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Research article

An empirical study on new-energy vehicle users' preferences of in-vehicle interaction input methods

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ABSTRACT

New energy sources are transforming the automotive market. This shift has also expanded the possibilities for in-vehicle interaction. Through a literature review, this study categorizes the in-vehicle interaction activities into three types: driving tasks, comfort tasks, and entertainment tasks. This study conducted empirical survey of 377 users to understand their preferences of in-vehicle interaction input methods inside new energy vehicles. The results show that gender, educational level, income, driver's license type and driving experience have significant influence on the perception and preference of the in-vehicle interaction input methods. However, age and experience with new energy vehicle didn't show significant results. The findings of this study can assist manufacturers in developing targeted solutions and meeting the personalized needs of users in future vehicle market segments.

1. Introduction

Passenger cars are a significant source of air pollution, particularly in urban areas [1,2]. Consequently, new energy vehicles are increasingly gaining attention from governments and consumers worldwide due to their potential to reduce emissions of atmospheric pollutants [3]. Bach and others have noted that an increasingly important area in human-computer interaction within mobility is the design of in-vehicle systems [4]. The shift towards new energy vehicles is speeding up the use of new technologies for in-vehicle interaction. This has sparked ongoing innovation in systems, control devices, and features. The goal is to make travel more comfortable and enjoyable for drivers and passengers [5]. Additionally, Detjen and his colleagues highlight that higher-level autonomous vehicles will become a reality within decades, and vehicle automation will have a significant impact on in-vehicle interaction, expanding the range of human-vehicle interactions [6]. These intelligent changes will bring corresponding alterations in vehicle interior design. However, public opinions on these technologies are polarized, with some people excited about the new possibilities and others skeptical about the new technologies [7].

Currently, during driving, we interact with various digital technologies and use them to control in-vehicle settings such as climate control, cruise control, or safety systems. Additionally, we use other interactive digital systems in the car, sometimes even while driving, such as mobile phones, GPS (global positioning system) navigation systems, or entertainment systems for playing music or

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videos [8]. However, regardless of technological changes, the essence of driving remains unchanged [9]. Li and Boyle point out that in-vehicle information systems can cause driver distraction, thereby posing a threat to driving safety [10]. Under government initiatives and promotion, China has become a global leader in new energy vehicle sales, particularly electric vehicles, and will continue to drive related technology and applications in the future [11]. Many Chinese new energy vehicle manufacturers, especially new forces like NIO, XPeng, and Li Auto, have made significant innovations in intelligent cockpits [12]. However, these manufacturers, proficient in computer and electronic product manufacturing, often lack experience in vehicle safety [9]. Meanwhile, in several major global automotive markets, such as North America and Europe, the sales proportion of new energy vehicles is also rising. With the introduction of these new technologies, the basic roles of drivers and passengers have undergone significant changes, presenting new needs, requirements, and challenges for designers in creating safe, comfortable, and optimal human-machine interaction systems for autonomous vehicles [13]. Therefore, it is necessary to examine these changes while applying new technologies to reduce user skepticism and increase acceptance, making it crucial to investigate user preferences and listen to their feedback.

Past research has primarily evaluated the impact of IVIS (in-vehicle information systems) on driving tasks from a safety perspective. Zhang and his team argue that the use of IVIS can raise safety concerns [14]. Previous studies have shown that operating IVIS leads to greater vehicle deceleration [15], more lane deviations [16], more frequent eye movement [17], and higher driving workload [18], among other effects. Detjen and his colleagues emphasize that, in addition to technological application and safety, it is more important to keep users inside the vehicle and to make them accept and use these technologies and systems [6]. The bridge between users and these tasks and systems is the 'modality,' defined as the channel of sensory input/output between a human and a system [19]. Traditional in-vehicle interaction primarily relied on physical buttons, then touchscreens became more common [20], followed by the popularity of speech-based and gesture-based interaction (as exemplified by BMW (Bayerische Motoren Werke AG) Natural Interaction Unveiled at MWC (Mobile World Congress) 2019). However, research on these in-vehicle interaction input methods is still quite limited. For example, Ba H and his team compared tactile, touch, and gesture interactions, finding that gesture interaction requires quick hand-eye coordination, touch interaction is faster and more efficient in completing tasks, while tactile is less effective than the other two [4]. Angelini and his team compared the driving task performance of gestures, touch, and voice interactions on the steering wheel, finding no significant statistical differences among them. However, each input method displayed its own advantages: voice interaction required the fewest interactions, touch interaction took the shortest time, and all three were comparable in perceived usability, cognitive load, and emotional response [21]. Zhang and his colleagues found that touch-based interaction led to poorer driving performance, gesture-based was slightly better, and speech-based had the least impact on driving and vision [14].

In summary, most existing research on in-vehicle interaction input methods has been conducted from the perspective of driving safety. While a substantial body of scientific literature has reported useful results and generated knowledge for designing in-vehicle interactions based on gestures and voice, this knowledge is scattered and needs consolidation [22]. Additionally, there is a necessity for comprehensive comparative studies of physical buttons, touch, voice, and gestures [23]. Therefore, this study aims to collect data from the perspective of consumers, focusing on users' preferences and needs for in-vehicle interactions, behavior, and use of technology while driving or traveling by car. This study intends to reveal the preference characteristics of different types of consumers and the differences among them. Hence, the following research question is proposed to guide this study: What are the preferences and needs of users regarding in-vehicle interaction input methods (physical buttons, touch, voice, and gestures) while using new energy vehicles and what are the differences between different groups of users? The results of this study will assist new energy vehicle manufacturers in developing targeted solutions to meet the personalized needs of users in future vehicle market segments.

The subsequent content of this paper is organized as follows: Section 2 presents a literature review, focusing on the categorization and scenarios of activities within new energy vehicles, as well as related functionalities, and the research hypotheses are proposed. Section 3 describes the research methods and details of the survey conducted for this study. Section 4 presents the data results and discusses the differences in functional preferences for new energy vehicles among different types of users, offering potential explanations and related design rationales and references. Section 5 concludes the paper, explaining its research limitations and outlining directions for future research.

2. Literature review

To investigate user preferences for input methods of human-vehicle interaction within new energy vehicles, this study initially organizes and categorizes the types of activities consumers engage in inside vehicles. Based on this, the study further clarifies the input methods corresponding to different types of in-vehicle activities. Building on the literature review, the study summarizes the research gaps and, based on these, proposes research hypotheses.

2.1. In-vehicle activities

The most needed basic function people have for vehicles is driving, which encompasses fundamental tasks such as braking, accelerating, clutching, gear shifting, and steering. There are also auxiliary functions related to driving, including windshield wipers, defogging, and rearview mirror adjustments. Beyond basic driving functions, people's functional needs for vehicles also include comfort and entertainment features. High-frequency in-vehicle scenarios like navigation, communication, entertainment, car apps, and temperature control are categorized [24]. The primary human-vehicle interaction tasks include navigation, making and receiving phone calls, music selection and switching, radio tuning, interaction with car apps, adjusting air conditioning temperature, monitoring the dashboard, voice activation, and central control screen interaction [16]. Furthermore, with the advancement of autonomous driving technology, users can perform more tasks beyond driving, such as writing emails or documents, relaxing, or leisure activities

[25–27].

With the deepening of new energy transformation and the advancement of autonomous driving technology, the types of activities users engage in inside vehicles are progressively diversifying. These functions can be broadly summarized into three categories. The most basic category involves driving-related tasks, including gear shifting, acceleration, braking, and steering. The second category pertains to comfort needs, such as seat configuration [28], air conditioning adjustment [29], and sunshade adjustments. The third category relates to entertainment needs [30], which include adjusting media like music, videos, games, etc. Following this classification, this study will organize and examine the input methods for in-vehicle human-vehicle interaction based on these three types of activities.

2.2. In-vehicle human-vehicle interaction input methods

Traditional vehicle interaction design is based on the requirement that the driver can reach the pedals, steering wheel, and gear shift in any sitting position [31]. Tasks related to driving, such as gear shifting, acceleration, and braking, are typically accomplished through physical tactile interactions and do not require much visual attention. Tactile control provides stability and, to some extent, contributes to safety [24]. The shape of the steering wheel, its gripping experience, and ease of operation are crucial for the steering experience [32]. The static feeling during gear shifting is the most remarkable activity related to comfort in the gear shifting process [33]. Steering wheels, accelerators, brakes, and gear shift levers control the vehicle's basic mobility functions and usually have similar positioning layouts in vehicles [34]. Skilled drivers can often perform actions like turning and shifting gears without taking their eyes off the road [35]. Based on this, the study proposes the following hypotheses:

Hypothesis 1. (H1): There are no significant differences in steering wheel shape preferences among users with different background characteristics.

Hypothesis 2. (H2): There are no significant differences in gear shift mechanism preferences among users with different background characteristics.

Modern new energy vehicles are increasingly seen by users as mobile offices [36], spaces for dialogue, mental entertainment, play, or self-extension [37]. They are also considered ideal places to pursue personal hobbies, such as playing music [38] or exercising [39]. This means that, in addition to providing fun interactions for the driver [40], new energy vehicles also serve an entertainment function for passengers to enhance their travel experience. Today's vehicle interiors follow this pattern: frequently used functions are physical buttons, and touch screens are used for less common functions [6]. In recent years, touchscreens as an efficient mode of interaction have been widely used in in-vehicle interaction. Compared to traditional physical button-based interactions, touch-based interactions have the advantages of simplicity and style and are reported to be more user-friendly and preferred [41]. However, unlike physical button-based interactions, touch-based interactions lack tactile feedback, and in many cases, requires visual confirmation by the driver to ensure the input is correctly received [42]. This extra confirmation requirement could lead to distraction from the primary driving task and increase the risk of accidents [43]. Voice is a natural way for humans to communicate, and interacting with a voice assistant is as natural as talking to another person [44]. With the maturity of voice recognition technology and language models [45], voice has become a popular in-vehicle interaction input method. Functions like navigation, music playback, and phone calls are now controllable by voice [46]. Compared to touch interaction, voice interaction allows the driver to focus more on the road. Additionally, the high recognition accuracy and the now-realized concept of "speakable visibility" make in-car voice interaction technology quite practical. Gesture control is a natural way of interaction. Gesture interaction includes touch-based gestures and in-air gestures [47]. If well-designed, with recognizable metaphors, in-air gestures can be effective for a small command set or choosing from several options [48]. Compared to traditional touch sensing, gesture control is not confined to a specific car location [49]. However, studies have found that compared to touch-sensitive steering wheels [50], the convenience and accuracy of gesture control have not shown a substantial improvement. It is evident that drivers and passengers have different preferences for in-vehicle interaction input methods. Therefore, it is necessary to investigate these preferences based on the users' background characteristics. Based on this, the study proposes the following hypotheses:

Hypothesis 3. (H3): There are no significant differences in preferences for music playback interaction methods among users with different background characteristics.

Hypothesis 4. (H4): There are no significant differences in preferences for air conditioning control interaction methods among users with different background characteristics.

2.3. Summary

In China, the increasing market share of new energy vehicles has also driven the popularization of autonomous driving technology, which diminishes the emphasis on driving performance as a selling point for traditional fuel vehicles. This shift creates space for new types of interactions and changes the way people use cars—potentially in a more hedonistic [51] and comfortable manner. These changes open possibilities for the introduction of new forms of in-vehicle interaction. However, the ultimate determinant of the success of these technologies is user adoption. Therefore, understanding technology adoption is a crucial issue for vehicle interior designers. Our study, through literature review, has established three basic types of in-vehicle interaction tasks: driving, comfort, and entertainment. On this basis, four hypotheses were formed to assess whether there are significant differences in the preferences for in-vehicle interaction input methods among users with different background characteristics in new energy vehicles. The TAM (Technology Acceptance Model), proposed by Davis in 1989 [52], is one of the most influential models in the field of information system acceptance. Research in many fields has posited that perceived usefulness and perceived ease of use are critical variables in measuring user adoption of technology [53–55]. Additionally, self-efficacy provides a mechanism for explaining individual behavior, defined as a person's perceived ability to perform a behavior [56]. This is often used to assess individual adoption and use of information systems [57,58]. Therefore, this study will utilize items from the scales related to the Technology Acceptance Model and self-efficacy theory in subsequent questionnaires to measure the preferences for in-vehicle interaction input methods among users with different background characteristics in new energy vehicles.

3. Methodology

This study was conducted according to the guidelines of the Declaration of Helsinki and received academic ethics review and approval from the review committee of the Ministry of Social Science, Changshu Institute of Technology. Our survey's informed consent was obtained from all participants and all methods were performed per relevant guidelines and regulations.

Through literature review, this study identified several important human-vehicle interactive functions that influence everyday driving and vehicle control. These include the control of vehicle steering, gear shifting, audio-visual entertainment, and air conditioning comfort by users. Subsequently, this study conducted a survey to gauge user perceptions and preference needs for different input methods of these functions. The questionnaire used in this study was modified from the TAM [52,59] and the concept of self-efficacy [56,60], focusing on aspects of usefulness, ease of use, and self-efficacy. All the questionnaire items were streamlined for the purpose of this study and employed Likert's 5-point scale.

The questionnaire can be divided into two parts: the first part focused on the respondents' preferences and needs regarding in-vehicle interaction input methods, and the second part collected basic background information about the respondents. During the process of translating the English items into Chinese, this study invited two Ph.D. (Doctor of Philosophy) holders in design to independently translate the original English scale. The translation results were then discussed, and appropriate modifications were made based on the discussion outcomes. The revised scale was back-translated by two Ph.D. holders specializing in English, and further modifications were made to the Chinese scale content based on the back-translation results. Before the official questionnaire survey, the study consulted an expert in the automotive field and a veteran automotive journalist to evaluate the measurement tool. Additionally, 13 respondents with experience using new energy vehicles were invited to participate in a pilot test of the questionnaire. The questionnaire's wording and some items were adjusted based on the feedback from these experts and respondents to ensure the scientific validity and readability.

The content of the questionnaire is as follows. In terms of driving function, we selected steering function and the gear shifting function as subjects of study. For the steering function, typical input methods like round steering wheels, polygonal steering wheels, and semi-circular yoke steering wheels were chosen. For the gear shifting mechanism, typical input methods include manual gear shifts, electronic gear shifts, mechanical gear levers, and button-based gear shifts. In terms of entertainment function, we focused on music play function, typical input methods included physical buttons, touch buttons, knobs, screen touch, gesture control, and voice control. In terms of comfort function, the air conditioning adjustment was selected, typical input methods chosen were knob control, physical buttons, touch buttons, screen touch, and voice control.

Regarding the sampling method, this study employed random sampling method and snowball sampling method. The first batch of respondents was drawn from the researcher's social circle, focusing on individuals who had rich experience in using vehicles and showed a keen interest in them. The researchers initially informed the participants of the purposes of this study. Respondents were also asked if they would be willing to help disseminate the survey after completing it. Upon agreement, these respondents then invited new participants, and so on. The survey was conducted from October to November 2022. Due to restrictions related to the pandemic, the survey was carried out online. All respondents were informed of the scope of data use before filling out the questionnaire through an online link.

4. Results

This section comprehensively introduces the specific procedures, methods, and tools used in the data analysis, as well as the results of the data analysis. The data analysis software employed in this research is IBM SPSS 25. Initially, we cleaned the collected sample data, identifying and eliminating invalid samples. Subsequently, we conducted descriptive statistical analysis on the valid samples to obtain basic demographic information of the samples. Following that, we verified the reliability of the data to ensure its validity and reliability. Finally, we carried out independent samples t-tests and ANOVA (analysis of variance) tests on the data to compare whether there are differences in the input methods preferences for new energy vehicles among different users.

4.1. Sample description

Considering the restrictions during the COVID-19 pandemic, this study recruited respondents through an online survey platform (https://www.wjx.cn) during October to November 2022 in China. More than 80 % of the respondents are from Jiangsu Province, Zhejiang Province, and Anhui Province. A total of 407 questionnaires were distributed in this study. After manually removing invalid responses due to duplicate responses and extremely short completion times (like completing 60 questions in 120 s), 377 valid questionnaires remained. Among these respondents, males (57.6 %) account more than females (42.4 %). Respondents aged 25–35 (27.6

%) and those aged 36–45 (46.7 %) were the majority. Regarding educational background, 246 respondents (65.3 %) had a bachelor's degree or college diploma. In terms of driving experience, only 88 respondents (23.3 %) had one year or less driving experience. For driver's license types, 37 (9.8 %) had a type A license, 22 (5.8 %) a type B, 237 (62.9 %) a manual type C, and 81 (21.5 %) an automatic type C. Monthly income distribution was as follows: 132 respondents (35 %) earned 5000 RMB or below, 173 (45.9 %) earned between 5001 and 12000 RMB, and 72 (19.1 %) earned above 12,001 RMB. 117 respondents (31 %) had experience driving new energy vehicles, while 260 (69 %) did not. The survey covered all age groups, with a majority being middle-aged and young adults, which aligns with the actual age distribution of drivers. A high proportion of respondents, 77.7 %, had received higher education, indicating an overall high level of education among the participants. The detailed demographic information of respondents is presented in Table 1. Based on these results, the respondents selected for this study broadly matched the user profile of new energy vehicles, and the sample met the research needs.

4.2. Reliability analysis

To test the reliability of the data, this study employed Cronbach's alpha (α) value for determination. The results showed that the overall reliability of the questionnaire was 0.966, exceeding the threshold of 0.7 [61]. Additionally, the Cronbach's alpha value did not show a significant increase after the deletion of any item. This indicates that the results of this questionnaire survey are reliable and suitable for further analysis.

4.3. Differential analysis results

This study aims to explore whether there are significant differences among different groups of subjects on a specific project. To this end, we used the independent samples *t*-test and one-way analysis of variance (ANOVA) as the main statistical methods. The independent samples *t*-test is used to compare the average score differences on the project between two groups to determine whether there is a statistically significant difference between the two groups. When it comes to more than two groups, we use one-way analysis of variance to assess the differences in scores between the groups. For the significant results revealed by the analysis of variance, we further use eta squared values (η^2) to quantify the effect size [62].

4.3.1. Preferences of driving functions

Both male and females users believe that steering wheel shapes including round, polygonal, and semi-circular yoke can meet their control needs for vehicle steering, with no significant differences observed. In terms of the perceived usefulness of round and polygonal steering wheels, there were no significant differences between males and females. However, significant differences existed in the PEOU (perceived ease of use) of the yoke steering wheel, with male scores being lower than females scores. This suggests that females find the yoke steering wheel easier to use. Notably, regardless of gender, the average score for perceived ease of use of the yoke steering wheel did not exceed three, and its perceived ease of use average score was lower than that of the polygonal steering wheel (2.84) and the round steering wheel (4.05). There were also significant differences in SE (self-efficacy) regarding the Yoke steering wheel between male and females, with male scoring lower than females (See Table 2).

Respondents holding different types of driver's licenses showed significant differences in their use of round steering wheels, PEOU

Table 1
Demographic of valid samples (n = 377).

Background variable	Category	Number	Ratio
Gender	Male	217	57.6
	Female	160	42.4
Age	≤24	38	10.1
	25–35	104	27.6
	36–45	176	46.7
	46–60	50	13.3
	≥61	9	2.4
Educational level	High school and below	85	22.5
	College or bachelor's degree	246	65.3
	Postgraduate	46	12.2
Year of driving experience	≤1 Year	88	23.3
	2–5 Years	96	25.5
	≥6 Years	193	51.2
Type of driving license	A	37	9.8
	B	22	5.8
	C1	237	62.9
	C2	81	21.5
Monthly income (RMB)	≤5000	132	35
	5001–12000	173	45.9
	≥12,001	72	19.1
Experience of using new-energy vehicle	Yes	117	31
	No	260	69

of round steering wheels, and SE in using round steering wheels (See Table 3, Fig. 1). Post-hoc testing using the L.S.D. (Least Significant Difference) method revealed that users with a type A driver's license scored significantly lower than those holding C1 and C2 licenses. Additionally, the SE of users with a type A license in using round steering wheels was significantly lower than that of users with B, C1, and C2 licenses.

Respondents with different income levels showed significant differences in their use of yoke steering wheels and PEOU of these steering wheels (See Table 3, Fig. 2). Post-hoc testing using the L.S.D. method revealed that respondents with incomes between 5001 and 12000 RMB showed a significantly lower acceptance of yoke steering wheels compared to those earning less than 500 RMB per month. Respondents with an income below 5000 RMB rated the perceived ease of use of semi-circular yoke steering wheels significantly higher than those earning between 5001 and 12000 RMB and those earning above 12,001 RMB.

Regarding SE in using mechanical gear shift levers, significant differences were found between males and females, with male scoring higher than females (See Table 4). There are also significant differences in SE in using mechanical gear shift levers among respondents with different driving experiences (See Table 4, Fig. 3). Those with more than six years of driving experience have significantly higher SE in using mechanical gear shift levers compared to those with five years or less. Additionally, significant differences exist in the use of button-controlled vehicle gear shifting among drivers of different ages, with those having more than six years of driving experience scoring significantly lower than those with one year or less (See Table 4, Fig. 4). Differences in PEOU for button-controlled vehicle gear shifting were also observed among respondents with different income levels. Respondents with incomes higher than 12,000 scored significantly lower than those earning below 5000 (see Table 5).

4.3.2. *Entertainment functions*

Significant differences were observed in the use of touch buttons to control music playback, the PEOU of touch buttons for music playback, the use of screen touch to control music playback, the PEOU of screen touch for music playback, SE in using screen touch for music playback, the use of voice control for music playback, the PEOU of voice control for music playback, and SE in using voice control for music playback. Males scored lower than females in these areas (See Table 6).

Respondents with different levels of education exhibited significant differences in the PEOU of using touchscreen to control music playback, with those having a high school education or below scoring significantly higher than those with a master's degree or above. There were also significant differences in SE for using touchscreen to control music playback. Post-hoc tests revealed that respondents with high school or undergraduate education scored higher than those with graduate education (See Table 7, Fig. 5). For the PEOU of gesture control to play music, post-hoc tests showed that respondents with high school or undergraduate education scored higher than those with graduate education. Additionally, there were significant differences in SE for using gesture control music playback, with high school education scoring significantly higher than undergraduate, which in turn scored significantly higher than master's degree or above. For using voice control to play music and the perceived ease of use of voice control, post-hoc tests indicated that high school and undergraduate respondents scored higher than graduate-level respondents. Notably, respondents with higher educational levels showed a lower acceptance of control methods such as touch buttons, touch screens, and voice commands.

Users with different lengths of driving experience showed significant differences in their use of touchscreen to control music playback, with those having more than six years of driving experience scoring significantly lower than those with less than one year of experience. There were also significant differences in the use of voice control to play music among drivers of different experiences, with those having more than six years of experience scoring significantly lower than those with two to five years and less than one year of driving experience (See Table 7, Fig. 6).

Respondents holding different types of driver's licenses showed significant differences in the perceived ease of use and self-efficacy of using touchscreen to control music. Those with a type A license scored significantly lower than those with a type C license. Typically, holders of a type A license in China are qualified to drive large vehicles (See Table 7, Fig. 7).

Significant differences were also observed among users with different income levels in their PEOU and SE in using touch buttons to control music playback, using knobs for music playback, and using touchscreen, gestures, and voice to control music playback. Lower-income groups scored significantly higher than higher-income groups in these aspects (See Table 7, Fig. 8).

4.3.3. *Comfort functions*

Significant differences were observed between males and females in using touchscreen to control air conditioning, the PEOU of touchscreen for air conditioning control, SE in using touchscreen to control air conditioning, and SE in using voice control for air conditioning. In all these aspects, males scored lower than females (See Table 8).

Users with different educational backgrounds showed significant differences in SE when using voice control for air conditioning. Post-hoc tests revealed that users with a graduate degree or higher scored significantly lower in this aspect than those with undergraduate or high school education or less (See Table 9, Fig. 9).

Table 2
Independent *t*-test results of steering functions.

Variable	Group	Mean	Stand deviation	t	Significance (two-tailed)
PEOU of yoke steering wheel control over vehicle steering	Male	2.76	0.995	−2.053	0.041
	Female	2.96	0.944		
SE of yoke steering wheel control over vehicle steering	Male	2.78	1.020	−2.107	0.036
	Female	3.00	0.938		

Table 3
ANOVA results of steering functions.

Source of Variance		SS	df	MS	η^2	F	p	Post-hoc L.S.D.
Type of driving license								
Round steering wheel control over vehicle steering	SS_B	8.220	3	2.740	0.021	2.730	0.044	A<(C1<C2)
	SS_W	374.332	373	1.004				
	SS_T	382.552	376					
PEOU of round steering wheel control over vehicle steering	SS_B	8.708	3	2.903	0.029	3.655	0.013	A<(C1<C2)
	SS_W	296.231	373	0.794				
	SS_T	304.939	376					
SE of round steering wheel control over vehicle steering	SS_B	9.202	3	3.067	0.030	3.909	0.009	A<(B < C1<C2)
	SS_W	292.686	373	0.785				
	SS_T	301.889	376					
Monthly income (RMB)								
Yoke steering wheel control over vehicle steering	SS_B	6.932	2	3.466	0.020	3.730	0.025	5001-12000 < less than 5000
	SS_W	347.519	374	0.929				
	SS_T	354.451	376					
PEOU of yoke steering wheel control over vehicle steering	SS_B	9.775	2	4.888	0.027	5.223	0.006	(More than 12,001 < 5001–12000) < less than 5000
	SS_W	349.991	374	0.936				
	SS_T	359.767	376					

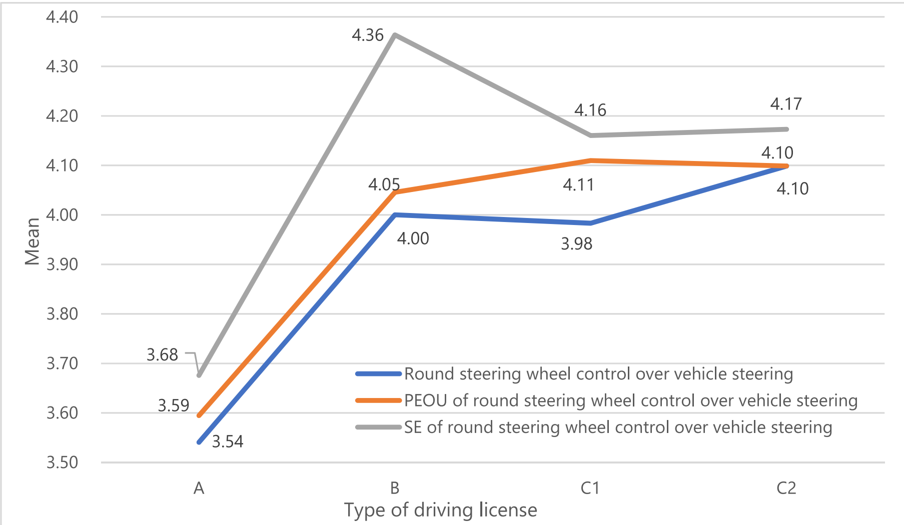

Fig. 1. ANOVA results of steering functions (Source of Variance: Type of driving license).

Users with different driving experiences demonstrated significant differences in using touchscreen to control air conditioning. Owners with more than six years of driving experience scored significantly lower than those with two to five years and one year or less of driving experience (See Table 9, Fig. 10).

Users from different income levels exhibited significant differences in using touch buttons to control air conditioning, PEOU of touch buttons for air conditioning control, SE in using touch buttons for air conditioning control, using touchscreen to control air conditioning, PEOU of touchscreen for air conditioning control, and SE in using touchscreen for air conditioning control. These differences were notably characterized by owners with incomes of 5000 RMB and below and 5001–12000 RMB scoring significantly higher than those with incomes above 12,001 RMB (See Table 9, Fig. 11).

Interestingly, regardless of whether respondents had experience using new energy vehicles, no significant differences were observed in any of the questionnaire items. Additionally, respondents of different age groups did not show significant differences in their experiences with the tested interaction methods.

5. Discussion

This section will discuss the results of the data analysis obtained in Section 4. All eta squared values in this study are between 0.01 and 0.06, indicating that all independent variables have a small to moderate effect range on the total variance of the dependent variable [62]. The following is a detailed discussion about the findings of our study.

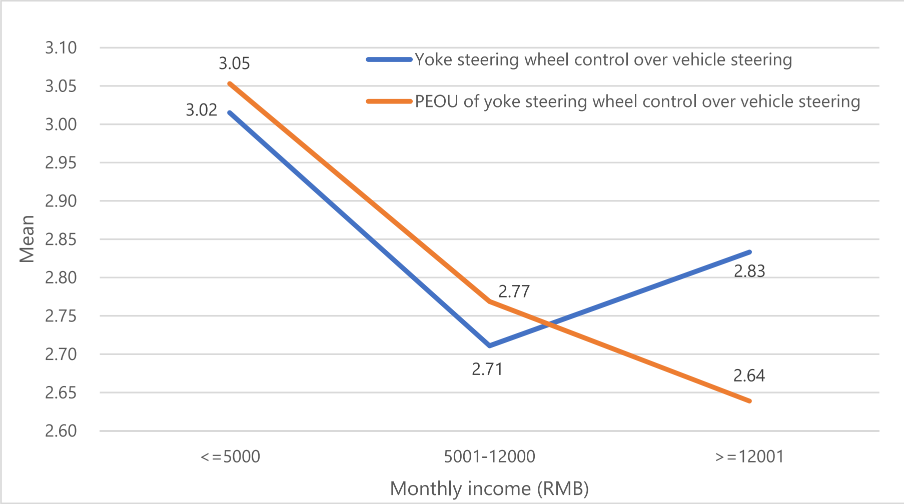

Fig. 2. ANOVA results of steering functions (Source of Variance: Monthly income).

Table 4
Independent *t*-test results of gear shift functions.

Variable	Group	Mean	Stand deviation	t	Significance (two-tailed)
SE of mechanical gear handle control over gear shift	Male	3.66	1.006	2.137	0.033
	Female	3.44	0.909		

Table 5
ANOVA results of gear shift functions.

Source of Variance		SS	df	MS	η^2	F	p	LSD post hoc
Duration of licensed driving								
SE of mechanical gear shifter control over gear shift	SS_B	7.583	2	3.791	0.021	4.087	0.018	6 years or more < 1 year or less
	SS_W	346.942	374	0.928				
	SS_T	354.525	376					
Monthly income								
Button control over gear shift	SS_B	6.491	2	3.245	0.018	3.384	0.035	12,000 and more <5000 or less
	SS_W	358.682	374	0.959				
	SS_T	365.172	376					
PEOU of button control over gear shift	SS_B	4.584	2	2.292	0.013	2.500	0.083	12,000 and more<5000 or less
	SS_W	342.943	374	0.917				
	SS_T	347.528	376					

5.1. Users' preferences and perceptions of driving functions

Survey results validation indicates that Hypotheses 1 and 2 received partial support. The results of this study suggest that there are nuanced differences in user preferences and perceptions of steering wheel design. While there was a consensus among users on the control effectiveness of various steering wheel shapes, gender differences were observed in the ease of use and self-efficacy of yoke steering wheels, highlighting the need for further exploration of ergonomic design and user interaction. Lin and Chien state that gender differences should be considered when developing automotive products [63]. This study found that both males and females scored lower on perceived ease of use of the yoke steering wheel, while there were significant gender differences in self-efficacy. Both males and females still preferred the traditional round steering wheel, and acceptance of polygonal or yoke-shaped steering wheels could be improved. People's preference for steering wheel shape presenting such results may be based on their driving experience. Of course, in addition to the shape of the steering wheel [32], the material of the steering wheel and the feel of steering [64] also influence people's preference for steering wheels. This implies that user experience differences due to different hardware design options as well as preference differences due to gender need to be considered when designing automotive steering controls. Males and females show significant differences in SE in using mechanical gear shift levers. This could be because mechanical gear shift levers often remind females of manual gear shifting mechanisms. This finding echoes earlier research in computer acceptance, which suggests that females generally display lower initial levels of self-efficacy under similar conditions [65]. Eksioglu and Kizilaslan find significantly higher absolute force and net grip force values for the male drivers in comparison to the female drivers [66]. So, designers and manufacturers

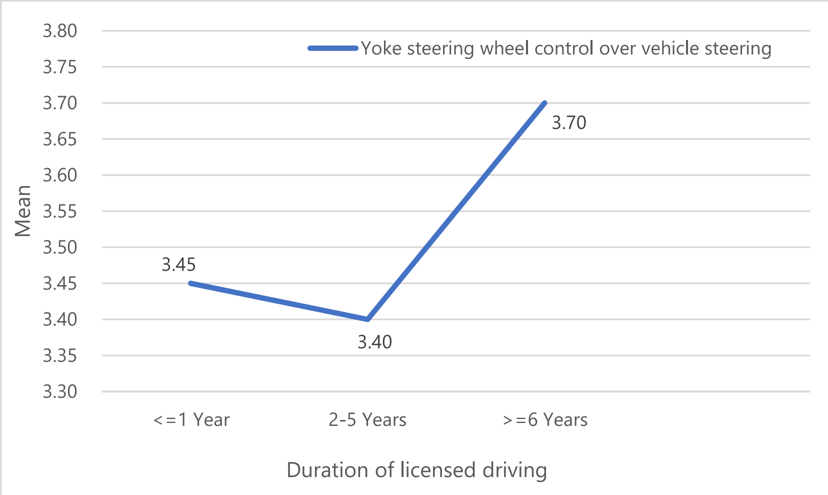

Fig. 3. ANOVA results of steering functions (Source of Variance: Duration of licensed driving).

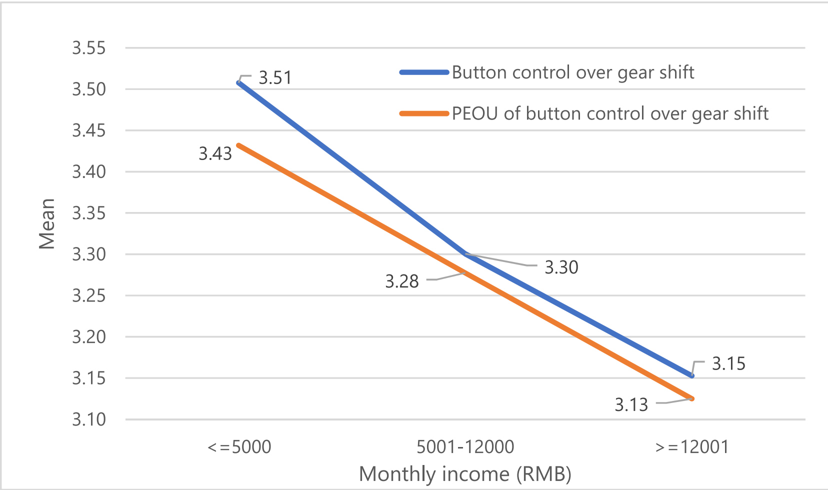

Fig. 4. ANOVA results of gear shift functions (Source of Variance: Monthly income).

Table 6
Independent *t*-test results of entertainment functions.

Variable	Group	Mean	Stand deviation	t	Significance (two-tailed)
Touch button control over music playback	Male	3.53	0.861	−2.419	0.016
	Female	3.74	0.722		
PEOU of touch button control over music playback	Male	3.52	0.903	−2.526	0.012
	Female	3.74	0.748		
Touchscreen control over music playback	Male	3.59	0.948	−2.330	0.020
	Female	3.81	0.756		
PEOU of touchscreen control over music playback	Male	3.60	0.938	−2.053	0.041
	Female	3.79	0.796		
SE of touchscreen control over music playback	Male	3.55	0.952	−2.758	0.006
	Female	3.80	0.759		
Voice control over music playback	Male	3.58	0.984	−3.540	0.000
	Female	3.91	0.759		
PEOU of voice control over music playback	Male	3.59	1.001	−3.241	0.001
	Female	3.89	0.741		
SE of voice control over music playback	Male	3.60	1.018	−3.468	0.001
	Female	3.93	0.728		

Table 7
ANOVA results of entertainment functions.

Source of Variance		SS	df	MS	η^2	F	p	Post Hoc L.S.D.
Educational level								
PEOU of touchscreen control over music playback	SS_B	4.756	2	2.378	0.016	3.073	0.047	Master or above < High school or below
	SS_W	289.409	374	0.774				
	SS_T	294.164	376					
SE of touchscreen control over music playback	SS_B	5.538	2	2.769	0.019	3.600	0.028	Master or above < (Bachelor or associate < High school or below)
	SS_W	287.634	374	0.769				
	SS_T	293.172	376					
PEOU of gesture control over music playback	SS_B	13.309	2	6.655	0.036	6.909	0.001	Master or above < (Bachelor or associate < High school or below)
	SS_W	360.245	374	0.963				
	SS_T	373.554	376					
SE of gesture control over music playback	SS_B	13.712	2	6.856	0.038	7.310	0.001	Master or above < Bachelor or associate < High school or below
	SS_W	350.802	374	0.938				
	SS_T	364.515	376					
Voice control over music playback	SS_B	8.327	2	6.655	0.027	5.151	0.006	Master or above < (Bachelor or associate < High school or below)
	SS_W	302.304	374	0.938				
	SS_T	364.515	376					
PEOU of voice control over music playback	SS_B	7.884	2	3.942	0.025	4.845	0.008	Master or above < (Bachelor or associate < High school or below)
	SS_W	304.312	374	0.814				
	SS_T	312.196	376					
Duration of licensed driving								
Touchscreen control over music playback	SS_B	4.828	2	2.414	0.017	3.172	0.043	More than 6 years < less than 1 year
	SS_W	284.609	374	0.761				
	SS_T	289.438	376					
Voice control over music palyback	SS_B	7.867	2	3.934	0.025	4.859	0.008	More than 6 years < 2–5years < less than 1 year
	SS_W	302.764	374	0.810				
	SS_T	310.631	376					
Type of driving license								
PEOU of touchscreen control over music playback	SS_B	10.597	3	3.532	0.036	4.646	0.003	A<(C1<C2)
	SS_W	283.568	373	0.760				
	SS_T	294.164	376					
SE of screen touch control over music playback	SS_B	8.567	3	2.856	0.029	3.743	0.011	A<(C1<C2)
	SS_W	284.605	373	0.763				
	SS_T	293.172	376					
Monthly income								
PEOU of touch button control over music playback	SS_B	8.731	2	4.365	0.032	6.257	0.002	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	260.951	374	0.698				
	SS_T	269.682	376					
SE of touch button control over music playback	SS_B	7.900	2	3.950	0.030	5.866	0.003	More than 12,001 < (5001–12000 < less than 5000
	SS_W	251.851	374	0.673				
	SS_T	259.751	376					
PEOU of knob control over music playback	SS_B	4.848	2	2.424	0.018	3.345	0.036	(More than 12,001 < 5001–12000) < less than 5000
	SS_W	270.988	374	0.725				
	SS_T	275.836	376					
Touchscreen control over music playback	SS_B	10.448	2	5.224	0.036	7.003	0.001	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	278.989	374	0.746				
	SS_T	289.438	376					
PEOU of touchscreen control over music playback	SS_B	10.660	2	5.330	0.036	7.031	0.001	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	283.505	374	0.758				
	SS_T	294.164	376					
SE of touchscreen over music playback	SS_B	11.382	2	5.691	0.039	7.553	0.001	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	281.791	374	0.753				
	SS_T	293.172	376					
Gesture control over music playback	SS_B	14.958	2	7.479	0.042	8.112	0.000	(More than 12,001 < 5001–12000) < less than 5000
	SS_W	344.798	374	0.922				
	SS_T	359.756	376					
PEOU of gesture control over music playback	SS_B	19.958	2	9.979	0.053	10.555	0.000	(More than 12,001 < 5001–12000) < less than 5000
	SS_W	344.798	374	0.945				
	SS_T	359.756	376					
SE of gesture control over music playback	SS_B	15.141	2	7.571	0.042	8.104	0.000	(More than 12,001 < 5001–12000) < less than 5000
	SS_W	349.373	374	0.934				
	SS_T	364.515	376					
Voice control over music playback	SS_B	5.466	2	2.733	0.018	3.349	0.036	5001-12000 < less than 5000
	SS_W	305.165	374	0.816				
	SS_T	310.631	376					
PEOU of voice control over music playback	SS_B	6.787	2	3.394	0.022	4.156	0.016	(More than 12,001 < 5001–12000) < less than 5000
	SS_W	305.409	374	0.817				
	SS_T	312.196	376					
SE of voice control over music playback	SS_B	5.179	2	2.589	0.016	3.095	0.046	5001-12000 < less than 5000
	SS_W	312.864	374	0.837				
	SS_T	318.042	376					

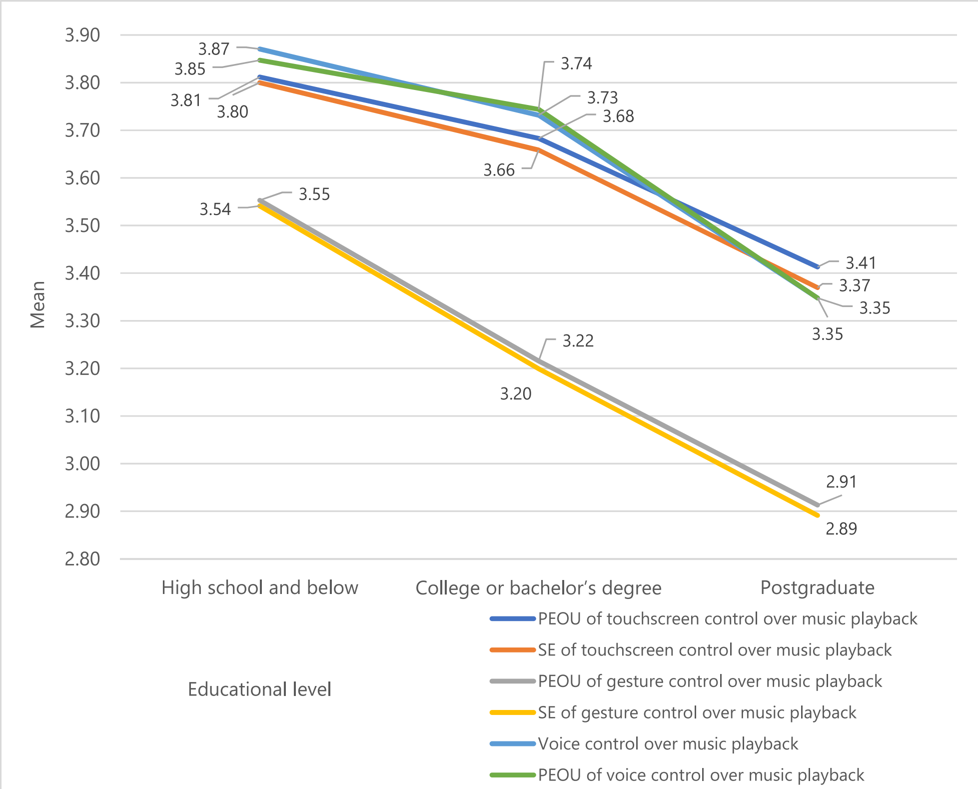

Fig. 5. ANOVA results of entertainment functions (Source of Variance: Educational level).

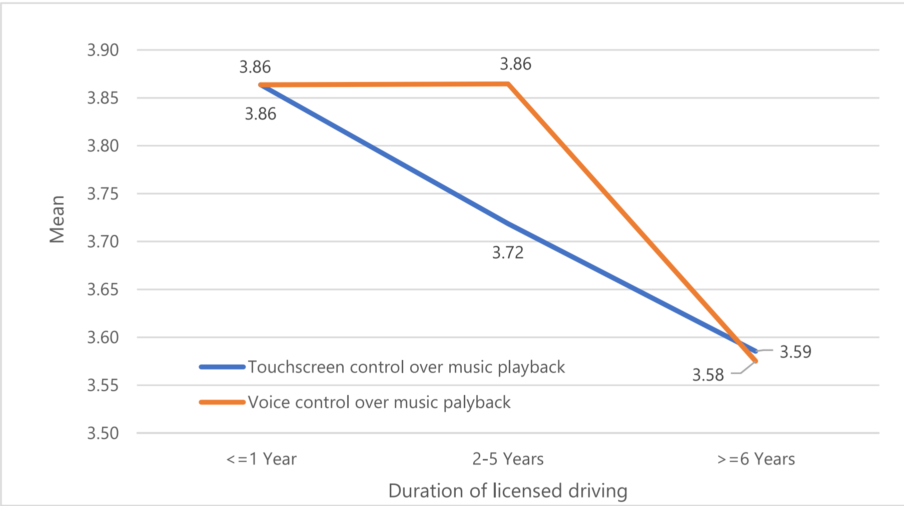

Fig. 6. ANOVA results of entertainment functions (Source of Variance: Duration of licensed driving).

should use female benchmarks as a reference when it comes to operations with higher strength requirements, thus making it easier for female users. The research by He, Lin, and Xu demonstrates that different gear shifting mechanisms align differently with various driving styles [67]. Consequently, it is essential for manufacturers to cater to diverse users by utilizing various types of gear shifting mechanisms that align with the preferences of different types of drivers. As men show higher self-efficacy with mechanical gear shift levers, manufacturers should consider incorporating mechanical gear shifting mechanisms in new energy vehicles primarily targeted at male consumers. Additionally, experienced drivers exhibit more confidence in operating mechanical gear shift levers compared to novice drivers. Shen et al. had the same argument, and they highlighted the potential benefits of button shifting for enhancing vehicle

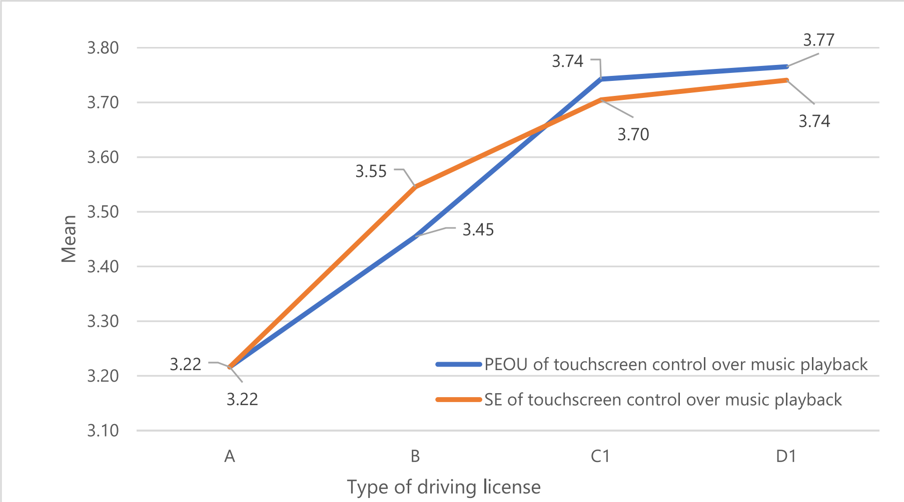

Fig. 7. ANOVA results of entertainment functions (Source of Variance: Type of driving license).

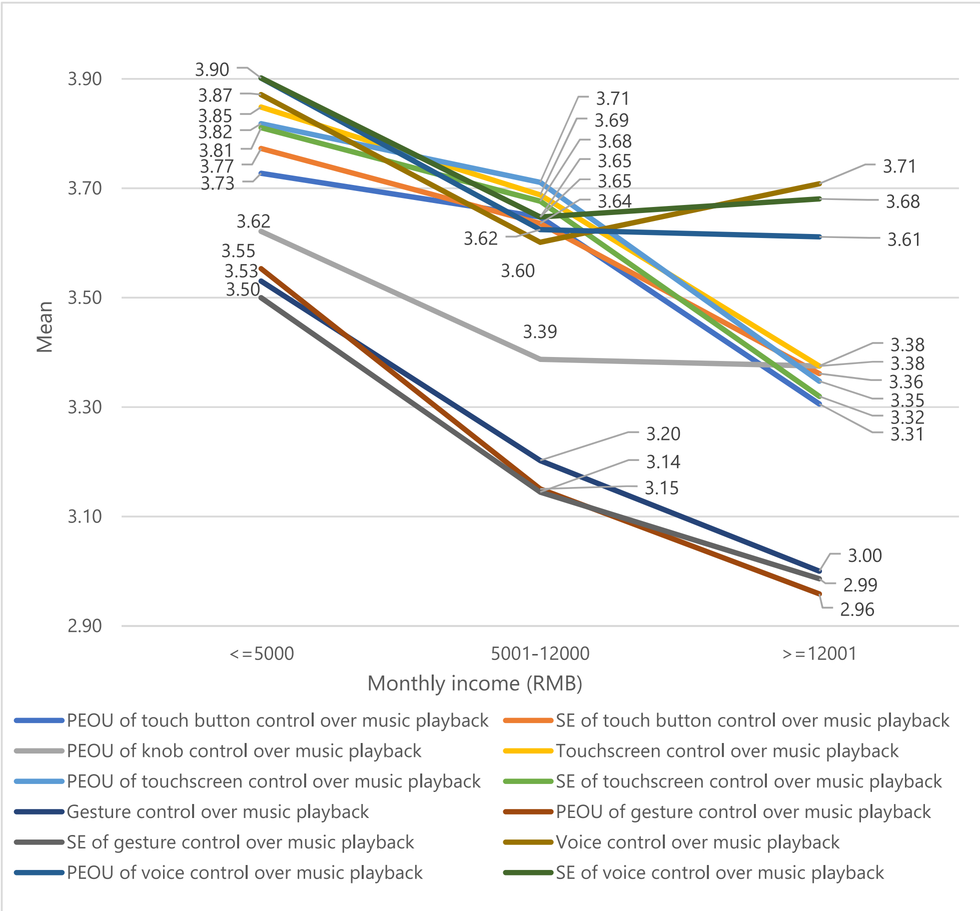

Fig. 8. ANOVA results of entertainment functions (Source of Variance: Monthly income).

handling comfort and optimizing gear shifting performance for broader market accessibility [68].

Respondents holding different types of driver's licenses showed significant differences in their preferences and perceptions of round steering wheels. The current market offers wider choices of steering wheel shapes for small vehicles, and after comparison, users still

Table 8
Independent *t*-test results of comfort functions.

Variable	Group	Mean	Standard deviation	t	Significance (two-tailed)
Touchscreen control over air conditioner	Male	3.58	0.905	−3.396	0.001
	Female	3.86	0.731		
PEU in touchscreen control over air conditioner	Male	3.59	0.924	−2.147	0.032
	Female	3.79	0.772		
SE of touchscreen control over air conditioner	Male	3.56	0.916	−2.583	0.010
	Female	3.79	0.778		
SE of voice control over air conditioner	Male	3.64	0.953	−2.426	0.016
	Female	3.86	0.813		

Table 9
ANOVA results of comfort functions.

Source of Variance		SS	df	MS	η^2	F	p	Post Hoc L.S.D.
Educational level								
SE of voice control over air conditioner	SS_B	6.347	2	3.174	0.021	3.962	0.020	Master or above < Bachelor or associate < High school or below
	SS_W	299.594	374	0.801				
	SS_T	305.942	376					
Duration of licensed driving								
Touchscreen control over air conditioner	SS_B	6.475	2	3.237	0.024	4.603	0.011	More than 6 years < 2–5 years < less than 1 year
	SS_W	263.053	374	0.703				
	SS_T	269.528	376					
Monthly income (RMB)								
Touch button control over air conditioner	SS_B	5.863	2	2.932	0.026	5.078	0.007	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	215.893	374	0.577				
	SS_T	221.756	376					
PEOU of touch button control over air conditioner	SS_B	11.857	2	5.929	0.051	10.007	0.000	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	221.581	374	0.592				
	SS_T	233.438	376					
SE of touch button control over air conditioner	SS_B	10.788	2	5.394	0.049	9.720	0.000	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	207.531	374	0.555				
	SS_T	218.318	376					
Touchscreen control over air conditioner	SS_B	7.846	2	3.923	0.029	5.607	0.004	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	261.682	374	0.700				
	SS_T	269.528	376					
PEOU of touchscreen control over air conditioner	SS_B	7.799	2	3.900	0.028	5.309	0.005	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	274.721	374	0.735				
	SS_T	282.520	376					
SE of touchscreen control over air conditioner	SS_B	7.576	2	3.788	0.027	5.153	0.006	More than 12,001 < (5001–12000 < less than 5000)
	SS_W	274.965	374	0.735				
	SS_T	282.541	376					

find round steering wheels more practical and easier to use. This also indirectly suggests that steering wheel design should primarily consider functionality. When using steering wheel designs that deviate from traditional shapes, attention must be paid to the accompanying ergonomic challenge [69]. Sadeghian Borojeni et al. also suggest that the utility of steering wheel design may not only be about shape, but also about how additional features can be integrated to assist the driver [70].

Respondents with different income levels showed significant differences in their preferences and perceptions of yoke steering wheels. This implies that new energy vehicle manufacturers need to consider functionality, performance, aesthetics, and cost-effectiveness [71] when designing in-vehicle interaction systems. In terms of PEOU for button-controlled vehicle gear shifting, respondents with incomes higher income scored significantly lower than those with lower income. This contradicts the mainstream literature's notion that lower-income individuals are laggards in technology adoption [72] and aligns with findings from Tavera-Mesías and his colleagues [73], suggesting that lower-income individuals may be more receptive to new technological applications. This study found that income level is an important factor influencing user acceptance and perceived ease of use of new steering wheel designs. For designers and manufacturers, understanding the needs and preferences of different income groups is key to optimizing product design and improving user satisfaction and market acceptance.

SE in using mechanical gear shift levers among respondents with different driving experiences. Typically, drivers with longer driving experience are also older. Arning and colleagues noted that younger people, when evaluating the usefulness of devices, consider factors beyond ease of use, such as price or value, hence may exhibit higher perceived ease of use [74].

5.2. Users' preferences and perceptions of entertainment functions

The survey results indicate partial support for Hypothesis 3. Females are more inclined than males to accept and use touch buttons, touchscreen, and voice control for music playback. This finding complements previous research that explored age differences in

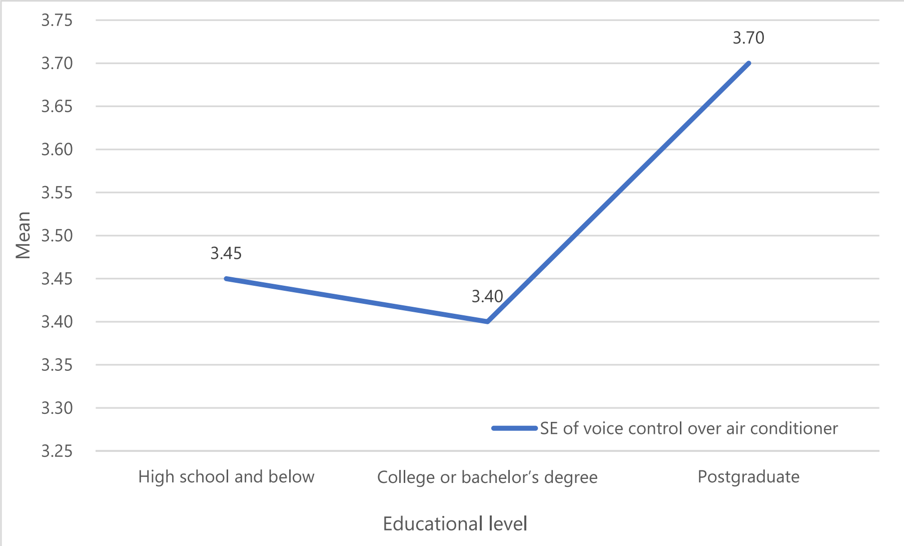

Fig. 9. ANOVA results of comfort functions (Source of Variance: Educational level).

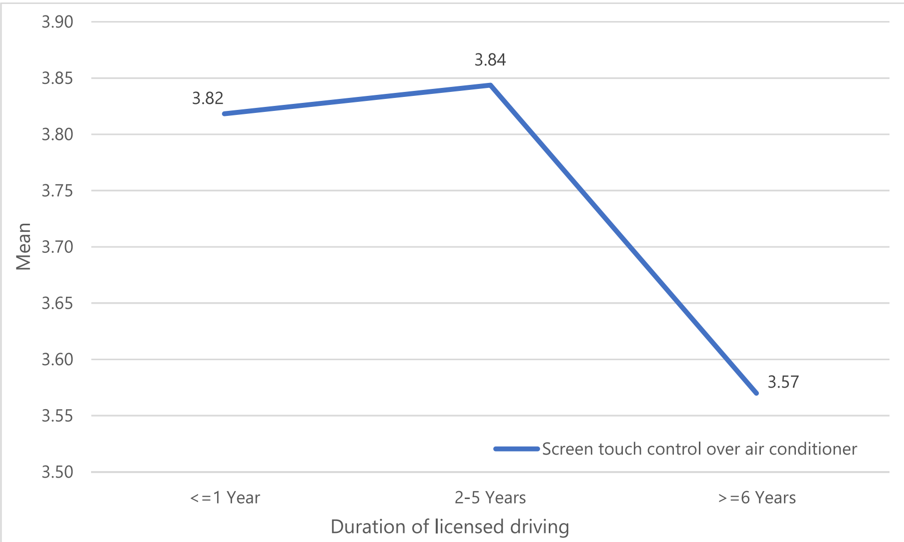

Fig. 10. ANOVA results of comfort functions (Source of Variance: Duration of licensed driving).

preferences for voice and gesture interactions [5]. Furthermore, the acceptance, perceived ease of use, and self-efficacy for using voice control to play music were significantly higher than other control methods. This is primarily due to the advancements in natural language processing technology, which have made in-vehicle voice interaction a mature technology [75]. Additionally, using voice interaction to control music playback while driving helps ensure driving safety [76].

Notably, respondents with higher educational levels showed a lower acceptance of control methods such as touch buttons, touch screens, and voice commands. This suggests that user preferences for in-vehicle interaction methods can vary notably based on their educational background. Touch-based interactions are known to affect vehicle control and prolong response times [20], while voice interactions may require multiple exchanges, impacting interaction efficiency. Both touch-based and voice interactions may cause distraction. Previous studies have shown a significant correlation between educational level and the emphasis on safety [77]. A. Juhász and M. S. Molnár emphasized phone conversations while driving, which may involve touch and voice interactions, leading to distractions that negatively impact driving safety [78]. Operating the car's center screen or other touch devices can lead to the same distraction. This supports the notion that safety concerns may underlie the lower acceptance of these technologies among users who prioritize driving safety, including those with higher education.

Users with longer driving experience tend to prefer more direct input methods for music playback control. This finding aligns with previous research that revealed the moderating role of driving experience on risk perception and dangerous driving behaviors [79].

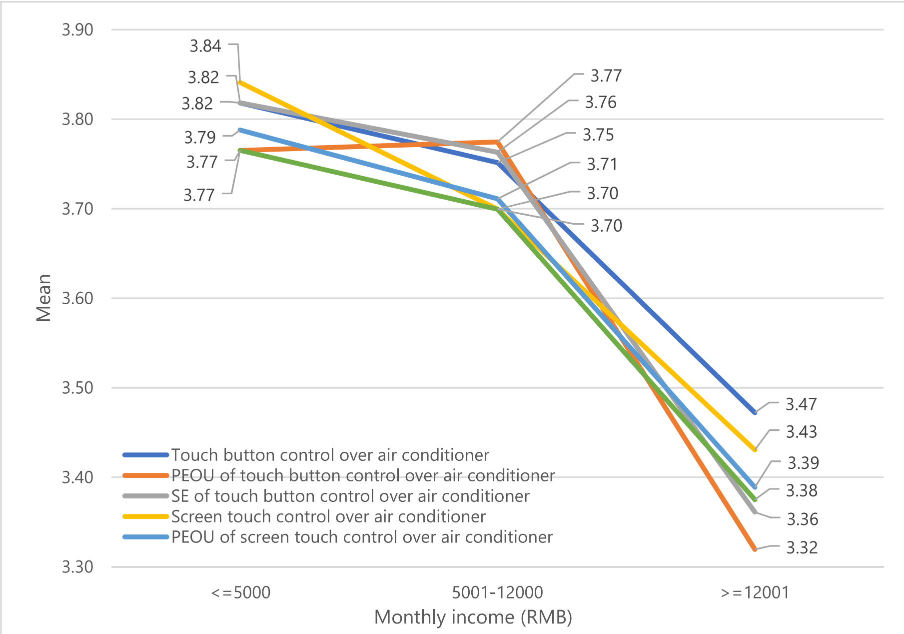

Fig. 11. ANOVA results of comfort functions (Source of Variance: Monthly income).

This study's findings align with previous research indicating that drivers of large vehicles tend to avoid inputting on touchscreens [80]. Controlling music playback through touchscreen, which sometimes involves searching for songs, can compromise safety by not providing an efficient interaction experience. Additionally, research has shown that drivers of large vehicles prefer interaction methods like knobs with displays [81].

This indicates that there are clear preference differences in in-vehicle entertainment control between low and high-income groups. Manufacturers need to carefully understand the preferences of their target audience when designing vehicles for different market segments. This finding contradicts the view that lower-income individuals are laggards in technology adoption [72] and supports the notion proposed by Tavera-Mesías and his colleagues [73] that lower-income individuals may actually be more receptive to new technological applications.

5.3. Comfort functions

The survey results indicate partial support for Hypothesis 4. This study's finding is consistent with the survey conducted by Rocha, Carneiro, & Novais (2019), which found that females outperformed males in touch decision time and duration during touchscreen interactions [82].

This study's finding suggests that users with higher educational levels may have lower acceptance of voice control for adjusting comfort functions. Research by Zhong et al. (2022) indicates that voice is a preferable input method over touch in both static and driving contexts [45]. However, this preference relies on the advancement and reliability of voice technology [83]. The results of this study could be attributed to respondents having experienced vehicles equipped with less mature voice technology, leading to their lower self-efficacy and acceptance.

This data analysis result aligns with the research results of Jing and her team [79], which revealed that drivers with longer driving experience have a sharper perception of risk. They tend to choose in-vehicle interaction input methods that are more conducive to driving safety.

Income was found to have significant association with choice of car price range [84]. Research by Duarte and Amaro indicates that focusing on low-income consumers helps in better understanding technological trends [85]. Therefore, it is essential for new energy vehicle manufacturers to pay attention to the in-vehicle interaction input method preferences of users across different price segments to better meet their needs.

Last but not least, respondents with different age and user experience with new energy vehicles showed no differences in various input methods preferences and perceptions. The study by Neuhuber, Lechner, Kalayci, Stocker, and Kubicek found differences in trust and acceptance of autonomous driving among participants of different age groups before experiencing manual driving, with the differences becoming apparent after the manual driving experience [86]. In addition, Lv and colleagues find that 'Coolness' is a fundamental factor influencing millennials' purchase intention of new energy vehicles [87]. This implies that the impact of new technologies as well as new interaction input methods on the preferences and experiences of consumers of different age groups, and even on the final purchasing decision, still needs to be examined in more depth.

6. Conclusion

Through a combination of literature review and empirical research, this study has delineated the types of in-vehicle interaction activities in car cabins in the context of the ongoing transition to intelligent driving and energy transformation. An empirical survey was conducted among users of different genders, ages, driving experiences, educational backgrounds, types of driver's licenses, and experiences with new energy vehicles. This survey successfully validated the four hypotheses proposed and revealed the input method preferences of users with different background characteristics for driving, entertainment, and comfort tasks within the cabin of new energy vehicles. The findings provide valuable insights for manufacturers to develop targeted solutions and meet the personalized needs of users in future vehicle market segments. This research contributes to a better understanding of user preferences in in-vehicle interactions, aiding in the design of more user-friendly and effective in-car systems, especially in the rapidly evolving field of new energy vehicles.

6.1. Theoretical contribution

This study, based on a literature review, categorizes the in-vehicle interaction tasks of new energy vehicle users into three main types according to their needs: driving-related tasks, comfort-related tasks, and entertainment-related tasks. This classification of interaction tasks can serve as a reference for further organizing user in-vehicle interactions in new energy vehicles. Furthermore, the study identifies and summarizes the differences in input method preferences among users with different background variables, such as gender, age, driving experience, educational background, type of driver's license, and experience with new energy vehicles, in the same interaction task scenarios. These findings not only supplement existing theories but also provide a reference for subsequent research.

6.2. Practical implications

The results of this study offer valuable insights for new energy vehicle manufacturers in terms of in-vehicle interaction design, with specific conclusions as follows:

1. In steering control of new energy vehicles, the traditional circular steering wheel remains the preferred choice among users. In terms of steering function design, it is necessary to focus on the control of the steering wheel and convenient operation, followed by fun [88].
2. Users with different genders, driving experiences, monthly incomes, and types of driving licenses have varying preferences for vehicle driving control functions. However, there are no significant differences in preferences based on educational level, age, and experience with new energy vehicles. Manufacturers should focus on differences in gender, vehicle price, and specifications when designing driving control functions.
3. Users with different genders, educational levels, driving years, types of driving licenses, and income levels have different preferences for entertainment function controls. Females prefer more diversified forms of entertainment control, while users with higher education, longer driving experience, large vehicle driving licenses, and higher income levels tend to prefer simple and traditional forms of entertainment control.
4. Users with different genders, educational levels, driving experiences, and income levels have varied preferences for comfort function control forms [89,90]. Females favor more diversified comfort control forms, whereas those with higher education, longer driving experience, and higher income lean towards simple and traditional forms.

In summary, for vehicle driving control forms, new energy vehicle manufacturers should adopt traditional and conservative strategies. Vehicles targeted at females and entry-level markets can opt for bolder designs in entertainment and comfort function controls. In contrast, vehicles aimed at driving performance, high-end, and luxury segments should stick to basic and traditional entertainment and comfort function controls. The conclusions of this study can provide guidance for manufacturers in designing the interiors of new energy vehicles.

6.3. Limitations and future research

There are still some limitations in this study. Firstly, all the samples in this study are from Chinese consumers, which may reduce the reference value of the research results when applied to other markets. Future studies can expand the sample size and introduce respondents from other markets. Secondly, this study was conducted during a period of pandemic lockdown, and the results of online surveys may not be as accurate as feedback obtained through offline experiences and communication. Therefore, future research can consider setting up experimental scenarios and inviting respondents to experience before conducting surveys, which can enhance the accuracy of communication and the reliability of the results. Finally, this study did not consider regional differences among respondents, user experience differences caused by different hardware [91], as well as differences in roles between drivers and passengers in the design phase. Subsequent research can further explore whether regional differences and roles of respondents will lead to differences in preferences for in-vehicle interaction input methods of new energy vehicles.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Ethics statement

This study was conducted according to the guidelines of the Declaration of Helsinki and received academic ethics review and approval from the review committee of the Ministry of Social Science, Changshu Institute of Technology. Our experiments informed consent was obtained from all participants and all methods were performed per relevant guidelines and regulations.

CRediT authorship contribution statement

Weibo Sun: Software, Formal analysis, Conceptualization. **Yanan Wang:** Methodology, Investigation. **Wei Miao:** Writing – review & editing, Investigation, Formal analysis. **Wei Wei:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Chao Gu:** Writing – original draft, Software.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:Wei reports financial support was provided by Jiangsu Education Department Philosophy and Social Sciences Projects of Higher Education, grant number 2022SJYB1508. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e33376.

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