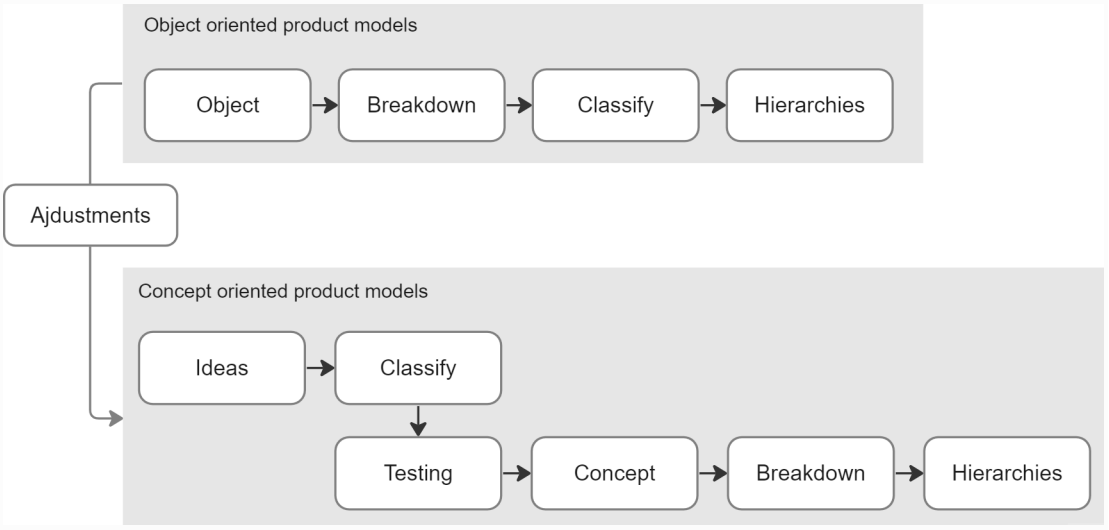


Figure 5. The concept oriented product models

- Culture-oriented design, is one of the models that link cultural value attributes and product attributes, aiming to incorporate the culture and values of the user into the design process of a product, service or system. It emphasises understanding and respecting the influence of different cultural contexts on design decisions to ensure design acceptability, adaptability and sustainability. It is commonly applied to human-machine systems [52], and also to product design [53]. For example, Aaron used this approach to correlate high power distance cultural values with region-specific website user interfaces to develop a more culturally appropriate design strategy for each website element, and demonstrated its effectiveness in a subsequent validation phase [51]. Richie Moalosi et al. transformed specific socio-cultural factors (materials from local traditions) into product design features, allowing products that are integrated with cultural values to empathise with users

based on the basic satisfaction of their functional needs, attracting them to use them for a long time and aspiring to preserve them [50].

Finally, although the framework of the ABA approach is clearly described in Aryana, B's study, because of the qualitative distinction between design objects (between custom design of an already existing product and conceptual innovation design), the ABA model has been adapted to;

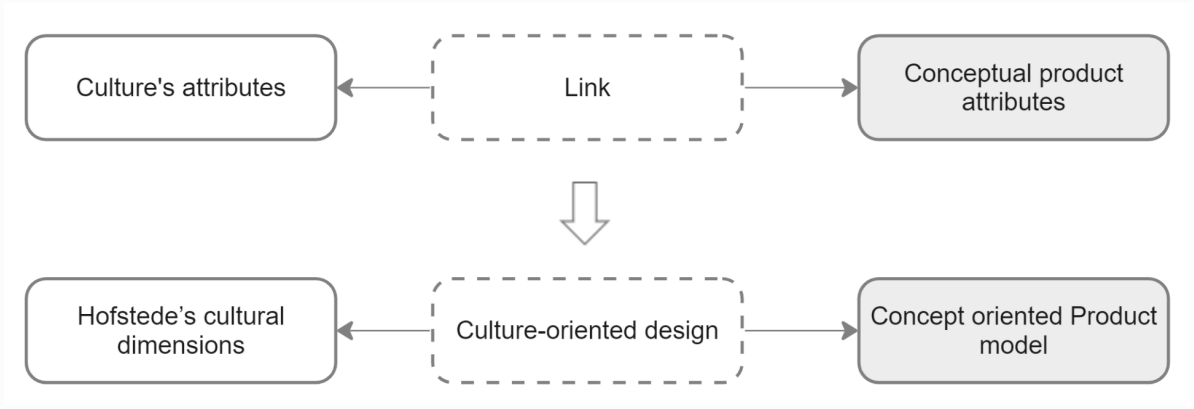


Figure 6. The adjusted attribute-based method

Empirical approaches, the process of testing hypotheses through direct or indirect observation and experience, which typically collect observable data and design a repeatable set of processes to produce verifiable results, which require data analysis methods to support them. Because of the geographical limitations of this thesis project, it is difficult to observe and record data using this design approach and therefore it will not be used in this project.

User-centered approaches, which were alluded to in the previous section Human-centered design. In summary, HCD is an extension of UCD and the design process between the two is similar, but the focus is different. The difference lies in the fact that UCD is a user-centered design approach that emphasises user involvement in the design process and outcome, aiming to improve the ease of use and user experience of the product; the main goal of UCD is to design products that are best suited to the user through in-depth research and understanding of user needs and behaviour; HCD is much broader, focusing not only on the user, but also on the wider human needs and The goal of HCD is to create more human and social designs that enable people to interact more naturally with technology and the environment. The similarity lies in the fact that both need to establish a connection with users and try to understand their expectations, attitudes, needs, and problems in depth.

It may be helpful to note that Aryana B. mentions that there is little experience of using HCD methods to study users in country-specific contexts, and that Clemmensen's research also points out that HCD design tools require some systematic adaptation when geared towards country-specific design, including: who the participants are, how the data is collected and analysed, etc [57].

3.5.Framework of Research Methods

Models of research methods which, because of their logical or top-down strategy, present models ranging from relatively broad dimensions to progressively more subdivided dimensions, as shown in the figure;

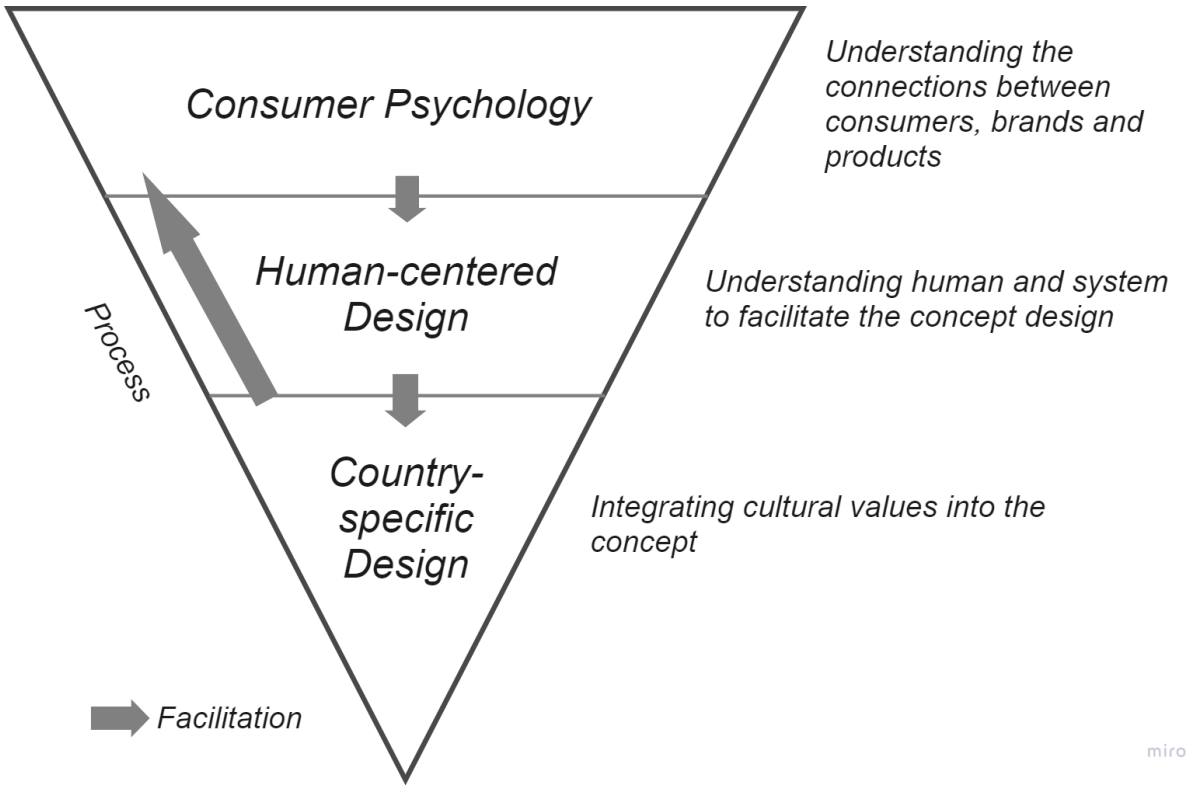


Figure 7. Research methods framework

At the beginning of the project, the designer needs to clarify the logic of the research methods and the relationships between them, in order to clarify their significance to the project. As can be seen from the framework in the diagram above, the three research methods are in a mutually reinforcing and influential relationship in the design of the project, while they exist in a sequential order:

1. Consumer psychology focuses on the psychology and behaviour of users when making purchasing decisions. It guides design decisions by analysing the factors that influence consumer attitudes, behaviour, purpose, decision-making styles and purchasing preferences in a particular geographic area, thereby facilitating the design of designs that are consistent with their positioning in the business strategy (a medium for enhancing brand loyalty). The dimensions of Consumer psychology are therefore broader and the research approach should be focused on a broader scope.
2. Human-centered Design, after understanding the psychological aspects of the consumer, further investigates the target user group and the IVA product. For example, segmentation of the target user group and analysis of which segments are dominating the preference choices. In-depth analysis of the target users' needs, experiences and problems with the IVA product. Analyse the specific preferences of the target user group for the IVA product. Exploration of design entry points through

analysis of target users and formation of a general design direction for the build (concept solution).

3. Country-specific design, after defining the needs of the target users and the design direction, further deepens the design direction. An attribute-based approach is used to incorporate the cultural values of a particular region into the design, so that the design fits perfectly into the local context and meets the needs of the user.

Once the relationships, logic and value of the research methods are clear, it is appropriate to consider the use of a number of different research tools at each stage of the research, the process and results of which are discussed in the following sections.

4

Research tools Used in the IVA Project

In order to effectively address research questions, a number of research tools need to be specified, including how they are to be used, when they are to be used, what the implications of their use are, and so on. In discussing the design process and the design tools used in each process, a very well-known design model is called the double diamond, which specifies a list of events, actions or methods by which a procedure or set of procedures are followed in order to achieve an intended purpose, goal or outcome [58]. However, when the double diamond process model is applied to certain projects it can be made more useful by customising it, for example, Sohaj Singh in 2017 customised a new double diamond model so that designers and stakeholders are clear about their position and actions in the project process to drive the successful establishment of the Indian Metro ticketing system [59]. Thus, in conjunction with the previous research framework, the entire logic of research and design can be clearly mapped out, as shown in the below figure.

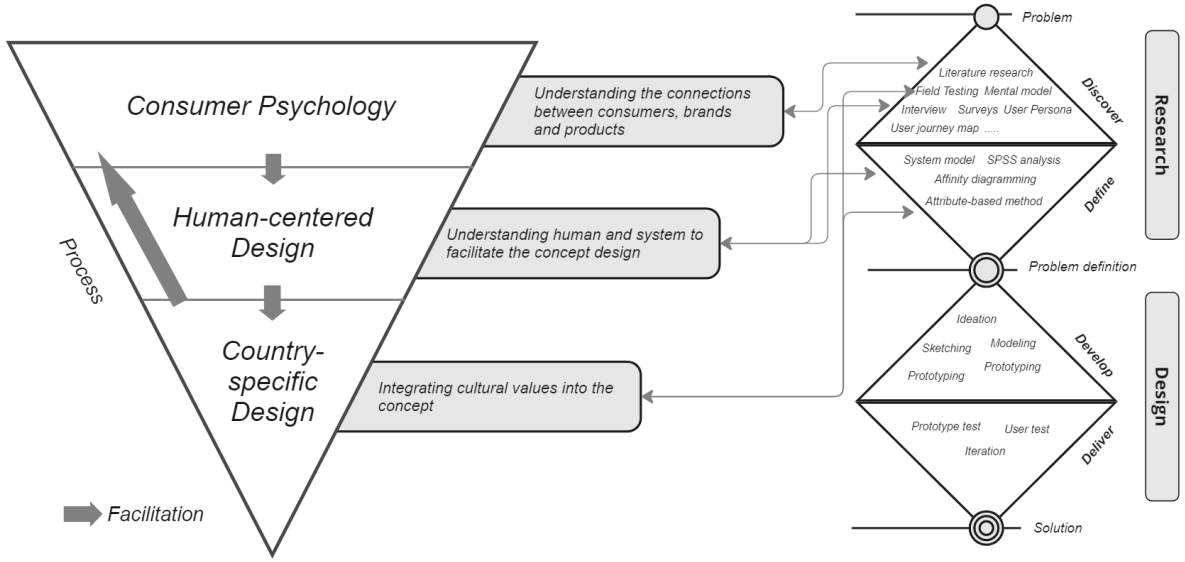


Figure 8. Combining the research framework with Double diamond process model

4.1.Field Testing(Nio & Benz’s IVA driving test)

Generally, in order to understand the actual process and experience of using IVAs, the designer carried out field tests on two classic types of IVAs that exist on the market. Two participants were invited and were not informed about the test subjects and the focus of the test in order to avoid user bias. The designer also participated in the test after the participants had completed the test and summarised the product model. The purpose of this field test was primarily twofold: firstly, the designer understood the basic components and the specific interaction flow by directly using and experiencing the existing IVA. Secondly, to observe and record the participants' experience of using the IVA and the interaction issues that arise during use. Detailed experimental procedure:

Participants: 3 people (1 recorder, 2 paricipants)
Test subjects: Nomi - IVA of NIO. Mercedes - IVA of Mercedes Benz
Test time: 60 minutes of recorded driving
Functions tested: Navigating routes, finding restaurants, playing music, adjusting the driver's seat, changing the temperature, etc.
Test focus: IVA feedback and participant's user experience in case of functional problems with human-computer interaction

Figure 10. NIO and Mercedes Benz’s IVA testing

Detailed test results are presented in the following table:

Table 1. NIO and Mercedes Benz's IVA testing result

	Product	Testing time	Testing functions	Usability errors	IVA feedback	Participant's feedback
NOMI		35 min	Play music, Navigation, Adjust the In-car temperature, Change CAR settings	Voice not recognized*6 Execution error*4 Unclear feedback*2	When the user interacts with NOMI, it turns in a direction to indicate that it is listening or speaking in a certain direction. Different visual expressions appear to indicate different interactions, and when a problem arises, a specific aggravated expression and tone of voice appears.	Complained* 4 times Appreciated 6 times. More interactive, clearer feedback, immediate functionality still lacking.
Mercedes		25 min	Play music, Navigation, Adjust the In-car temperature, Change CAR settings	Voice not recognized*4 Execution error*1 Unclear feedback*3	The floating colours and horizontal movement mean that the IVA is listening or speaking in a certain direction. In the event of a usability error, nothing changes except that the voice says sorry.	Complained* 13 Appreciated* 2 The flowing colour feedback is relatively new and techy. But there is also a sense of distance as the emotionless feedback seems unapproachable.

As can be seen from the image above, the in-car voice assistants of the two car brands are of two different types altogether; Mercedes' is a flowing light that is integrated with the CSD(Central display panel) and is fixed to its top section. When the driver/user calls out to Mercedes, it gradually appears as a blue flowing light in the dark screen and constantly floats, which is its default image. When the driver interacted with Mercedes, there were usability errors where the voice assistant did not understand the commands and gave the driver cold voice feedback without any visual feedback. As a result the participants' experience with Mercedes was very poor. In contrast, when participants encountered the same usability errors while using NOMI, NOMI showed a higher level of tolerance and satisfaction by expressing apologies through interesting visual elements (emojis indicating sorry) and the rotation of the physical component.

In addition to this, the test documents the components of different product types and incorporates the results of previous competitor product analysis and user research to help establish product mode, which is discussed in section 4.7.

4.2.System model

Previously, in the Field testing section, the designer recorded detailed video recordings of the driver using the IVA during driving. Thus, reviewing these videos and the field tests, the system model was built up quickly and efficiently. The following is a complete model of the user's use of the IVA while driving.

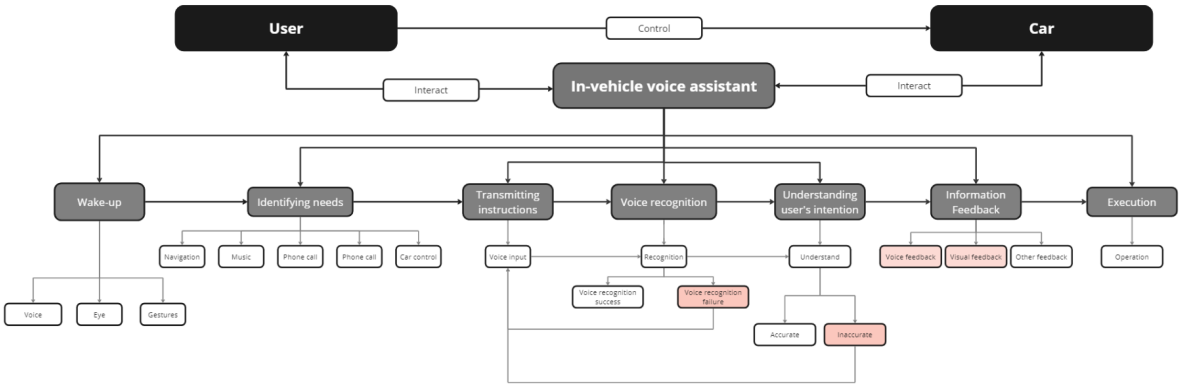


Figure 11. IVA system model

System model helps designers to understand the workings and inner mechanisms of complex systems by visualising and representing the relationships between each step or component. System models can also be used in IVA system analysis to identify bottlenecks, improvement points and potential problems in the system through performance evaluation, failure analysis, optimisation, etc.

According to the test results, table 1 the driving test, the most frequent failures occurred in the speech recognition, speech understanding and information feedback phases, which caused the most negative emotions for the driver. However, as we learned in the previous background chapter, although intelligent speech recognition has reached an accuracy rate of 95%, its speech understanding technology is not very intelligent and the chances of system failure are still high. Therefore, in the face of the voice interaction technology bottleneck, IVA product design can only target the feedback phase of the system as the entry point, that is, the visual feedback of the product.

4.3.Semantic differential Scale & User Mental Model

The Semantic Difference Scale has been widely used in the study of industrial appearance perception images to obtain more accurate user perceptions of products [60]. The contrastive semantic scale has been extended to the perceptual evaluation of products where users experience mixed emotions or ambivalent states as a result of being continuously stimulated by complex external factors [61, 62]. This form of scale can be used to detect user attitudes, user mental models and product experiences with pairs of contrasting adjectives [63].

IVA products have emerged in the rapidly evolving automotive industry in many types, such as physical, virtual, embedded, cute, cold, etc. Therefore, the Semantic Difference Scale is suitable for creating dyadic scales to detect users' perceptions of IVA products. The Semantic Difference Scale also has categories for ranking and assessing the semantics of the product. Adjectives are placed at both ends of the scale, and the test principle of the Likert scale, which gives a fixed value for sentiment concentration, is more effective and accurate in detecting the user's definition of the product.

However, the Semantic Difference Scale relies more on subjective understanding, so the existence of different interpretations of the adjectives by the user can lead to perceptual distortions. Therefore, each adjective needs to be interpreted when testing the scale, for

example, physical IVA that has a physical vehicle that can be touched and perceived. Virtual - a product that has no physical vehicle and exists only within the in-car CSD screen.

In the field of human-computer interaction, the user mental model is a key factor influencing user perception and interaction behaviour [64]. Susan states that the user mental model is the process of guiding the way a person thinks and works based on unfinished reality, past experiences and even intuition, which helps the user to form actions and behaviours, influences user thinking and determines the approach to problem solving [65]. Donald Norman demonstrates the relevance of user mental models in terms of user human-computer interaction and usability, which he considers in relation to the production and understanding of discourse [66].

In summary, the Semantic Difference Scale measures the user's understanding of a product or service by measuring the user's mental model as representing information about the user's expectations, understanding, needs, experiences, etc. of the product or service. The Semantic Difference Scale provides a framework to help designers understand and construct user mental models. The figure below on the left shows a scale experiment conducted with 25 participants (Drivers) and the figure on the right shows a preliminary user mental model based on the results of the scale.

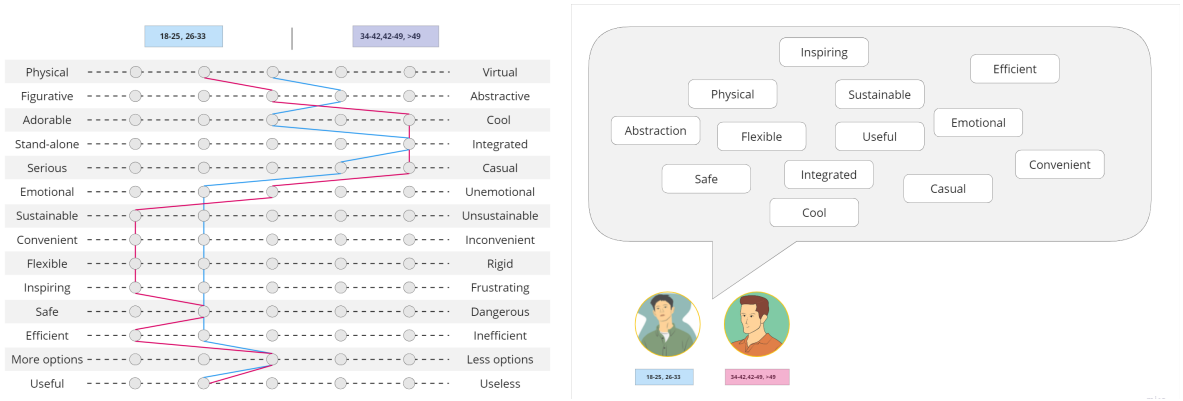


Figure 12. Contrastive scales and user mental model

As can be seen from the figure above, even for the different age groups of participants, their perception curves for IVA products are largely consistent, with only some minor differences in degree. Thus, there are similarities in the mental models of perceptions of IVA products between these two groups (18-33 years and 34+ years). However, the mental model constructed from the dyadic scale1 is not necessarily accurate, as there may be differences in the understanding and definition of adjectives in the dyadic scale between users. Therefore, this user mental model needs to be validated using a comparative ranking scale to validate the mental model. The designer made small adjustments to the Ranking scale. Firstly, after categorising the key adjectives in the mental model1, it was found that there are two types of IVA products in the user mental model: the bionic oriented type and the industrial oriented type.

Figure 13. VA product collected from Chinese market

The designer then collected images of intelligent voice assistants that existed on the market (including in-car voice products) based on these two types and invited ten designers and ten drivers to rate them on a scale of 0-5 based on the bionic-oriented and industrial-oriented types, and then calculated an average score for comparison. The results are shown in the figure below:

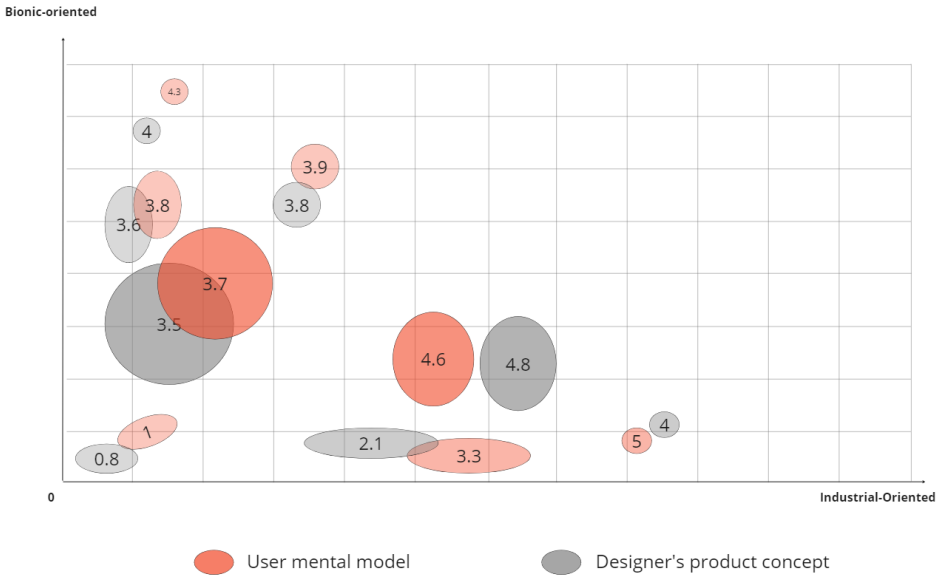


Figure 14. Comparative ranking scale between Designers and Users

The results were found to be very similar for the designer's product concept and the user's mental model, with a gap range of [0.2,0.4]. This suggests that the contrasting adjectives in the previous comparison scales are consistent in the perceptions of users and designers, thus demonstrating that the results of the user mental model1 are accurate.

4.4.Qualitative Interviews

Interviews are one of the most common and effective strategies for collecting qualitative data. Qualitative interviews are often classified in a number of ways, with many studies classifying qualitative interviews as unstructured, semi-structured and structured [67]. Broadly speaking, unstructured interviews are conducted in conjunction with the collection of observational data, semi-structured are usually pre-defined with open-ended questions organised and other questions drawn from conversations between the interviewer and interviewee, while structured interviews are highly controlled and set up with fixed questions, interview styles and procedures that are specific to the direction of the research [68]. However, semi-structured in-depth interviews are the most widely used form of interview in qualitative research and can be conducted with individuals or small groups.

Semi-structured in-depth interviews were also a more efficient qualitative research strategy for the IVA project. The interview method was limited by geography, so an online video tool had to be used. The interviewees needed to fit in with Lynk&Co's consumer target group. The content of the interviews should be closely related to the research questions. The interview process should also pay due attention to efficiency and ethical issues so as not to cause distress to the interviewees. In summary, the interviews were planned as follows:

Purpose of the interview: To study the target users' experiences, scenarios, attitudes, purposes and problems with the IVA product.
Interviewee: Group with more than 3 years driving experience and who have used voice interaction products
Number of interviews: 12
Interview location: Online meetings
Interview questions: 8 questions

1. *Have you used in-car voice assistants before? In what scenarios? How's the experience?*
2. *Tell me about your personality, are there any connections between your personality and preference of VA product's form and functions? Will it influence your decision?*
3. *.What do you think of the VA's feedback? is it good? why? Bad? why? How do you feel about those feedback cues?*
4. *What factors influence you ? Attracting you to use it or stopping you to use it.*
5. *Do you feel that the VA products are able to solve your problems, such as overtime pressure, reducing driving burden, traffic congestion, loneliness?*
6. *Do you think a better experience of VA will improve your favorarity towards a car brand?*
7. *Which one is better for you, Anthropomorphic or abstract?*
8. *Will you accept different VA designs? like different styles and functions. Any suggestions?*

Duration of the interview: 30 minutes

All interviews were recorded in the form of video conference recordings of Zoom, teams and Wechat meetings, and then transcribed into textual form for subsequent qualitative analysis.

4.5.Quantitative Survey 1

Creswell et al. state that quantitative research employs investigative strategies such as experiments and surveys and collects data on predetermined instruments that produce

statistical data [95]. Leedy and Ormrod state that the results of quantitative research can be predictive, explanatory and confirmatory, and that quantitative researchers seek explanations and predictions that will arise from other people and places, with the aim of establish, confirm or validate relationships, and develop generalisations that contribute to theory [70]. There are also many classifications of quantitative research methods, such as: descriptive, experimental and randomised comparative. In this case , descriptive quantitative research and causal comparative quantitative research are more appropriate for this project because of the limitations. Descriptive focuses on examining the current situation and involves re-observation-based identification of attributes of a particular phenomenon or exploring correlations between multiple or multiple phenomena, while causal comparisons examine how independent variables are influenced by dependent variables and design causal relationships between variables [69].

In general, quantitative surveys are a very effective and useful method of user research when studying user preferences for IVA products in a particular region. Firstly, a descriptive quantitative survey is used to test the predictive preferences of these users by setting comparative questions about the components of the IVA product to examine the value, satisfaction and importance of these elements in terms of user preferences. Secondly, a quantitative cause-effect comparison survey was used and multiple hypotheses were developed. By testing the hypotheses of the independent and dependent variables, the subjective factors (geographical, age and gender) that influence users' preferences for IVA products are identified. Therefore, hypothetical questions that are closely related to the research question need to be clarified;

I.H0: It is hypothesized that the influence of the user's preference for IVA product type product form is related to age.

II.H1: It is hypothesized that the influence user's preference for IVA product type product form is not related to age.

III.H0: It is hypothesized that the influence user's preference for IVA product type product form is related to geography.

IV.H1: It is hypothesized that the influence user's preference for IVA product type product form is not related to geography.

V.H0: It is hypothesized that the influence user's preference for IVA product type product form is related to gender.

VI.H1: It is hypothesized that the influence of the user's preference for IVA product type product form is not related to gender.

Ⅶ.H0: It is hypothesized that users of different ages do not differ in their preferences for visual elements of IVA products (shapes, graphics, animations, satisfaction, favorability, importance .....)

Ⅶ.H1: It is hypothesized that users of different age groups have different preferences for the visual elements of IVA products (shapes, graphics, animations, satisfaction, favorability, importance...)

Once the hypotheses have been established, the quantitative survey is ready to build the question structure of the questionnaire step by step. The first step was to create multiple choice questions on product form preferences in relation to age, geography and gender. Of these, the age group setting needed to cover the age group of Lynk&Co's user target group. The purpose was to explore commonalities in IVA product form preferences among specific age groups of users in a given region. Secondly, the relevant IVA product elements are: IVA type (physical, virtual), shape, expression, feedback method, timbre and other factors to explore the relationship between different age groups of users within a specific geographical

area and IVA product element preferences to drive the establishment of design directions. Collectively, the quantitative survey1 included six descriptive questions, three cause-effect comparative questions and five complementary questions, for a total of 20 questions.

A total of 466 valid responses were received from China (Mainland) through a quantitative survey distributed through various online channels.

4.6. Phase analysis

In this section, the findings of the previous research tools are summarised. In this section, the findings of the previous research tools are summarised and the design direction is further clarified by using additional research tools to gain insight into the users' needs, problems, expectations and so on.

4.6.1.Affinity Diagramming

An affinity diagram is the simplest way to organise data, arranging notes from dictation into a hierarchy that reveals in one place all the issues, concerns and key factors in the user's life that are relevant to the team's focus [71]. The affinity diagram should be constructed in a bottom-up manner, in the purest form of inductive reasoning. Putting related and similar notes in a basket does not require proof of why, but the designer needs to be sure that a certain 'affinity' is being driven. If two notes describe similar intentions, aims and problems, and are related to a design focus, then they have an affinity [71].

After collating all the dictated notes from the qualitative interviews, and summarising them from the bottom-up:

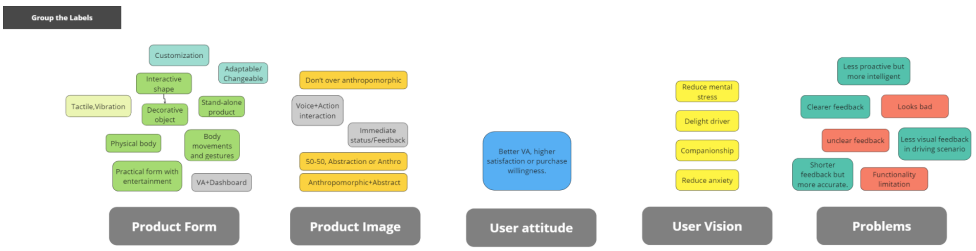


Figure 15. Affinity Diagramming of qualitative interview data

As can be seen from the diagram, the affinity diagram consists of four steps: Data collection, Categorize data, Table, Group the labels. In the first step, valid data are extracted from the texts of the qualitative interviews, those that point out/imply/reveal any value text that relates to the design concerns. In the second step, the data was divided according to the affinity of the notes. The third step is to label and characterise the segmented data. And the last step groups these labels according to their design relevance to the project.

Finally, five different user insights were obtained, as follows:

1. ***Product form(IVA Body).*** *Respondents prefer IVA product forms that are physical, touchable, interactive, customisable, entertaining, changeable and adaptable, and stand-alone.*
2. ***Product Image(IVA graphic)****. Respondents wanted an IVA image that was not too anthropomorphic.*
3. ***User attitude****: Respondents indicated that a better IVA product would increase satisfaction with the matching vehicle brand and willingness to buy.*
4. ***User Visions****. Respondents wanted an IVA to provide a sense of companionship, reduce mental stress, reduce anxiety, and to please the driver.*
5. ***Problems.*** *Respondents indicated that there are many problems with existing IVAs, such as lack of intelligence, poor appearance, unclear feedback, inaccessible feedback, and lack of functionality.*

Although some user insights were gained from the quantitative analysis, there are some drawbacks to this method. Subjectivity is one of the main drawbacks; the categorisation of ideas in affinity diagrams relies heavily on the participants' ability to understand them, and this subjectivity is likely to lead to distorting respondents' views and ideas and grouping them into groups where they do not belong, which can introduce bias and inconsistency [71]. Therefore, designers need to use SPSS analysis to analyse the large amount of quantitative data and try to validate some of the findings from the qualitative analysis (user insights) from it.

4.6.2.Statistical Analysis (SPSS) for Quantitative Surveys 1

In order to test the hypotheses of Quantitative Surveys 1 to advance the IVA project study and to validate the findings of the qualitative interviews, the SPSS tool was used in this section to conduct the data analysis. SPSS provides a quick data filtering option to select specific cases or variables based on specific conditions [72], making the tool well suited to have multiple components of the IVA product preference studies.

For hypotheses I to VI, Cross (chi-square) analysis was used to test the relationship between three factors, geography, gender, and age, and the form of the IVA product.

Table 2, Analysis of product form preference

Cross (chi-square) analysis results — percentage

topic	name	Product form preference for voice assistants.			total	χ^2	p
		physical product	digital product	other____			
The area you live in	North China	42.34%	17.20%	0.00%	31.76%	70.200	0.000**
	North-east area	8.76%	18.82%	50.00%	13.30%		
	Huadong Region	23.36%	18.28%	16.67%	21.24%		
	South Central	13.87%	26.88%	0.00%	18.88%		
	Southwest Region	9.12%	14.52%	0.00%	11.16%		
	North-west region	2.55%	4.30%	33.33%	3.65%		
total		274	186	6	466		
Gender	male	57.45%	53.23%	50.00%	55.67%	0.883	0.643
	female	42.55%	46.77%	50.00%	44.33%		
total		275	186	6	467		
Age	18-29	28.47%	46.77%	33.33%	35.84%	24.538	0.000**
	30-39	62.77%	39.78%	50.00%	53.43%		
	40-49	6.20%	9.14%	16.67%	7.51%		
	above 50	2.55%	4.30%	0.00%	3.22%		
total		274	186	6	466		

* p <0.05** p <0.01

As seen in the above graph, different Product form preference for voice assistants for Gender does not show significance (p>0.05), meaning that different Product form preference for voice assistants for Gender all show that there is no difference. Also the preference for the product form of the voice assistant is significant for the region and for age (p<0.05), meaning that the preference for the voice assistant for different product forms is different for the region and for age.

Therefore, hypotheses I, III and VI are valid and the preference for product form is influenced by the age and geography of the user. Furthermore, it is found from the graph that 58.9% of the 466 users from the random sample chose the physical product, which proves the conclusion of the qualitative study regarding the preference for the physical IVA product form.

Regarding hypotheses VII and VIII, ANOVA was used to verify the relationship between the visual elements (shape, graphics, animation, satisfaction, favorability, importance...) of IVA products by different age groups of users.

Table 3. Analysis of the importance and satisfaction of various factors of IVA products by different age groups

ANOVA

	Ages (Mean±Std. Deviation)				F	p
	18-29 (n=167)	30-39 (n=249)	40-49 (n=35)	50以上 (n=15)		
The level of attention paid to the visual elements of the in-car voice assistant.	3.71±1.15	3.92±0.95	3.09±1.25	3.40±1.55	7.051	0.000**
Product styling for voice assistants	3.69±1.22	3.71±1.13	2.97±1.32	3.47±1.60	4.216	0.006**
Types of voice assistant images	3.52±1.24	3.73±1.15	2.97±1.34	3.47±1.41	4.374	0.005**
Tone of voice assistant	3.62±1.19	3.79±1.10	2.74±1.31	3.00±1.73	9.693	0.000**
Emotions of the voice assistant	3.56±1.29	3.81±1.05	3.11±1.18	3.20±1.66	4.951	0.002**
Voice assistant interaction	3.56±1.24	3.79±1.13	3.09±1.36	3.33±1.40	4.345	0.005**
How much an in-car voice assistant can improve your satisfaction with a car brand.	3.56±1.23	3.73±1.13	3.31±1.28	3.53±1.46	1.677	0.171
The extent to which better voice assistants influence purchase decisions for the same class of car.	3.49±1.32	3.79±1.14	3.09±1.44	3.20±1.57	4.877	0.002**

* p<0.05 ** p<0.01

As can be seen from the table, there is little difference between the age groups, except for satisfaction, i.e. the question "How much an in-car voice assistant can improve your satisfaction with a car brand". However, we found by comparing the mean and standard deviation that 30-39 age group's Std Deviation is significantly smaller than 18-29 age group's and they converge to 1, indicating that 30-39 age group's users are highly similar in assessing the importance and satisfaction in term of product components and product influence. This means that users in the 30-39 age group have a high degree of similarity and

all express higher importance and satisfaction values for IVA product elements than users in other age groups. Therefore, hypothesis VIII is valid.

In addition, a review of market research reveals that the average age of car purchase in mainland China is 34 years old and gradually rising to 40 years old. Also combined with Lynk&Co's target group of 20-40 year olds. Therefore, the user research should be dominated by users in the 30-40 age group and supplemented by users in the 20-29 age group.

Once the target user group for the study has been identified, the project needs to be taken a step further. The table below shows the supplementary question that examines the level of preference for different IVA product types in different age groups. It can be seen that Table 4 received the most votes for Ipzation, 43%. in any age group. However, this does not mean that Ipzation is the design direction for the IVA, which will need to be considered in conjunction with subsequent research into the specific culture of the region.

Table 4. Analyzing the preference of product images

Cross Tabulation %

Categories	Ages				Total (*n*=466)
	18-29 (*n*=167)	30-39 (*n*=249)	40-49 (*n*=35)	50以上 (*n*=15)	
Robot	29.34%	29.72%	45.71%	0.00%	29.83%
IPization (characters such as movie stars, football stars, cartoon characters)	46.71%	40.56%	65.71%	0.00%	43.35%
Animals	15.57%	26.10%	11.43%	0.00%	20.39%
Irregular shape	23.95%	26.10%	17.14%	0.00%	23.82%
Geometric	31.74%	27.31%	34.29%	0.00%	28.54%
Planet, Constellation	40.12%	33.33%	34.29%	0.00%	34.76%
Flowing light	17.37%	23.69%	11.43%	0.00%	19.74%
Microphone shape	35.33%	33.73%	34.29%	0.00%	33.26%
Sound waves	19.76%	27.31%	11.43%	0.00%	22.53%
Loading circle	25.15%	20.08%	20.00%	0.00%	21.24%
No image	0.00%	0.00%	0.00%	100.00%	3.22%

Chi-Square Test: χ^2=1335.376 *p*=0.000

Table5. is also a supplementary question in the quantitative questionnaire that explores the preferences of different age groups of users for the presentation of IVAs. This product expression belongs in the system model as a form of visual information feedback, which is also the entry point for the design. Therefore, studying the different information feedback styles will further help to construct the design direction. The table below shows that in the target age group, the preference for 'customised images' and 'different images for different tasks' is 50.6% and 29.7% respectively. 29.7%.

Table 5. Analyzing performing types

Chi-Square Analysis %

Items	Categories	Ages				Total	χ^2
		18-29	30-39	40-49	50 above		
Do you prefer that the voice assistant present different images or a fixed image when performing different tasks?	Different images for different tasks	35.93%	29.72%	28.57%	53.33%	32.62%	
	Fixed images	26.95%	18.07%	37.14%	6.67%	22.32%	
	Customized images	35.93%	50.60%	25.71%	20.00%	42.49%	46.423
	No images	1.20%	1.61%	8.57%	20.00%	2.58%	
Total		167	249	35	15	466	

* *p*<0.05 ** *p*<0.01

To conclude, through SPSS, it was verified that the qualitative study of the user insight of preference for physical products, also verified that the factors that influence the preference of the IVA's product form are age and geography, and also studied the importance and satisfaction of different ages on the components of the IVA product. As for the age factor, the study concludes that the preference of users in the 30-39 age group is the most important because they are highly similar, value IVA products more and are more in line with the main consumer group in the market for car purchases. Therefore, the preferences of users in this age group are more design-directed, which helps to build a user profile and leads to a user journey map to gain deeper insights.

4.6.3.User Persona & User Journey Map

User personas provide the 'face' of a specific group of users within a group of people, and intuitively they can assist in the decision making of complex systems, products, or services [73,74]. Ideally, user personas convey the attributes, behaviours and subjective goals of people and help designers understand their target user groups [73]. The advantage of creating data-driven user personas is that they can present user goals that differ from those of decision makers, thereby changing preconceptions about users [74].

In the previous quantitative study, the typical user, aged 30-39, was more similar in assessing the importance of multiple IVA elements, making the user profile more accurate and realistic. Therefore, the target group was identified as being around 30 years of age. Understanding the lives, personal habits, values, expectations, etc. of this group helps designers to explore design opportunities that are in line with them.

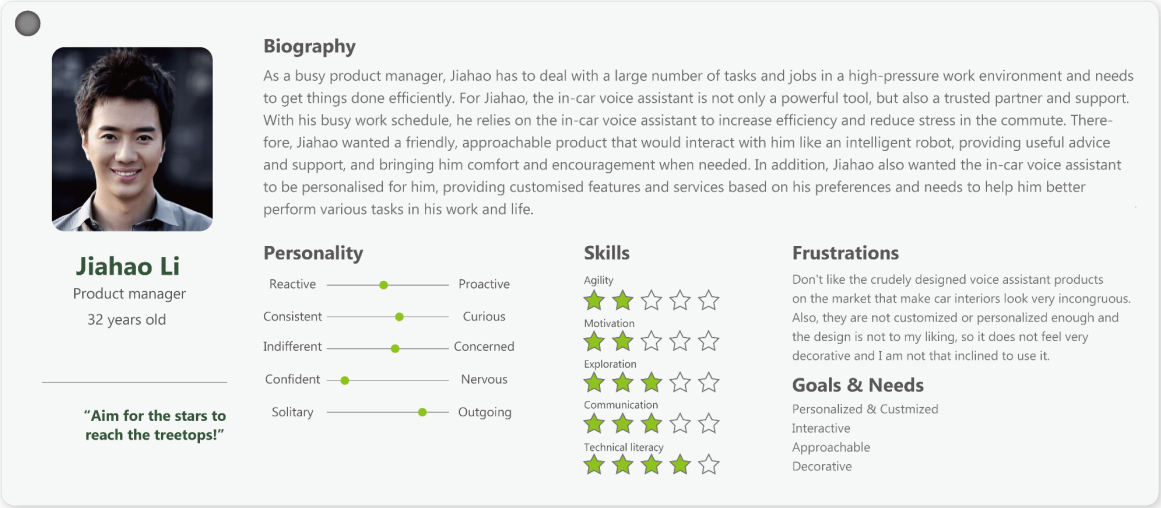


Figure 16. User persona

However, there is a close relationship between the user profile and the user journey map, with the user profile providing basic information about the user and the characteristics that inform the user's context and needs. The user journey map, on the other hand, provides a more specific description of the user's behaviour and experience in a given situation, providing the user profile with detailed information about the user's behaviour and emotional state at different stages of the journey. Both can provide a pragmatic indication of the requirements of the body by aggregating the overall pleasantness of most users, meaning that designers can understand the user experience and identify problems and opportunities

for improvement by inferring common characteristics of typical users in the journey map, such as low affect, perceptions, needs and behaviours, etc.

The designer embedded the user portrait model into the journey map to get a holistic view of the user experience through a series of frustrating and joyful moments in the interaction, the following diagram reveals the user's pain points in using the IVA product in everyday driving scenarios:

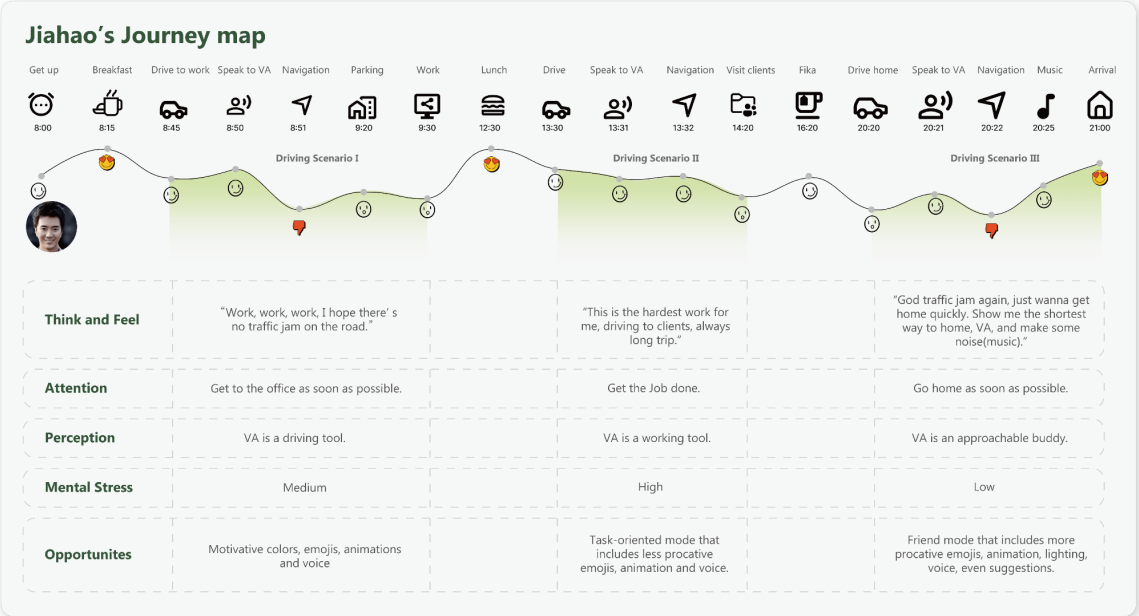


Figure 17. User journey map

The journey map shows that negative emotional lows occur in both driving scenarios 1 and 3. On the one hand, this is because congestion during the peak commuting period is common in the more developed cities of China. As a result, users' negative emotions increase when the navigation system is used and the IVA feedback shows navigation routes that are basically congested. On the other hand, mental stress caused by work reaches above medium in the morning. So, when subjective stress is overlaid with objective traffic congestion, these are pain points that can help designers build design opportunities, for example, explored in Driving Scenario 1, which uses motivational colours, expressions, animations and sounds to reduce the user's negative emotions.

In Driving Scenario 3, although there are also traffic congestions that create negative emotions for the user, the mental stress of the user is lower than in Scenario 1, due to the high degree of collectivism that is a key feature of Chinese cultural values, as mentioned in the introduction to the research methodology section. This is coupled with the traditional Chinese concept of the importance of family in general. Therefore, going home from work is a relaxing and stress-relieving event. The design opportunity for this scenario should therefore be to give the user a sense of 'companionship' in advance to counteract the negative emotions caused by traffic jams, e.g. friendly expressions, animations, light, sound, etc.

In addition, in Driving Scenario 2, the user is working during a relatively high level of stress, so in this scenario the IVA product should be kept in a serious mode to allow the user to concentrate on their work.

4.6.4.User research summary

When the above qualitative and quantitative research has been completed, there is a need for a milestone summary, which can drive the next design phase.

A literature review explores the latest research on factors that influence user preferences for IVAs other than function-based, such as product form, personalisation, linguistics, emotional interaction, feedback methods, etc. From a consumer psychology perspective, it is understood that the complementary relationship between product function and visual information, the perceived attributes of the product (status, emotion and experience), the hedonistic mentality, the cultural context, etc. all influence the user's preference making. From a human-centered design theory perspective, it was found that Chinese users generally prefer physical IVA products that are personalized and customised, entertaining, decorative, more interactive, multi-modal, stress-relieving and provide a sense of companionship. So after understanding user preferences, how to design region-specific IVA products?

From a country-specific perspective, the design and development of IVA products needs to be in line with the cultural values of a particular region, which are analyzed in Hofstede's cultural dimensions model for mainland China: High power distance, High collectivism, Masculinity but deeply affected by femininity in new generation, Low uncertainty, Long-term orientation. The next section will explain how these cultural values can be translated into the design features of an IVA and be adapted to user preferences.

4.7.Experiment Design of Attributes-based

Attribute-based refers to an approach that considers and compares specific attributes or characteristics as the basis for a decision, evaluation or analysis process. Attribute-based methods focus on individual specific attributes of a product, service or concept and compare, evaluate or make decisions based on the different characteristics of these attributes. It helps people to better understand and compare the differences between different options, products or solutions and to make decisions based on the importance and weighting of attributes.

Therefore, when the cultural backgrounds, needs and preferences of the target users are clearly researched, culture-oriented design as mentioned above can be used to incorporate region-specific cultural values into the design to ensure that the design is acceptable, adaptable and sustainable for local context.

4.7.1.Creating a product model of the IVA concept

In chapter 3.4 the definition of the Object-oriented product model was mentioned, which allows the display of components and classification of products, modular production and personalisation through the provision of customised components. So, recalling the stage

summary of 3.7.4, the design direction of the IVA concept gradually becomes clear, mainly consisting of an interactive physical body, display areas, display of customised and personalised components, images for information feedback, colour cues for different modes, etc. The specific product model hierarchy is as follows:

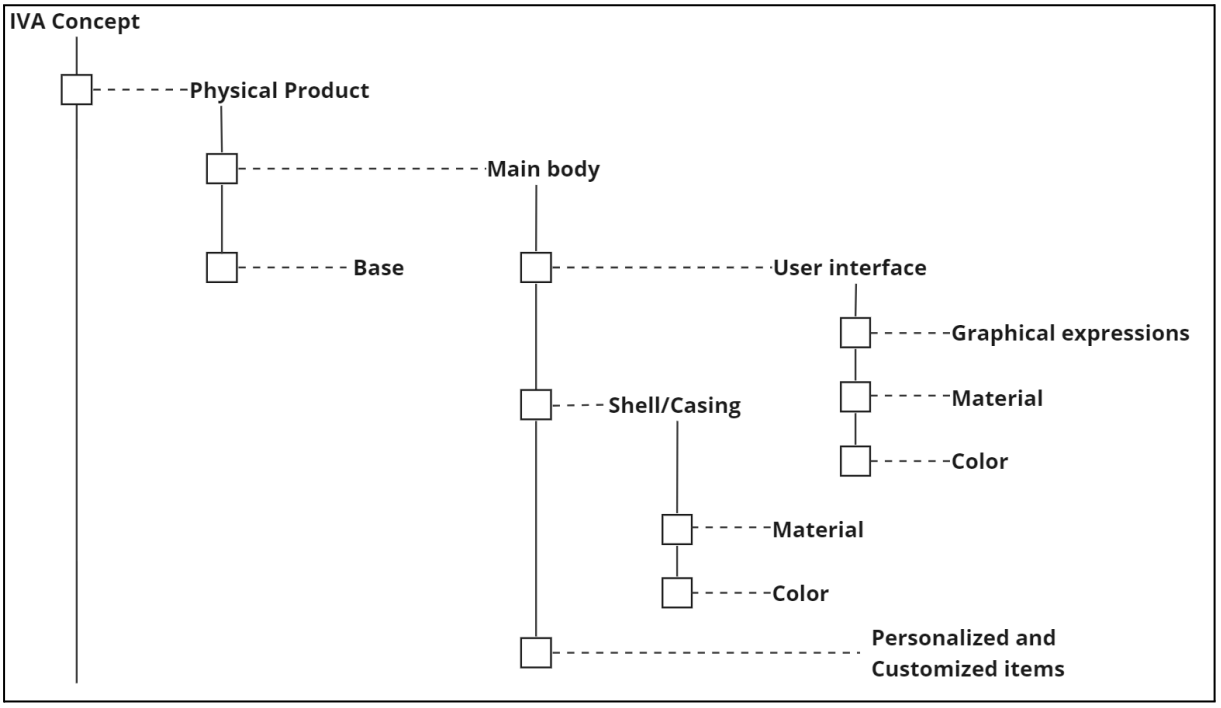


Figure 18. Conceptual product model diagram

4.7.2.Translating the cultural values to the components that meet user preferences

As mentioned earlier, culture-oriented design is an effective design model that helps designers to bridge Hofstede's cultural dimensions and the conceptual product model, incorporating cultural values attributes into product attributes. However, not all design features influenced by cultural values are suitable for the IVA concept, as they need to be validated by current users, as the new generation experiences a variety of social, cultural and technological influences that are different from those of their predecessors due to rapid social change, economic development and technological advances. For example, the "post-90s," and "post-2000s" generations, whose traditional cultural perceptions have changed dramatically. They place more emphasis on the pursuit of personal dreams, individuality and self-fulfilment, and show a more prominent tendency towards individualism [75]. Consequently, when transferring the values of different cultural dimensions into the design features of the IVA concept, it is necessary to first clarify the meaning of each cultural value in the product design, and then test the design features of cultural values by testing their preferences among the target user groups.

Step1. identify the meaning of specific cultural values in product design
In the last decade only a few researchers have considered the relationship between Hofstede's cultural dimensions and design features, but they have all studied website design, and given that website design is also under the influence of symbolic culture, the findings from this area can also be useful to the field of product design [76]. Accordingly, in this step

the literature review method was primarily used to explore the relationship between specific cultural values and product design features. And by understanding the design implications of these cultural values, images of products which have their representations were selected ,also contain some elements of IVA products.

High power distance. Eugene Cheng-Xi Aw et al. found that individuals with high power distance beliefs are more likely to be influenced by brand salience, they are more sensitive to external features such as the visual salience of a brand, and they are more likely to buy luxury goods with higher external salience because it is in line with their identification and pursuit of power and social status [77]. Sabina's article comparing the design of McDonald's websites in high and low power distance locations found that high power distance visitors want websites that provide facts and clear statements and do not burden them with too much searching for information, and that they are less discerning [78]. In his article, Bas Wallet compares BWM websites from different regions to confirm that cars are the focus and subject of photographs and the logos are larger and more visible on BMW websites from high power distance regions [79]. Therefore, by analogy, the Chinese region is a high power distance region and the cultural values that characterise the design of IVA products should be such that the product body is visible and distinctive. In more detail, the size, colour or material of the product component is to be prominent, e.g. a visible logo, a figurative body, etc.

Figure 19. Products with high power distance design features

High collectivism. Kim and Coyle found that collectivists prefer websites with animated images when browsing, as well as information-rich websites that load data [80]. Tanveer, Haralambos et al. found in their study that collectivist-minded people have a preference for web designs with ethnic identity images and symbols, family themes, and features that allow for the sharing of concerns, opinions and emotions [81]. Therefore, the design implications of collectivist perceptions for IVA products should be rich in emotive motifs (expressions), materials and forms, etc.

Figure 20. Products with high collectivism design features

Masculinity. There are few studies in the English literature that describe the relationship between masculinity and product design features, but the relationship between masculinity and design semiotics is discussed in many marketing reports, fashion design analysis

reports, graphic design, and interior design. For example, Ana's article discussing stereotypes in brand design uses actual brand case studies to illustrate that highly masculine design features are dark colours, geometric forms, sharp edges, bold looks, and the dominance of large swathes of dark colours[82]. The White Dahlia Interior Design Studio marketing report identifies five major masculine design elements: leather elements, rough textures, dark or warm neutral materials, artistic accessories, and geometric forms[83].

Figure 21. Products with Masculinity design features

Low uncertainty avoidance. One study concluded that cultures with high uncertainty avoidance have a greater preference for rule-based and structured work environments, while cultures with low uncertainty avoidance have the opposite [84].Hofstede's research also implies that product design for such cultures can include elements of flexibility, adaptability and experimentation [85]. Norman and Draper emphasise that low uncertainty-averse cultural perceptions in User-centered design emphasise user autonomy and individual decision-making, and that product design should reflect this cultural preference tendency by providing users with choices and customisation options [86]. Lidwell, Holden, & Bulter state that low uncertainty avoidance cultures often prefer simple and straightforward interactions and communication, which in the field of product design can be understood as a minimalist design aesthetic and intuitive interfaces [87]. Butxton's research concludes that a culture of low uncertainty avoidance in product design should allow users to customise, adapt and even co-create features of the product experience, fostering a sense of empowerment and ownership [88].

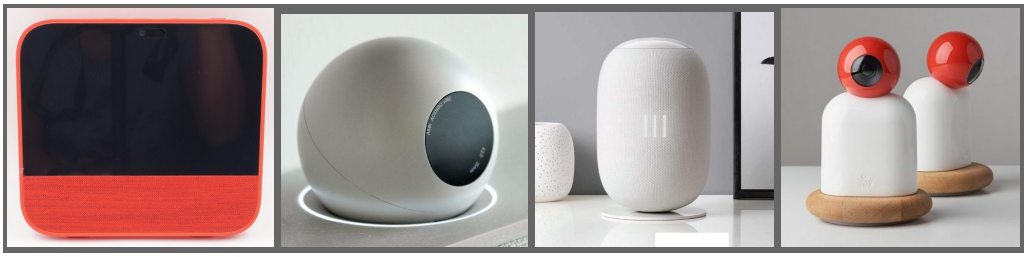


Figure 22. Products with Low uncertainty avoidance design features

Long-term orientation. which often have a strong connection to tradition and cultural heritage. Product design under the influence of long-term oriented cultures may include elements of traditional aesthetics, craftsmanship or cultural symbolism, as this enhances the perceived value and adaptability of the product [89].

Figure 23. Products with long-term orientation design features

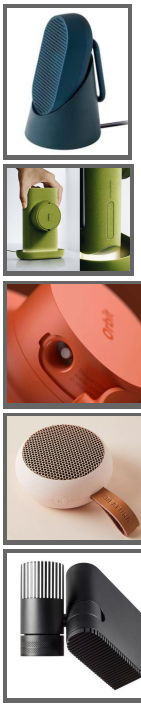
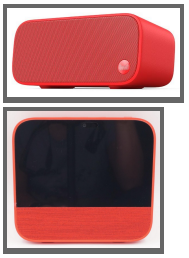
Step2. Supplemented survey to examine user preferences for IVA concept design features as influenced by cultural values.

From the previous research, the definition of different cultural values in design and the representative product images containing the corresponding cultural values were explored and then categorised according to their attributes (Figure 18. Conceptual product model diagram) and user needs. The categories are: Colour , Material, Design style, Decoration Interaction, Threatening.

A second quantitative survey was constructed by creating survey questions related to user preferences for the above factors. The survey was distributed through the same channels as Quantitative survey I. The target audience was 20-40 years old, living in any city in mainland China. 137 valid survey forms were returned.

The results of the Supplemented survey with the previous product model and Step 1 are shown in the table:

Table 6. The results of the Supplemented survey

	Main body+Base					User interface
Factors	**Color**	**Material**	**Design style**	**Decoration**	**Interaction**	**Threatening**
Products that contain design features or elements that represent different cultural values.						
Description	Colours represent traditional Chinese aesthetics.	Representative materials, metal, glass, leather, plaster, plush	Design languages and design directions	The degree of decorativen-ess.	The degree of interactivity	Which one is less threatening and aggressive?
Survey results						
User preference	70%	79.6%	69.3%	40%	70.1%	77.4%
Design features	1. Elements of traditional aesthetics, craftsmanship or cultural symbolism. 2. Rough textures, prominent subject features, dark or warm neutral materials, artistic accessories, geometric forms. 3. Richly emotive motifs (expressions), materials and forms. 4. Remove smooth black screens and replace them with mild materials.					

4.8. IVA design guidelines based on region(country)-specific user preference

Design guidelines are a set of recommendations, rules, or standards that provide guidance on how to create consistent, effective, and user-centered designs[87]. They outline specific design considerations, best practices, and constraints that designers should follow when creating products, interfaces, or experiences[66].

As the preliminary research and analysis was based on the research framework and the double diamond process model, the components of the IVA product design guidelines based on user preferences in specific regions can be summarised from the various stages of research and analysis to produce the following specific guidelines:

- ***Guideline 1***:*For the Ideation of the Main body of the IVA product design, it is necessary to identify a product shape with traditional aesthetics and cultural symbols of specific cultural influences, and which meets the user needs for entertainment, decorativeness and multi-components.*
- ***Guideline 2***:*After the main body has been conceptualised, it is time to think about the design of the user interface elements. The focus should be on how the expression element of the IVA is and how it fits in with the interactivity of the product body to meet the emotional needs of the user in different driving situations. For example, the expression element of the IVA is a type of feedback message, and in the event of usability errors during human-computer interaction, the feedback message presents a cute element to reduce the user's negative emotions (see Figure 10. NIO and Mercedes Benz's IVA testing results).*
- ***Guideline3***:*Following the finalisation of the basic shape and user interface of the main body of the IVA, materials, colours and processes are applied in line with cultural values. For example: spraying, sanding and oxidation to create a rough surface on the outer shell and the use of a dark coloured cloth mesh with a rough texture instead of a black glass screen to show masculinity. The use of traditional Chinese family motifs in some of the components is also used to ensure the cultural values of long-term orientation and collectivism, enhancing the acceptability, adaptability and sustainability of the product in the specific region.*
- ***Guideline4***:*Consider how customisation and personalisation of the experience can be achieved to meet the needs of the user. For example, IVA product personalisation combined with the brand's app, allows users to participate in the creation of some IVA components to achieve co-creation and help build a bridge between users and the brand.*

In conclusion, the sequential implementation of this four-point design guide will result in an IVA product that meets the preferences of users in a particular region/country. It is important to be aware that within each of the design guidelines, different design tools will be used to implement them, which will undoubtedly result in a more complex design practice process. Therefore, in the next chapter the whole design practice process is described in detail.

5

Design Practice

In his book, Norman states that design practice is the application of principles, processes and methods to create and improve all aspects of design, which involves a hands-on design process of understanding user needs, conceiving ideas, designing prototypes, testing and improving solutions [66]. At the same time, the goal of design practice is to create practical, easy-to-use, aesthetically pleasing and meaningful designs that improve the user experience and solve problems. Designers use a combination of practical techniques, skills, creativity and empathy to develop solutions that are visually appealing, user-friendly and consistent with the tone of voice goals and values of stakeholders [66]. The following section then demonstrates in detail how designers will use a combination of design skills to facilitate the effective design of IVA products.

5.1.Preparation

In the pre-preparation phase, designers need to identify the design sequence, design tools, design challenges and the impact of the design environment on the design practice. The purpose of this is to prepare the project sufficiently in advance of the start of the design process so that the project is carried out efficiently and the design content is produced at the appropriate point in time.

Generally speaking, designers can execute the design sequence according to the design guidelines, but the specific use of the design tools is entirely up to the designer's own experience. For this reason, designers need to prepare in advance the appropriate licensed software, such as: graphic design software (Adobe Photoshop, Illustrator), 3D modelling software (NX UG), model rendering software (Keyshot), and mind mapping software (Figma, Miro). Often, designers also need to anticipate design challenges and develop solutions in order to prevent the project from being held up. For example, if a lack of software proficiency means that ideas do not move effectively from ideation to modelling and rendering, a tutorial on how to use the software needs to be prepared in advance. As for the design environment, the Lynk&Co design department in the Geely Design holding building has all the design-related facilities and a number of excellent designers, so the design environment is not an issue.

5.2.Ideation

5.2.1.Brain storming for IVA product form

The aim of brainstorming is to stimulate designers' creativity, explore different forms of products and stimulate innovative thinking [90]. According to Guideline 1, the styling of IVAs needs to conform to the traditional aesthetics and cultural symbols of a particular cultural influence. However, for pre-research product design, it is not appropriate to set limits on certain specific features before conceptualizing the product form, which is not conducive to the diffusion of ideas and the exploration of optimal solutions. Therefore, brainstorming is used in the initial stages of conceptualisation to generate a large number of initial ideas. However, pre-research product design can set relatively empty or vague design specifications, for example, multi-component interaction, decorative, entertaining, and so on. As a result, the designer's understanding of these design specifications is quickly brainstormed and documented on the graphic software.

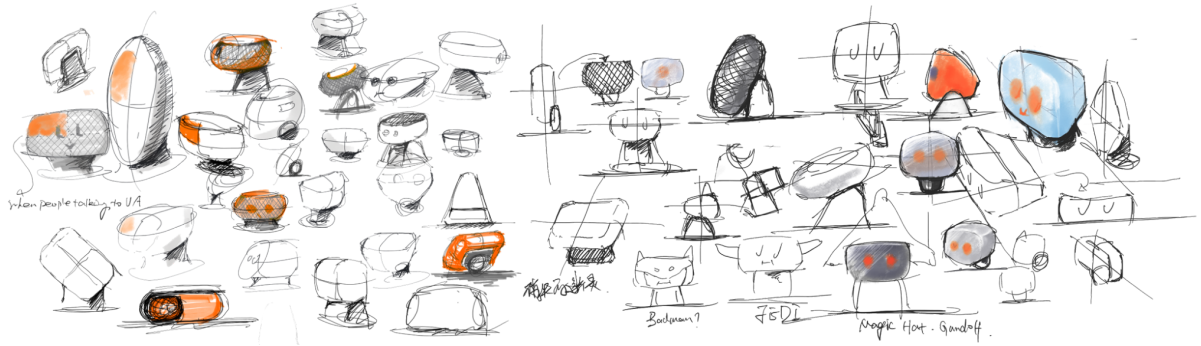


Figure 24. Brain storming of IVA concept

After a quick sketch of some concepts, the designer marks in colour those that meet the design specifications or can be further developed and continues to deepen them. It is clear that some of the concepts with colour are still very sketchy, while others are more developed. This is normal, however, as the designer's mind finds new inspiration in brainstorming and makes subtle breakthroughs.

5.2.2.IVA product form development

Brainstorming brought about several interesting concepts, the next thing the designers needed to do was to deepen these concepts and build on them trying to link them to traditional aesthetics and cultural symbols. The image below shows the use of traditional Chinese wind chime shapes and elements of the fortune cat shape incorporated into the IVA product shape.

Figure 25. Combining cultural symbolic elements into IVA concept

In the first concept, the traditional bronze wind chimes are transformed into the base of an IVA and an elliptical head is added to form the IVA robot, which is in line with the preference for robotic images by nearly 30% of people in quantitative research (Table 4. Analyzing the preference of product images).

In the second concept, the traditional element of the fortune cat was incorporated into the concept, and the ears needed to be conceptualised a little more to make the whole thing more of an in-car product rather than an animal image. Considering the compatibility of the IVA concept with the interior of the Lynk&Co car, the human-like robot concept in Table 4 would not be suitable for an enclosed car environment. This is mainly due to the Valley of Terror principle, where as the likeness of a robot to a human rises, the level of goodwill and trust also rises first, and then after a certain point, there is a shift to a negative reaction, forming a valley structure, before the level of goodwill and trust continues to rise with the level of realism [91]. The Valley of Terror effect is exacerbated to some extent in enclosed spaces, as the lighting makes the human like toy robot look closer to the Valley of Terror, thus causing discomfort and even fear to the user, as shown in the following figure:

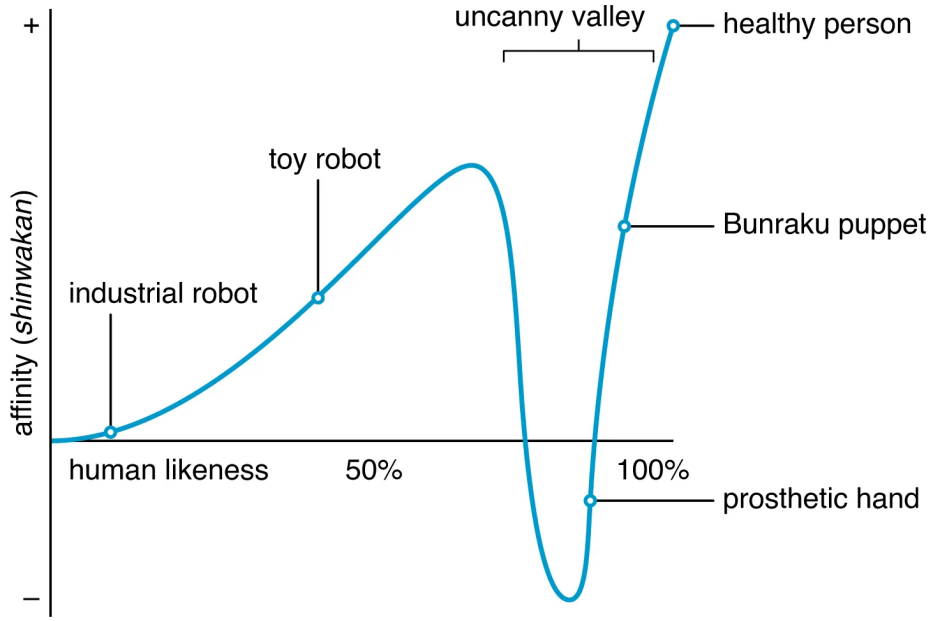


Figure 26. The Uncanny Valley

Therefore, the form of the IVA product leans more towards the traditional lucky cat form, as this form and element represents wealth, luck, career, and good things under traditional cultural values.

5.3.Modeling

Using NX UG software the product form for the second concept was 3D stereoscopic (note: at this stage only the product form was discussed, not the materials, colours, textures etc.) and more details were added to refine the product to meet Guideline 1.

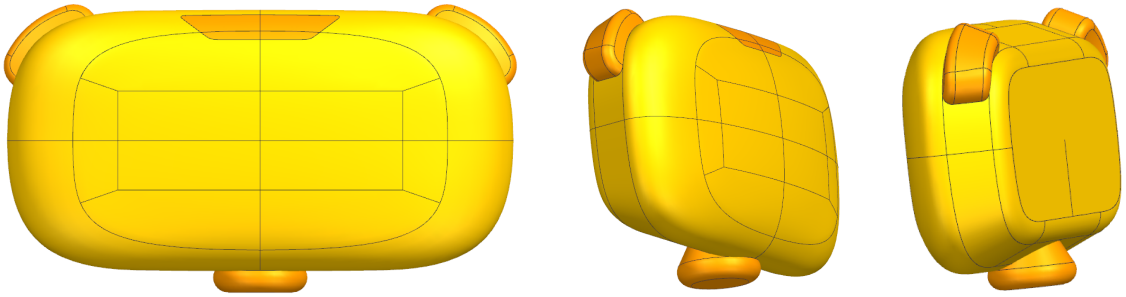


Figure 27. IVA concept model

It is obvious that the shape of the conceptual model is very similar to the flattened head of the cat, but the bulging shape and base, the ears do not fit together, and there are no obvious design features or elements influenced by specific cultural perceptions. However, the results of the supplemented survey show that the design features influenced by cultural values have many rounded elements. Therefore, iterative changes to this concept are required to better match the cultural values. For example, the body shape was adjusted to an oval shape, the ears were flattened, and more detail was added to the overall design.

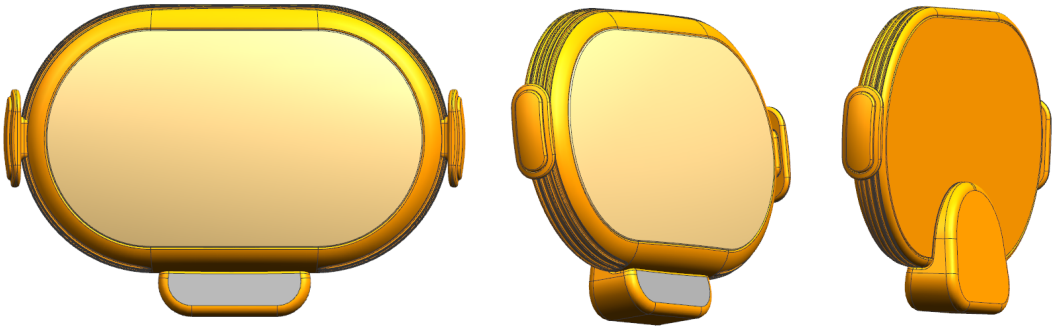


Figure 28. Iteration of IVA concept model

As can be seen from the diagram, the design of many components makes use of a number of "runway-shaped" ellipses, both in the main body, the ear component and the upper end of the base. Furthermore, the interaction of the components, the multi-layered relationship (referring to the ratio of the visual presentation of the size of the components, with the main body displaying: body shell and ear features: base = 6:3:1) and the use of multiple lines (parting lines, slots in the shell for attachment) are all in keeping with the high power distance and masculine cultural values that have influenced the design. At the same time, the wire slots in the housing with inlaid magnets give the user room for customisation and personalisation, allowing the user to make their own favourite items to decorate the in-car voice assistant, with the aim of allowing the user to attach emotional attributes to the product.

5.3.1.User testing 1

User testing is a very general, basic research method that refers to observing and collecting feedback from real users about their use of a product or system, and then analysing this feedback to assess usability, effectiveness and user satisfaction, and can also be used to identify and resolve any problems or areas for improvement. In general, designers and researchers can validate their assumptions, design decisions and user experience concepts

by testing with real users [92]. Therefore, the Iteration of IVA concept model is used to evaluate effectiveness and user satisfaction using user testing. The test model is as follows:

Test target：20-40 year olds with a driver licence
Number：20
Test dimensions：Satisfaction
Test instrument: Rating scale, 1 no feeling - 5 very strong
Test channel: Online survey
Test results:

Table 7. The result of user testing 1

Questions	Average score
To what extent do you feel the interactivity?	4.1
To what extent do you feel decorative?	3.8
To what extent do you feel it has elements of traditional aesthetics and cultural symbolism? (Using the lucky cat as a reference)	3.4
To what extent do you feel it is user-friendly?	4.1
To what extent do you feel it's emotional?	3.7

From the results of the test, it was found that the feedback from users on traditional aesthetic and cultural symbols was relatively low, due to the discrepancy between the perceived attributes of traditional aesthetics and cultural symbols in the product and those of the designer. What the designer needs to do therefore is to adjust the design features in this area in subsequent details, and also to strengthen the emotional and decorative features.

5.3.2.IVA graphic elements development

Once the shape of the product has been defined, it is time to think about the design elements of the User interface. From Figure 18. Conceptual product model diagram, it is clear that one of the most important design elements of the user interface is the graphical expressions, which are responsible for the output of information and core visual interaction in IVA products. The overall element needs to be in harmony with the product form and to contain certain design features that meet the needs of the user, such as emotionality, companionship, entertainment and interactivity. However, the timing of the appearance of these graphic expressions as feedback is not fixed, and the designer needs to determine the timing of the expression of different emotions or feedback based on the observation process of Figure 10, NIO and Mercedes Benz's IVA testing, e.g. when the feedback voice command is not recognised, the upset should appear. visual information and emotions to mitigate the negative impact of the lack of functionality on the user. When returning home from work or driving on a trip, visual messages such as Happy, Joking, etc. should appear to enliven the mood. The following diagram illustrates the idea of graphical elements:

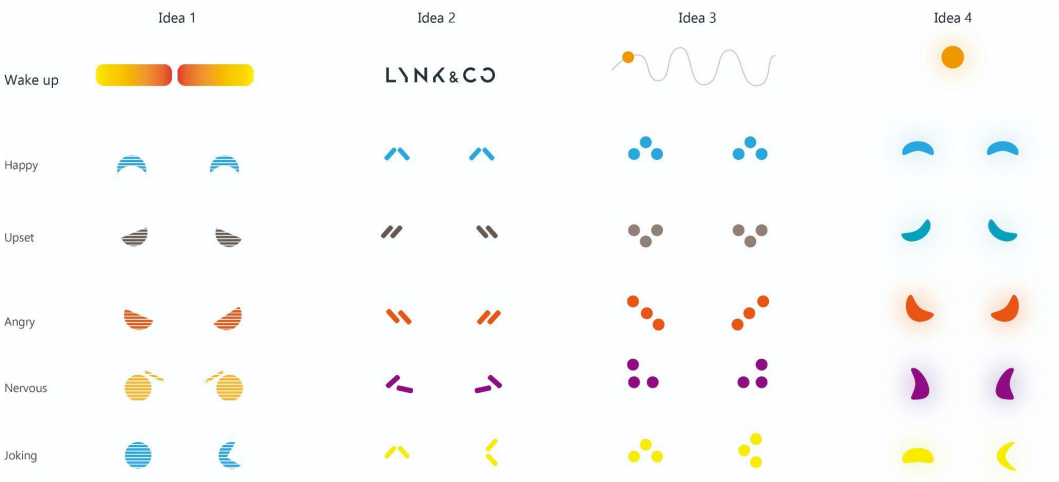


Figure 29. IVA graphic elements development

The designers sought to explore how well the four visual expressions matched the product form, using the Happy visual element as an example and forming an experimental model with the product form. In order to avoid the test users being influenced by the colour of the product model, only the outline elements of the product form were extracted and de-coloured for the test.

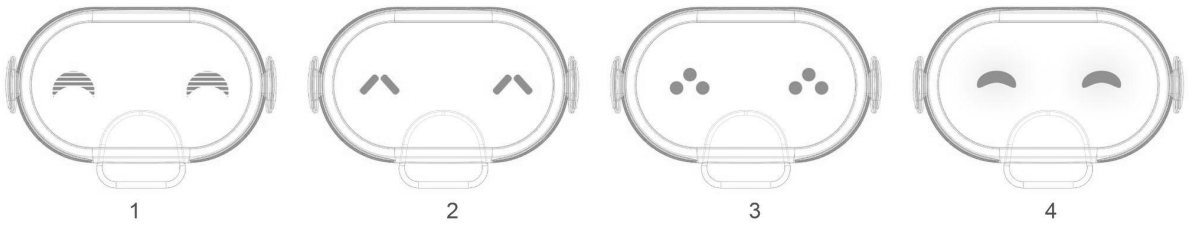


Figure 30. Explore how graphical expressions fit with product form

The test was simple, 10 employees from the Lynk&Co design studio were asked to do a quick test and the most preferred option was the fourth option, giving the reason that the expressions fit the design language of the main silhouette. The graphical expressions were therefore conceived using idear 4. However, the brand logo of Lynk&Co was used for the wake up visual elements, mainly to add more distinctive branding in line with the cultural values of high power distance and sunshine. At the same time, the emphasis on the brand also echoes the in-car control system of the Link car, increasing the continuity of the brand's products.

At this point, the design requirements for Guideline 2 have been completed and it is time to discuss how Guideline 3 can be applied to the rendered presentation of the product.

5.4. Rendering

In terms of product performance, there are two categories of rendering. The first is from a design point of view, which is used only to present the concept and design details of the product, and to do some product-specific testing. The second type of rendering is based on the design criteria of the stakeholders, mainly from a production point of view, to consider

whether the CMF (Colour, Material, Finishing) of the product meets their requirements for product continuity, cost control, realisability, etc. Therefore, in the first stage, the designer can present the concept and design details of the product, and then do a second rendering based on the stakeholder's needs.

Figure 31. Rendering for exhibiting the concept

For this design, the overall concept uses a rough, frosted matte plastic as the housing material, with the main display area occupying the largest volume while abandoning the smooth black glass material for a gentler, rougher cloth mesh texture. The ear parts are layered with different materials in order to add a more rigid quality to the product. This was done through a variety of renderings in order to verify how the IVA would fit into the driving scenario and the interior of the brand's cars, and to test the product in driving situations.

Figure 32. Different IVA styles

The four colourways shown above are all rendered according to the interior colours of the Link car, in order to integrate the IVA into the driving situation and not look out of place. However, through communication with the CMF department of Link Automotive, the dominant colours for the interior of Link are dark blue, dark grey and black. Therefore, in subsequent ah product testing, a black version of the IVA will be used.

5.4.1.IVA in driving scenarios

First, test the size, volume and scale of the IVA concept in a driving scenario. The model can be imported into a 1:1 cockpit simulator, adjusted to the right scale and then imported into Keyshot to animate the braking feedback, simulating the human-machine interaction by creating an animation and using this kinetic scene as a subsequent usability test. Figures 1-1, 1-2 and 1-3 below show the initial state, with the driver waking up the IVA and the IVA nodding its head when it receives a command.

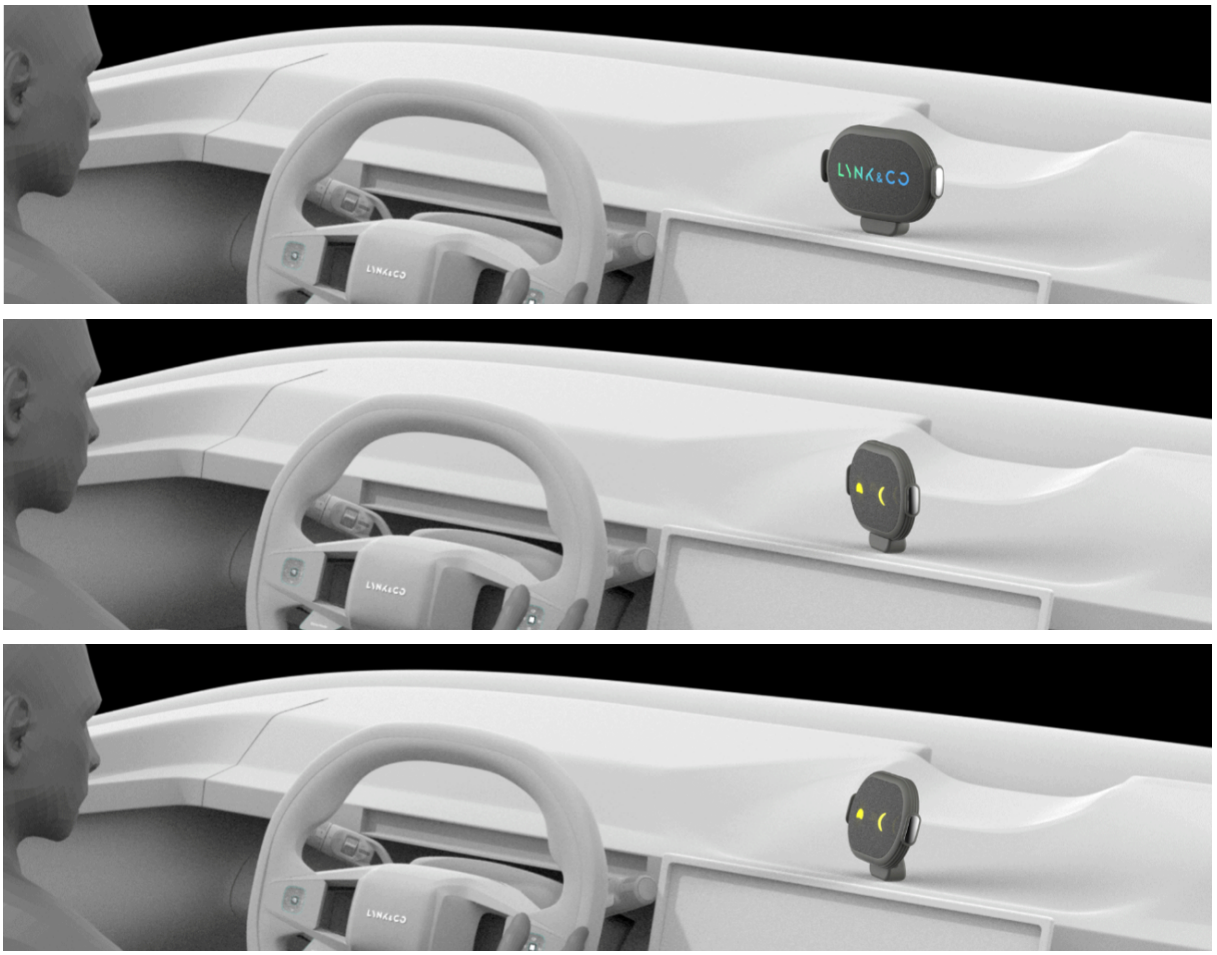


Figure 33. Simulation 1 of interaction scenarios

However, the simulated interaction states and animations were not enough to verify that the IVA concept would fit in with the interior of the Lynk&Co car, it needed to be placed in a real car environment, because in user testing, real scenarios are what evoke empathy. The image below shows a real Link car interior: when the user gives a voice command, the IVA lights up with a visual expression and replies with a message related to the command. When the car is started or the driver stops interacting with the voice command, the IVA visual emoji fades

to a standby state. In case of usability problems, the IVA does not recognise speech down to zero and its visual expressions will show aggravation, embarrassment and sorry.

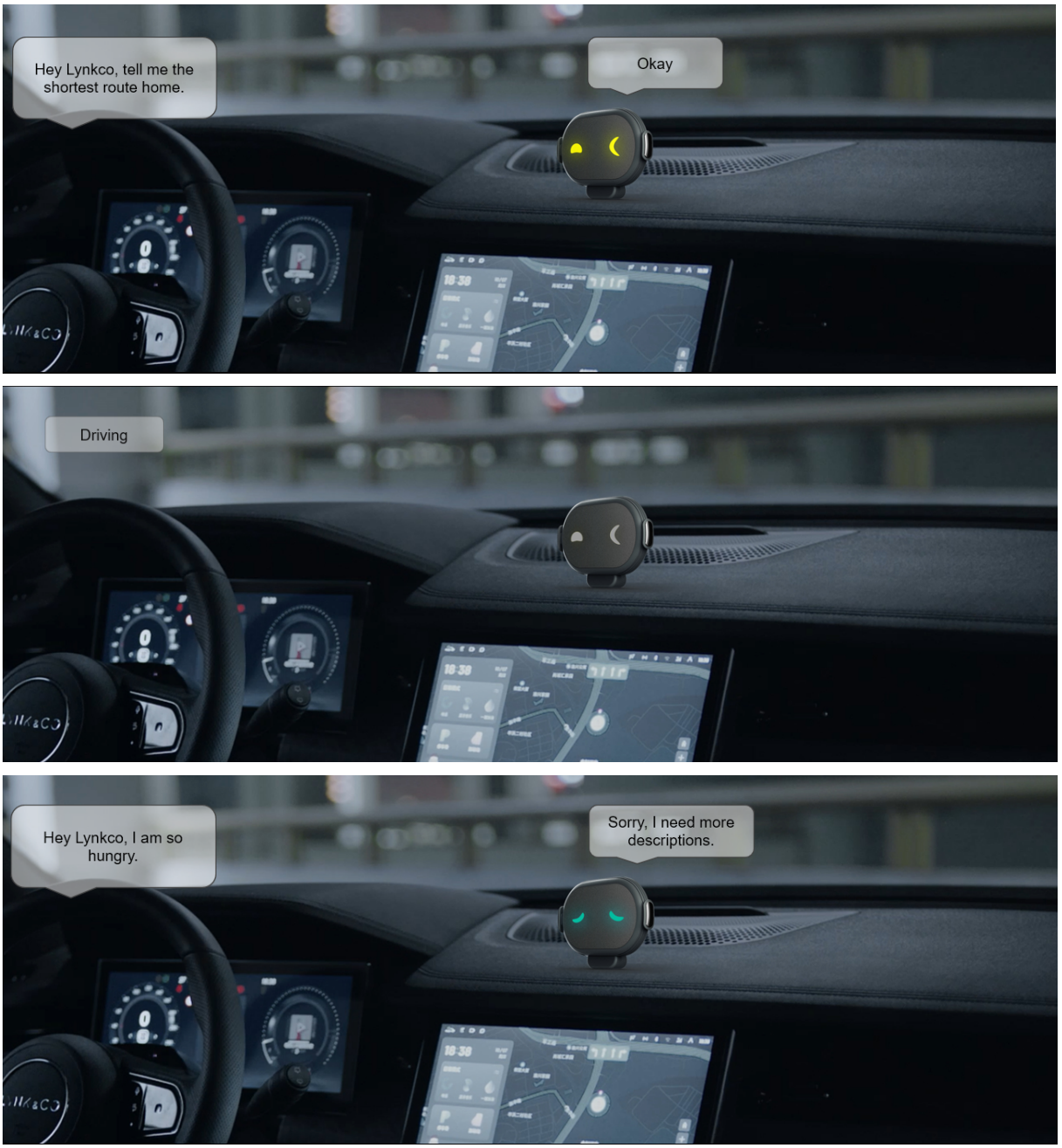


Figure 34. Simulation 2 of interaction scenarios

In short, after clarifying the proportions of IVA product forms and explaining the functions of IVA through simulated interaction scenarios, more traditional cultural elements are used in the material and finishing of IVA products in order to further strengthen the design characteristics of cultural values to increase the acceptability, continuity and adaptability of IVA products. However, as there are too many traditional cultural elements in China (mainland), only typical traditional cultural elements such as paper-cutting art and ceramic

culture (examples in appendix) can be used.

Figure 35. Integrating traditional cultural elements into the IVA concept

Cultural symbols such as the red elements above are used to decorate doors, desks, vases and even walls in homes during traditional Chinese festivals, and are sometimes used as pendants to decorate car interiors. In this case, this cultural symbol is used to decorate components of an IVA product, adding traditional cultural value to the product as well as enhancing its decorative qualities.

At this point, the design following guideline 3 is completed and the In-vehicle voice assistant design is also completed, based on the region-specific user preferences. As for the requirements of guideline 4, the customisation and personalisation of the product is not within the scope of this thesis, but is the subject of subsequent work and will therefore not be discussed here, but will be discussed in the future works.

5.5. Evaluate the concept with user satisfaction testing

To test user satisfaction with the IVA concept, the designer constructs a second user test. Using the scale questions from the online survey to investigate the subjectivity of the users, the following is the specific structure of the user test:

Testing target：20-40 year olds with a driver license
Responses：129
Testing dimensions：User subjective assessment
Testing method: Rating scale, 1 Negative - 5 Positive
Testing channel: Online survey
Testing results:

Table 8. The result of user testing 2

Questions		**Average score**	**Median**
Q1	To what extent do you feel that its visual expressions are adequate?	3.8	4
Q2	To what extent do you feel that its visual expressions are effective?	3.5	4
Q3	To what extent do you feel that its visual expressions are accurate and reliable?	3.6	4
Q4	To what extent do you feel it alleviates your negative emotions when it fails to recognise your voice commands or has usability errors?	3.7	4
Q5	To what extent do you find it enjoyable?	3.5	4
Q6	To what extent do you feel it is easy to use?	3.6	4
Q7	To what extent do you feel it's interactive?	3.6	4
Q8	To what extent do you feel it is decorative?	3.5	4
Q9	To what extent do you feel it's user-friendly?	3.5	4
Q10	To what extent do you feel it has an emotional design character?	3.6	4
Q11	To what extent do you feel its companionship?	3.6	4
Q12	To what extent do you feel it has elements of traditional aesthetics and cultural symbolism?	3.6	4
Q13	I know how to talk to this product	3.6	4
Q14	I feel that I am in full control of the interaction while using the product	3.7	4
Q15	I feel confident when I speak to that product	3.6	4
Q16	I feel at ease when I speak to that product	3.6	4
Q17	To what extent do you want to use the voice assistant in different driving situations?	3.5	4

The table above shows that the mean scores for all the scales are between 3.5 and 3.8 and the median for each scale is 4. This means that users are evaluating these product factors with extreme low values or outlier low values resulting in mean scores below the median. There are a number of possible reasons for this. Firstly, it could be that the IVA concept does not indeed meet the subjective needs of the user, secondly, it could be that the user does not fully understand the question, or it could be that the user is already evaluating with a subjective bias, thus resulting in a low score.

However, in terms of the user feedback, although there may still be some problems with the design of the concept or the scale survey that are responsible for the low outliers, the median score is 4, which means that most of the choices are on the 4 and 5 scale options. Therefore, these participants are positive about this IVA concept.

6

Conclusion

Review the research questions and summarize the core content and findings of this paper by answering the research questions.

Ⅰ. ***What are the latest findings on user preferences for IVA products?***
Ⅱ. ***How to set up the design guidelines for In-vehicle voice assistant innovation*** ？

In response to research question I, this study summarises the factors that influence users' preferences and potential influences on IVA products through a literature review, but these influences are largely function-based and few studies have analysed users' preferences from IVA visual information. The study also explores the latest work on users' preferences for IVA visual information from three areas: human-computer interaction, design science and behavioural science, and found that these studies only focus on one attribute or factor that influences users' preferences, acceptance and attitudes towards IVA products, but do not analyse the composition of the influencing factors from the users' perspective.

Based on Research Question II, the study summarises the user habits and preferences for in-car voice assistants in specific regions including preferences for visual elements, needs for using voice assistants in different scenarios, interaction styles and usage experience aspects. A user-centered research approach, including qualitative and quantitative research methods, was used to collect target user needs and preferences for IVA products in specific regions, and to filter and validate the data to produce accurate user data. Consumer psychology and country-specific methods were also used to explore the relationship between potential cultural value influencers and user preferences, and the relationship between user preference and cultural influencers was analysed. User preferences and factors influencing user preferences were then summarised separately, and they were filtered and blended to develop guidelines for the design of IVA products suitable for users in specific regions, which can be found in section 4.8.1.

Also, according to the design guidelines, IVA product concepts were developed based on user needs and cultural values were translated into product concepts to ascertain that the product concepts were also favoured by users when they were in line with specific cultural values. In addition to this, various design techniques such as product hand-drawing, 3D model design, product rendering, animation design, graphic element design, product testing and CFM process were used to design the in-car voice assistant based on the design guidelines to provide a viable solution for the stakeholders.

7

Discussion

The discussion section is an attempt to revisit the doubts and uncertainties in the study and to try to guide the follow-up work through the discussion. The discussion section does not summarize, but only develops ideas and reflections on the doubts and uncertainties. Therefore there will be no definitive conclusions in the discussion section.

7.1.Country-specific vs User preference

In general, country specificity and user preferences are two factors that need to be taken into account in design practice. They influence and interact with each other to shape the design of products and the positioning of markets. Country-specific refers to the differences in culture, values, laws, regulations, customs and traditions of different countries or regions. User preferences refer to the preferences and needs of individual users or specific groups of users for a product, service or experience. In design practice, understanding and considering country-specific factors and user preferences is essential for creating successful design solutions [66,87]. In past studies, there seems to be an emphasis on the relationship and importance of the two, but no research has indicated how to redesign when there is a conflict between country specificity and user preferences. For example, a study of country-specific methods may find that certain materials, features and design styles are appropriate for the region, but the results of this study may differ from user studies which find that users do not like these materials, features and design styles. In such cases, how can designers harmoniously blend the two findings to drive design?

In Figure 8. Combining the research framework with the double diamond process model, the designer attempts to integrate country-specific research methods into the discover and define stages of the Double diamond model . The Attribute-based method is used to identify design definitions that are culturally appropriate, mainly from studies in the field of HCI and business strategy, which compare China-Europe, China-US commercial branding, web design, graphic design and other design features that are culturally appropriate. These design definitions were used directly by the designer in this study to analyse the overlap with user preference studies to obtain results that are consistent with both culturally specific values and user preferences.

While this process of research and analysis has yielded some common design features that are country specific and in line with user preferences, it is in fact subject to a number of

uncertainties. Firstly, whether the design characteristics of commercial branding, web design, graphic design and other analyses that are consistent with specific cultural values can be used as a reference for product design. Although Marcus, Gould et al. point out in his study that only a few researchers have considered the relationship between Hofstede's cultural dimensions and design features in the last decade, they have all studied website design, and given that website design is also under the influence of symbolic culture, the findings in this area could be useful for the field of product design as well [76]. However, they do not indicate the extent of their validity and how symbolic culture has been transformed in different design fields. Secondly, the past country-specific studies have not thought about the temporal factor between Hofstede's cultural dimensions and design features.

It is well known that the situation in mainland China is relatively unique in the last decades, 60s-90s, people's thinking or cultural values were very conservative, which may indeed be highly consistent with Hofstede's cultural dimension assessment of China. However, since the 90s, cultural values have changed very rapidly and there have been major changes in certain cultural dimensions, for example, many young people have become more individualistic and more susceptible to the notion of Femininity. Therefore, defining design characteristics within the context of specific cultural values may require further consideration of the influence of time on cultural values.

7.2.Effectiveness of Research method(tools)

As for the validity of the research methodology, the designer was acutely aware of the drawbacks of qualitative research methods during the research process. In conducting qualitative interviews on user preferences, many of the responses given by the interviewees were influenced by subjective judgments and interpretations, resulting in biased responses that could affect the reliability and feasibility of the research findings. Also, the qualitative interviews in this paper were limited by time and resources, with only 12 eligible interviewees, resulting in an unrepresentative sample that did not cover the entire audience and the diversity of specific groups, for example, different driving experiences, different age groups of users, users with different car models, etc. There are also difficulties with replicability and generalisation, as qualitative research focuses on an in-depth understanding of individual experiences and perspectives, so the results are often difficult to generalise to whole populations or to make statistical generalisations. The low level of generalisation of qualitative research findings makes it difficult to make quantitative comparisons and build generalisable theories. Finally, the subjective and complex nature of data analysis, qualitative data is often unstructured and involves a large amount of text, image, audio or video material. The process of analysing data is subjective and complex, requiring the researcher to interpret, code and summarise the data. This subjectivity and complexity can lead to differences in interpretation and inconsistent results between researchers.

7.3. Challenges

There is no doubt that there are significant challenges in conducting user research across geographies. Firstly, there is the time and cost investment, as the designer is based in Gothenburg, Sweden, while the research subjects are in mainland China. Therefore, due to

the time difference, it took more time, resources and manpower to collect data in both qualitative and quantitative research. At the same time, the design practice challenge, the design phase of the project tested the designers' skills and techniques in many areas, as the IVA product concept covered not only design research, but also animation design, product design, CMF design, graphic design, HCI design and design thinking. The design tools to be used and the results to be produced in these areas are then a practical challenge for the designer.

8

Future work

In this section, the content or direction of future work on this study will be briefly described.

8.1.Brand loyalty and Customer retention

Based on the needs expressed by the stakeholders, they wanted to increase user loyalty to the brand around the fact that in-car voice assistants could improve the user driving experience and build a good relationship with consumers to retain customers. In this study, a number of approaches were identified during the consumer psychology research and user research phases when building good word-of-mouth about the product experience. For example, providing more hedonistic attributes while meeting the basic pragmatic needs of the consumer. In other words, providing more entertainment features in addition to the default product features can give consumers more pleasure than expected.In this case, reviewing the competitor products in the market context section, their products largely do not have hedonistic design attributes attached to them. Therefore, the addition of customisation and personalisation features was an advantage over the competitors in the project for this study.

In subsequent work, the designer proposed new customisation and personalisation features to the stakeholders. The diagram below shows the customisation and personalisation around this IVA concept in conjunction with the Lynk&Co App, while enhancing the user experience and user engagement with the aim of strengthening the user-brand relationship.

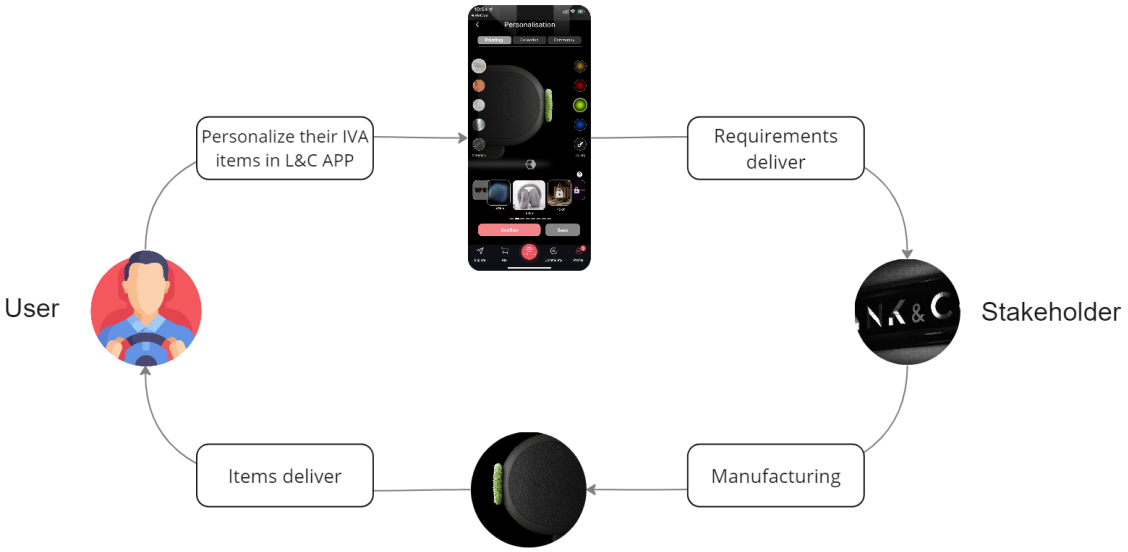


Figure 36. Personalization process

This personalisation feature allows users to adapt IVA components to their preferences on the Lynk&Co app. Once a DIY solution has been settled on, the request is sent to Lynk&Co Club and the personalised item is then produced by Link and delivered to the user by mail. During this process, Link could create special rewards in advance, such as sophisticated IVA accessories related to movie IPs, sports stars or pets, to reward users who drive Lynk&Co cars safely for a certain number of miles. Such rewards could be a "relationship trigger", fostering a personalised collection of hobbies and promoting safe driving. Of course the detailed design process of this solution is not part of the work of this study and therefore cannot be discussed in further detail.

8.2.Product testing for cognitive errors or risks

This study does not address the potential human perception errors of the IVA product due to time constraints and geographical limitations, mainly driver distraction. It is known that testing for human perception errors would require field tests to be carried out in mainland China, where actual driving tests were carried out with a camera + eye tracking device recording the distractions of the user to test whether the IVA concept affects the driver's concentration and therefore increases the driving hazard. This test is therefore inevitable for future work where the concept is likely to be applied in real projects.

8.3. Consistency

In the development of the IVA concept, this study does not delve into product continuity and can only roughly describe the main design styles and CMFs of the approximate Lynk&Co car interiors. The reason for this is that each generation of Link's interior design has different design features (different steel shapes, dashboard shapes and cabin front shapes.) However, the CMF design is relatively similar, so designers can only explore the design features and patterns from the use of CMF to drive the creation of the IVA concept design guidelines. A more in-depth discussion of product continuity therefore requires more analysis of the design language of automotive cockpit design.

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