Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

How stylized digital interfaces shape emotional value, self-expression and continuance intention in intelligent vehicles

Bo Liu
Shanghai Jiao Tong University
Xinliu Wu
Shanghai Jiao Tong University
Xinlei Ma
Shanghai Jiao Tong University
Jingyan Yang
rogersyoung@foxmail.com

Tongji University
Lei Dai
Hubei Institute of Fine Arts
Jie Zhang
Macao Polytechnic University

Article

Keywords:

Posted Date: September 29th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10586977/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

This study examines the impact of stylized in-vehicle human-machine interfaces (HMI) on drivers' emotional experience and willingness to continue usage. A theoretical model was constructed with six latent variables: perceived novelty, personalization affordances, aesthetic quality, perceived enjoyment, self-expression, and continuance intention. Analysis of 174 valid questionnaires revealed that perceived enjoyment plays a crucial mediating role in promoting the continued use of entertaining dashboards, especially when personalization enhances enjoyment. Moreover, perceived novelty, personalization affordances, and aesthetic quality indirectly affect continuance intention through perceived enjoyment. Notably, self-expression does not mediate the relationship between perceived novelty and continuance intention.

1 Introduction

The main function of human-machine interfaces (HMIs) in vehicles is to facilitate driving or assist in communication with autonomous systems. With advances in autonomous driving, the focus is shifting from driving functions to enhancing the user experience through emotive and intelligent cockpits, which offer comfortable, interactive environments for passengers. Thus, interface design is not just a communication tool but also a key factor in shaping users' emotional experiences (Wang et al., 2024; Jiang et al., 2024; Wang and Wang, 2023). In Human-Computer Interaction (HCI) research, interface stylization has been identified as a significant factor influencing the user's emotional experience. In the context of this study, a stylized interface is defined as an HMI design that incorporates visual elements derived from cultural themes or artistic features, transcending a purely functional presentation. The study by Wu et al. (2015), which compared skeuomorphic and flat design styles for in-vehicle navigation interfaces, found that the user's emotional experience is primarily composed of three dimensions: Stylization Cognition, Affective Cognition, and Decorative Cognition. Among these, the Stylization Cognition Factor (SCF) encompasses evaluative dimensions such as "traditional–modern," "common–unique," "old–novel," and "ugly–beautiful," which directly reflect the user's perception of the interface's novelty, uniqueness, and aesthetic characteristics. Their research demonstrates that stylization is not merely a visual design choice but one that significantly impacts the user's emotional response and overall experience.

Stylized interfaces fulfill emotional needs by providing immediate emotional impact, making the system appealing from the first interaction (Zhou et al., 2022). Features such as UI design and digital avatars can significantly affect the in-car experience. Therefore, stylized design must maintain customization, novelty, and aesthetic quality to evoke strong emotional responses. Personalization enhances system relevance to users, improving emotional engagement by meeting their specific needs (Fan and Poole, 2006). For example, NIO's NOMI voice assistant facilitates communication by identifying and locating sound sources within the car and responding with listening expressions. Fang et al. (2021) highlight that incorporating trust and emotional expression into personalized in-car assistants is an important trend, although current approaches need further development to address emotional needs and build trust.

Research also shows that novelty significantly enhances user interest and engagement. Novel designs spark curiosity and exploration, improving the overall experience (Fiore et al., 2005). For instance, immersive VR technology boosts user satisfaction and increases their willingness to continue using the technology (Talukdar and Yu, 2021). Audi's Holoride VR entertainment, which synchronizes with car movements, transforms driving into a physical game (Kemeny, 2023).

Aesthetic quality is another crucial factor influencing car HMI systems and user experience. The interface's visual appeal often shapes first impressions upon entering the vehicle (Ma and Gong, 2024). In a study on mobile websites, Cyr et al. (2006) found that visual quality significantly impacts users' perceptions of system usability, ease of use, and enjoyment. High aesthetic quality designs effectively communicate driving behaviors and decision-making, building trust.

Different stylized interfaces can significantly influence users' emotional experiences. Research shows that design elements like symmetry and complexity affect emotional arousal and valence (Wang and Wang, 2023). In recent years, scholars have conducted in-depth research on the user experience of in-vehicle HMIs. For instance, Jiang et al. (2024) validated the significant role of interface novelty and aesthetic design on users' continuance intention, while Wang and Wang (2023) emphasized the key value of personalization and emotional experience in enhancing user satisfaction. These studies have laid a solid foundation for understanding the relationship between in-vehicle interaction design and user behaviors. However, existing frameworks still exhibit a theoretical gap in explaining why users are willing to continue using these systems: most studies tend to treat emotional experience as a monolithic construct, such as "satisfaction" or "overall affect," failing to differentiate between emotional value pathways of distinct natures and thereby overlooking deeper psychological mechanisms.

To address this gap, we distinguish the interface's emotional value into two types: immediate enjoyment in use and deeper self-identification. The contribution of this paper lies in incorporating both types of experiences into our model to more comprehensively understand how in-vehicle HMIs affect users' continuance intention. The first is the Hedonic Path, which reflects the fun and sensory pleasure afforded by the interface through perceived enjoyment (PE); the second is the eudaimonic path, which reveals the interface's function as an extension of the user's identity construction and values through self-expression (SE). In particular, the explicit inclusion of self-expression in the model represents the core innovative contribution of this paper: it highlights that the in-vehicle HMI is no longer merely a functional tool but is evolving into a platform for users to manifest their individuality and affirm their identity. This deep-seated psychological need may be the key factor driving long-term user loyalty and continuance intention.

2 Literature review and research framework

The research model in this paper is constructed around the core characteristics of entertaining in-vehicle HMIs, with a focus on examining design-level input variables and user-level emotional mediating variables. First, for the input variables, we selected perceived novelty (PN), personalization affordances

(PA), and aesthetic quality (AQ). These three constructs form the key pillars that distinguish stylized interfaces from traditional functional ones: PN reflects the interface's appeal in terms of innovation and differentiation, stimulating user curiosity and exploratory motives; PA embodies the interface's customizability and user-centric features, endowing users with a sense of control and belonging; and AQ represents the standard of the interface's sensory presentation and craftsmanship, directly influencing the user's first impression and emotional resonance. Therefore, combining these three factors allows for a comprehensive capture of the unique design characteristics of stylized interfaces. Second, for the mediating variables, this paper introduces perceived enjoyment (PE) and self-expression (SE) to reveal the dual pathways of the emotional connection between the user and the entertaining HMI. Specifically, PE represents the immediate, hedonic experience—the direct fun and pleasure gained during the interaction. In contrast, SE represents a deeper, eudaimonic experience—the sense of meaning derived from conveying one's identity, taste, and values through the interface. Compared to previous research that often simplifies emotional experience into a single dimension, examining both PE and SE provides a more complete and in-depth revelation of the psychological mechanisms that drive continuance intention for entertaining HMIs.

2.1 Stylized interface design

Stylized interface design uses unique visual styles and design elements to give the interface personality and aesthetic appeal (Xi and Wu, 2018). In addition to adhering to general interface design principles such as consistency and usability, stylized interface design typically employs unique colors, fonts, and icon designs to create distinctive visual effects (e.g., retro or futuristic styles). Stylized interface design is often applied in game interfaces, creative applications, and certain brand websites to enhance immersion or to highlight the artistic and unique qualities of the product or brand (Tarafdar et al., 2019).

2.1.1 Perceived novelty

Perceived novelty (PN) refers to the user's subjective perception of the innovativeness and uniqueness of an experience or technology, implying that when experiencing a technology, the user feels a significant difference from their prior experiences, thereby generating a new sense of experience (Talukdar and Yu, 2021). Perceived novelty can stimulate users' curiosity and desire for exploration, making them feel excited and pleased during the experience (Fiore et al., 2005). According to Flow Theory, proposed by Csikszentmihalyi and Csikzentmihaly (1990), when users are immersed in a novel and challenging experience, they are more likely to enter a state of "flow," in which they feel great satisfaction and pleasure and are willing to continue the activity. For instance, in immersive virtual reality contexts, users are more likely to describe their experience as novel, different, and unique due to higher levels of interactivity and vividness, which generates a stronger sense of novelty (Talukdar and Yu, 2024). A novel experience can trigger an individual's intrinsic motivation, potentially allowing them to feel a stronger sense of autonomy and competence when exploring and accepting new things (González-Cutre et al., 2016). Furthermore, novel experiences may trigger discussions and interactions among users, which not

only enhances their sense of engagement but can also reinforce the effect of self-expression through feedback from others (Terras et al., 2015).

In the context of in-vehicle HMI research, perceived novelty is often leveraged to enhance the user experience through the introduction of novel interaction modalities. Augmented Reality (AR) interfaces, due to their ability to directly integrate virtual cues with the real driving environment, are considered a highly novel design approach. Research indicates that AR-HMIs can enhance the driver's situational awareness and sense of trust by highlighting environmental features, predicting future states, and communicating system intent, thereby improving the human-vehicle collaboration experience (You et al., 2025). Of course, this novelty can be a double-edged sword: if interface elements are overly complex or the information load is too great, it can lead to attentional distraction and cognitive interference, thereby reducing safety. However, a novel interface will inevitably become familiar to drivers and passengers with frequent use. Indeed, the enhancing effect of novel elements on user engagement is typically short-lived, diminishing after a few weeks due to habituation (Lee et al., 2025; Long et al., 2024). Consequently, the experience it affords is often a short-term surprise, and its influence on long-term factors such as identity affirmation and self-expression is likely to be weaker. Based on the above, this study proposes the following hypotheses:

• **Hypothesis 1**

• (H1): Perceived novelty (PN) can positively influence perceived enjoyment (PE).

• **Hypothesis 2**

• (H2): Perceived novelty (PN) can positively influence self-expression (SE).

2.1.2 Personalization affordances

Personalization changes a system's functionality, interface, information access, content, or originality to make it more relevant to an individual or group (Fan and Poole, 2006). Personalization affordances (PA) means the extent to which a product or thing can be customized or personalized by the user. Lambillotte et al. (2022) noted that people must perceive material as individualized to appreciate it subjectively, while actual personalization affects objective satisfaction. Personalized content can directly influence perceived enjoyment, thereby indirectly affecting users' intention for continuous use (Liu et al., 2021). The research by Shi et al. (2024) indicates that personalizing a product aesthetically or functionally can enhance its personal relevance for users and support their self-expression. In the context of autonomous driving HMIs, personalization not only enhances user experience and satisfaction but also plays a critical role in building trust and increasing acceptance (Florentino and Aquino-Junior, 2025). In recent years, the design of in-vehicle HMIs has increasingly emphasized personalization and adaptive functionalities. Modern vehicles commonly support the automatic adjustment of interface layouts, displayed information, and interaction modes based on user profiles to meet individual preferences. Such designs not only improve driving comfort and satisfaction but also enhance safety by reducing

unnecessary cognitive load. For example, a vehicle can dynamically adjust the presentation of navigation information or the simplicity of the interface based on the driver's historical usage habits, thereby achieving an interaction experience that is both familiar and efficient (Grobelna et al., 2025). Therefore, this study proposes the following two hypotheses:

• **Hypothesis 3**

• (H3): Personalization affordances (PA) can positively influence perceived enjoyment (PE).

• **Hypothesis 4**

• (H4): Personalization affordances (PA) can positively influence self-expression (SE).

2.1.3 Aesthetic quality

The term "aesthetics" comes from the Greek word "aesthesis," meaning sensory perception, which evolved to denote sensory satisfaction and pleasure (Hekkert, 2006). Beyond functionality, product aesthetics influence meaning and experience. Playful designs enhance enjoyment, even in non-play tasks (Legaard et al., 2020). Sosa-Tzec (2019) suggests that design pleasure lies at the intersection of aesthetics, semiotics, and rhetoric. Aesthetic design elements not only improve functionality but also boost self-esteem and social value, serving as an important form of self-expression (Byun et al., 2018). Research links visual aesthetic sensitivity with personality traits (Myszkowski et al., 2014; Cleridou and Furnham, 2014). Aesthetic experiences also contribute to self-identity and promote a healthy quality of life (Yu and Wang, 2018). Early HMI design primarily emphasized safety, efficiency, and usability, but as research progressed, "usability" was gradually extended to the broader concept of user-friendliness, which also incorporates aesthetic factors. Images and graphics can quickly attract user attention; therefore, the rational use of graphical elements in an interface can not only improve the perceivability of information but also optimize the interaction experience (Cimini et al., 2024). The aesthetic design of In-Vehicle Infotainment (IVI) systems has gradually become a key factor influencing users' continuance intention. Previous research focused more on usability, safety, and functionality, but with the increasing number of in-vehicle screens and the problem of interface homogenization, aesthetics have emerged as an important dimension for differentiation and enhancing the user experience (Jiang et al., 2025). Therefore, this study proposes the following two hypotheses:

• **Hypothesis 5**

• (H5): Aesthetic quality (AQ) can positively influence perceived enjoyment (PE).

• **Hypothesis 6**

• (H6): Aesthetic quality (AQ) can positively influence self-expression (SE).

2.2 Emotional value

Emotional value encompasses the emotional appeal of a product or service to consumers, which can influence their purchase attitudes and behaviors. Enhancing users' emotional experiences in HMI design can boost satisfaction and system utilization. The design of in-vehicle HMIs is not only concerned with functional operation and safety but also profoundly influences the driver's emotional experience. One of the key development trends for future intelligent vehicles is precisely the emotional experience, where the interface directly acts upon user emotions through its functional layout, visual effects, and interactive behaviors (Huo et al., 2023). As noted by DuFord (2017), emotional value connects users to their past through memories and emotions. This connection can bring about a deeper emotional experience during interactions with the HMI system, thereby increasing users' dependence on and satisfaction with the system. Additionally, the irreducibility of emotional value indicates that emotional design is not merely about adding functionality to the system, but also about enhancing user experience by eliciting emotional resonance. Through personalized interface themes, ambient light regulation, voice feedback, and bio-sensing-driven interactions, vehicles can establish a stronger emotional connection with the driver. The review by Grobelna et al. (2025) mentions that concept cars like Audi's "AI:ME" and systems such as Volvo's Driver Understanding System are already attempting to use AI to perceive user emotions and mitigate driving anxiety by adjusting ambient lighting, music, or information prompts. Therefore, incorporating emotional value into HMI design can effectively enhance users' willingness to use the system. This view is consistent with evidence that emotions can operate as both antecedents and outcomes of technology acceptance (Lu et al., 2019).

2.2.1 Perceived enjoyment

In the study by Hung et al. (2016), perceived enjoyment (PE) is defined as users' subjective evaluation during interactions with technology, specifically manifested through three dimensions: concentration, enjoyment, and curiosity. Perceived curiosity is typically embedded in some aspect of physical reality and is triggered by external stimuli. Curiosity can stimulate users' desire to explore the system, thereby increasing their willingness to use it (Hung et al., 2016). Research shows that there is a positive correlation between perceived enjoyment and users' attitudes toward using technology. Perceived enjoyment refers to the extent to which an activity is considered interesting and pleasurable, playing a crucial role in enhancing user engagement and motivation (Codish and Ravid, 2014). Therefore, this study proposes the following hypothesis:

• **Hypothesis 7**

• (H7): Perceived enjoyment (PE) can positively influence continuance intention (CI).

2.2.2 Self-expression

Self-expression (SE) refers to the behavior of individuals showcasing their inner world, values, and personality through various means such as language, behavior, art, and culture. This expression is not

limited to face-to-face communication but can also be realized through various media, including social media, writing, music, and art.

Digital identity provides a platform for showcasing and expressing oneself, allowing users to display their personality and build personal brands by sharing their interests, opinions, and life experiences. This freedom and expressiveness can enhance users' sense of engagement and belonging, thereby increasing their willingness to use the platform (Çöteli, 2019). In multimodal HMI design, the system should not only recognize user emotions but also consider how to support the user in leveraging the interface as a platform for self-expression; for instance, through mechanisms such as customizable themes, ambient lighting, and interactive tones that reflect their personal identity and preferences (Cui et al., 2024).

Web 2.0 technologies support diverse forms of content production, such as images, videos, and text, offering users rich means for self-expression that cater to different needs and preferences. At the same time, users need to actively manage their digital identities, which not only affects how they are perceived by others but also influences their online behaviors and interactions (Terras et al., 2015). Therefore, this study proposes the following hypothesis:

• **Hypothesis 8**

• (H8): Self-expression (SE) can positively influence continuance intention (CI).

2.3 Continuance intention

Continuance intention (CI) refers to an individual's intention to continue using a particular information system or technology after the initial acceptance and use of the system or technology. Bhattacherjee (2001) was the first to define CI as "the intention of an individual to continue using an information system (as opposed to initial use or acceptance)." Yan et al. (2021) summarized various factors influencing continuance intention, classifying them into four main categories: psychological, technological, social, and behavioral factors. Among these, psychological factors include satisfaction, overall attitude, and perceived enjoyment, which refers to the pleasure experienced while using the system; social factors include subjective norms and perceived critical quality, which pertains to the influence of society or groups on the user's decision to continue using the system. Researching and understanding the factors affecting continuance intention can help increase users' long-term usage rates and ensure the sustained success of the system or technology.

Based on the above literature review, Fig. 1 illustrates the eight research hypotheses and the research framework of this study.

3 Methods

3.1 Questionnaire design

Table 1
Constructs and items of the continuance intention of entertaining in-vehicle HMI application.

Constructs	Items	Descriptions	References
Aesthetic quality (AQ, reflective variable)	AQ1	Everything goes together on this interface.	Moshagen and Thielsch (2013)
	AQ2	The layout is pleasantly varied.	
	AQ3	The colour composition is attractive.	
	AQ4	The layout appears professionally designed.	
Personalization affordances (PA, reflective variable)	PA1	The car system allows me to personalize the in-car interface.	Luo et al. (2023)
	PA2	I used the app to set up a personalized in-car interface.	
	PA3	I was able to find a personalized interface in the app that meets my preferences.	
Perceived novelty (PN, reflective variable)	PN1	I found using the entertaining in-vehicle instrumentation application to be a novel experience.	Wells et al. (2010)
	PN2	Using the entertaining in-vehicle instrumentation application is new and refreshing.	
	PN3	Unlike traditional interfaces, the entertaining dashboard interface represents a new way of presenting in-vehicle information.	
Perceived enjoyment (PE, reflective variable)	PE1	I think it’s interesting to use an entertaining in-car interface.	Hsu and Chiu (2004)
	PE2	I think using the entertaining in-vehicle instrumentation application is enjoyable.	
	PE3	I think using the entertaining in-vehicle instrumentation application is exciting.	
	PE4	I think using the entertaining in-vehicle instrumentation application is fun.	

Constructs	Items	Descriptions	References
Self-expression (SE, reflective variable)	SE1	I feel that a personalized in-car HMI can express my personality.	Davis (2013)
	SE2	I like to experiment with different personalized interfaces to express my preferences, mood or aesthetics, etc.	
	SE3	I'll show my customised and personalised interface to my fellow passengers.	
Continuance intention (CI, dependent variable)	CI1	I would be inclined to use a car system with an entertaining in-car interface.	Davis (1989; Roca et al. 2006; Rauschnabel et al. 2017)
	CI2	I would introduce or demonstrate the features of this entertaining in-vehicle interface to my fellow passengers.	
	CI3	If I own a car, I want it to have entertaining in-car interface apps.	

To test the hypotheses and theoretical model proposed in this study and take into account the characteristics of entertaining in-vehicle dashboard applications and their interface designs, all measurement scales and methods used in this survey were adjusted and modified based on existing literature. This study used a two-part questionnaire. The first part includes demographic characteristics of the respondents, such as gender, age, and driving experience. The second part uses a 7-point Likert scale to examine elements affecting in-vehicle dashboard entertainment intention. The item sources include established measures of visual aesthetics and technology-related enjoyment and acceptance (Moshagen and Thielsch, 2013; Hsu and Chiu, 2004).

At the start of the questionnaire, we explained its goal, showed the app's operating scenario and some interface presets (see Fig. 2), and explained the entertaining app's features and interaction techniques. Our team created stylized interfaces for Chinese vehicle manufacturers with vacation, gastronomy, and landscape themes.

Additionally, we emphasized that the survey data obtained would be used solely for academic research, and the respondents' personal information would remain anonymous. After completing the initial draft of the survey questionnaire, the study first invited 120 participants for a pre-test. Furthermore, opinions from two experts in the relevant field were solicited. Based on the feedback received, we adjusted the number of questions and modified the wording of the items. A reference for the questionnaire items is shown in Table 1.

3.2 Sample and data collection

Table 2
Demographic information of respondents.

Sample	Category	Frequency	Percentage(%)
Gender	Male	80	45.98
	Female	94	54.02
Age	18–23	14	8.05
	24–29	50	28.74
	30–35	66	37.93
	36–41	31	17.82
	42–48	13	7.47
Occupation	Private enterprises	82	47.13
	State-owned enterprises	28	16.10
	Foreign-funded enterprises	23	13.22
	Freelancers	5	2.87
	Students	14	8.05
	Civil servants	9	5.17
	Professionals (doctors, lawyers, etc.)	13	7.47
Driving experiences	< 1 year	19	10.92
	1–3 years	21	12.07
	> 3 years	134	77.01

To ensure the reliability and representativeness of the study, we conducted detailed data collection and processing. This study used the PowerCX Questionnaire System Platform to recruit online respondents. In the one-week online survey, 208 questionnaires were collected. The research was conducted in mainland China, and all respondents were recruited in mainland China.

The questionnaire included an irrelevant attention check question ("The weather is nice today," select "4"). This ensured respondents were paying attention and answering meaningfully. Inattentive respondents who chose other numbers were omitted from analysis. We also removed questionnaire data with unusually short responses or identical replies. After screening, 174 valid questionnaires remained, corresponding to a valid-response rate of 83.65% (174/208). Table 2 shows respondent demographics.

The 24 to 35 age group accounted for the highest proportion of respondents, and private sector workers represented the largest occupational group. Notably, 77.01% of the respondents had more than three years of driving experience.

4 Data analysis and results

4.1 Measurement model

This study employed partial least squares structural equation modeling (PLS-SEM) using SmartPLS 4.0 to analyse the research model. PLS-SEM was selected because this study aims to predict key endogenous constructs, including perceived enjoyment, self-expression and continuance intention, and to examine a model involving multiple latent variables and mediating paths. PLS-SEM is also suitable for exploratory research and is less restrictive with respect to multivariate normality. All constructs in this study were specified as reflective measurement models. PLS-SEM builds on latent-variable soft modeling and is widely used for prediction-oriented behavioral research and the estimation of complex latent-variable relationships (Wold, 1975; Fornell and Bookstein, 1982; Chin et al., 2003; Lowry and Gaskin, 2014).

First, we evaluated the measurement model. This study examined the reliability, convergent validity, and discriminant validity of the constructs in the proposed model, and tested for common method variance (CMV). Specifically, Harman's single factor test (Podsakoff et al., 2003) was employed to address this issue. The total variance extracted by the first factor was 49.75%, below the 50% threshold (Podsakoff et al., 2003). Additionally, the study calculated the variance inflation factors (VIF) for all latent constructs to check for the risk of multicollinearity, with results all below the threshold value of 3.0 (Sarstedt et al., 2021). These findings indicate that CMV bias does not significantly affect the analysis results.

Table 3 shows that all constructs proposed in this study met reliability standards (Cronbach, 1951) because their composite reliability (CR) (Bagozzi and Yi, 1988; Urbach and Ahlemann, 2010) and Cronbach's alpha coefficients exceeded 0.7. Aesthetic quality, personalization affordances, perceived novelty, perceived enjoyment, self-expression, and continuance intention all had Cronbach's alphas of 0.839, 0.701, 0.742, 0.819, 0.776, and 0.766, respectively. The constructs in this study are adequate and have acceptable internal consistency reliability.

Table 3
Scales for reliability and validity of measurement model.

Constructs	Items	FL	α	CR	AVE
Aesthetic quality	AQ1	0.838	0.839	0.892	0.675
	AQ2	0.772			
	AQ3	0.845			
	AQ4	0.830			
Personalization affordances	PA1	0.747	0.701	0.834	0.627
	PA2	0.834			
	PA3	0.791			
Perceived novelty	PN1	0.784	0.742	0.853	0.660
	PN2	0.852			
	PN3	0.800			
Perceived enjoyment	PE1	0.769	0.819	0.880	0.648
	PE2	0.828			
	PE3	0.802			
	PE4	0.820			
Self-expression	SE1	0.860	0.776	0.870	0.691
	SE2	0.817			
	SE3	0.815			
Continuance intention	CI1	0.820	0.766	0.865	0.681
	CI2	0.810			
	CI3	0.846			

Convergent validity is assessed by average variance extracted (AVE) and factor loadings in Table 3. All elements exceeded the 0.7 factor loading criterion (Fornell and Larcker, 1981). The study found that the AVE for each construct exceeded 0.50, indicating that the underlying constructs explain over half of the variance observed in the items, indicating good convergent validity (Henseler et al., 2009; Schumacker and Lomax, 2004).

The square root of the AVE should exceed the highest correlation with any other construct (see the diagonal parts of the correlation matrix in Table 4) for discriminant validity, according to Fornell and

Larcker (1981). Table 4 further shows that all items' cross-loadings on their variables imply high discriminant validity of the scale.

Therefore, the test results show that this study's final scale is reliable, valid, and discriminatory.

Table 4
Discriminant validity and correlation matrix.

AQ	AQ	CI	SE	PA	PE	PN
	0.822					
CI	0.711	0.825				
SE	0.657	0.809	0.831			
PA	0.662	0.757	0.765	0.792		
PE	0.672	0.814	0.747	0.736	0.805	
PN	0.745	0.664	0.655	0.686	0.677	0.813

4.2 Structural model and hypothesis test

The second phase involved assessing the structural model (Henseler et al., 2009) using SmartPLS 4.0 and the bootstrapping method. We evaluated the model's predictive capability, path coefficients, R^2, and Stone-Geisser Q^2 (Hair Jr et al., 2016). As shown in Fig. 3 and Table 5, the PLS algorithm results yielded R^2 values for perceived enjoyment, self-expression, and continuance intention of 0.618, 0.632, and 0.754, respectively, all above 0.20, demonstrating strong explanatory power (Ajamieh et al., 2016).

Table 5
Results of hypothesis testing.

DV	Hypothesis	Path	R^2	β	p	Result	Q^2
PE	H1	PN → PE	0.618	0.203	0.021**	Supported	0.603
	H3	PA → PE		0.448	< 0.001**	Supported	
	H5	AQ → PE		0.225	0.008**	Supported	
SE	H2	PN → SE	0.632	0.138	0.149ⁿ/□	Not supported	0.616
	H4	PA → SE		0.540	< 0.001**	Supported	
	H6	AQ → SE		0.197	0.015*	Supported	
CI	H7	PE → CI	0.754	0.473	< 0.001**	Supported	0.633
	H8	SE → CI		0.456	< 0.001**	Supported	

Note: DV = dependent variable; GoF = 0.67; SRMR = 0.065. All hypotheses are supported except H2. The Q^2 values of 0.603, 0.616 and 0.633 for perceived enjoyment, self-expression and continuance intention, respectively, are above the acceptable zero threshold (Hair Jr et al., 2016), indicating good predictive capability for these dependent variables.

The R^2 value for perceived enjoyment is 0.618, indicating that 61.8% of its variance is explained by its predictors. Significant positive effects on perceived enjoyment are observed from perceived novelty ($\beta = 0.203,\ \mathrm{p} = 0.021$), personalization affordances ($\beta = 0.448,\ \mathrm{p} < 0.001$), and aesthetic quality ($\beta = 0.225,\ \mathrm{p} = 0.008$). For self-expression, personalization affordances ($\beta = 0.540,\ \mathrm{p} < 0.001$) have the largest impact, followed by aesthetic quality ($\beta = 0.197,\ \mathrm{p} = 0.015$), while perceived novelty ($\beta = 0.138,\ \mathrm{p} = 0.149$) has no significant impact. For continuance intention, both perceived enjoyment ($\beta = 0.473,\ \mathrm{p} < 0.001$) and self-expression ($\beta = 0.456,\ \mathrm{p} < 0.001$) have significant positive effects. These results support most hypotheses, except H2.

The model's predictive capability was further tested using PLSpredict, with Q^2 values for perceived enjoyment, self-expression, and continuance intention of 0.603, 0.616, and 0.633, respectively, all exceeding the zero threshold (Hair Jr et al., 2016), indicating good predictive capability.

The model's fit was also assessed using the Goodness of Fit (GoF) and Standardized Root Mean Square Residual (SRMR). The GoF value was 0.67, surpassing the medium effect size threshold of 0.25, and the SRMR value was 0.065, below the acceptable threshold of 0.08 (Hu and Bentler, 1999), confirming an acceptable model fit.

Table 6
Specific indirect effects.

Path	O	M	STDEV	|O/STDEV|	p	VAF (%)
PN → PE → CI	0.096	0.098	0.045	2.149	< 0.001**	60.38
PN → SE → CI	0.063	0.065	0.044	1.417	0.157ⁿ/□	39.62
PA → PE → CI	0.212	0.209	0.049	4.338	< 0.001**	46.29
PA → SE → CI	0.246	0.245	0.053	4.645	< 0.001**	53.71
AQ → PE → CI	0.106	0.106	0.042	2.509	0.012*	54.08
AQ → SE → CI	0.090	0.088	0.040	2.221	0.026*	45.92
Note: O = original sample; M = sample mean; STDEV = standard deviation; |O/STDEV| = T statistic.						

Table 6 presents the Variance Accounted For (VAF), which indicates the strength of indirect (mediating) effects. VAF values above 20% and below 80% suggest partial mediation (Hair Jr et al., 2016).

The results show that perceived enjoyment significantly mediates the relationship between perceived novelty and continuance intention, with a VAF of 60.38%. It also mediates the effects of personalization affordances and aesthetic quality on continuance intention, with VAFs of 46.29% and 54.08%, respectively. However, self-expression mediates these effects as well but does not mediate the relationship between perceived novelty and continuance intention ($p = 0.157$).

In summary, perceived enjoyment serves as a more crucial mediator than self-expression in the indirect effects of personalization affordances and aesthetic quality on continuance intention. Additionally, the indirect pathway from perceived novelty to continuance intention through self-expression was not significant.

5 Discussions

This study enriches the understanding of how specific design characteristics of stylized interfaces impact user emotional experience and behavior. The proposed model between in-car HMI design features and user emotional experience considers stylized interface design factors (aesthetic quality, personalization affordances, and perceived novelty) and their impact on users' continuance intention. It also examines the mediating role of users' perceived emotional value in this influence relationship. The data analysis results from the online questionnaire indicate that most of the hypotheses proposed in this study were supported, providing support for the proposed model within the present sample.

5.1 Interface design features and emotional value

The main purpose of an infotainment in-car instrument application is to provide fundamental functional needs, but entertainment's emotional value also affects consumers' continued use. Entertainment-

oriented interfaces for this application differ from typical HMI in style and appearance. These artistically designed or culturally themed interfaces give a unique user experience and are entertaining.

Research by Pantano and Di Pietro (2012) has already found that interesting ways of presenting information can positively impact perceived enjoyment. On the basis that the vehicle information can be intuitively and effectively received by the driver, unique interface design elements such as icon styles, graphics, colors, or overall styles, compared to traditional or commonly seen in-car HMIs, exhibit higher novelty. The novelty of the interface indeed has a direct positive impact on users' perceived enjoyment (H1 is supported). This finding is consistent with Jiang et al. (2024), who discovered that various selectable interfaces bring a sense of novelty to users, enhancing the appeal of in-car interfaces and improving user experience from an emotional perspective.

Personalization affordances are added to the application by offering many interface designs. In certain personalization research, Byun et al. (2018) evaluated how design-driven consumers express their personal and social identities through product design and how this affects brand loyalty. According to their questionnaire analysis, socially identity-driven consumers are more inclined to employ individualized designs for self-expression. Similar conclusions have been found in research on wearable devices, where personalization promotes effective interaction between users and products, leading to higher satisfaction and a positive impact on continuance intention (Sergueeva et al., 2020).

Choosing interface defaults based on aesthetics is like customizing smartphone or computer themes. A user-defined interface shows that the product belongs to the user and reflects their taste, preferences, personality, and mood. Having a selected interface preset in the infotainment in-car HMI application and customized interface settings improves playability and user satisfaction. Thus, personalization affordances positively affect self-expression and perceived enjoyment (H3 and H4 are supported), with the direct effect on self-expression being more significant ($0.540 > 0.448$).

Notably, our findings indicate that perceived novelty did not have a significant direct effect on self-expression (H2: $\beta = 0.138,\ p = 0.149$). We propose a two-fold explanation for this result. Firstly, within our model, although both perceived enjoyment and self-expression fall under the umbrella of emotional value, they can be further conceptualized as representing hedonic and eudaimonic value, respectively. Hedonic value is associated with pleasure, excitement, enjoyment, and novelty, whereas eudaimonic value relates to personal growth, self-realization, meaningfulness, and authentic self-expression (Mekler and Hornbæk, 2019). Therefore, as a trigger for hedonic value, the influence of perceived novelty naturally flows towards perceived enjoyment—a construct within the same hedonic dimension—but struggles to cross over to the eudaimonic dimension of self-expression, which is centered on meaning and identity construction. Secondly, we argue that perceived novelty is a cognitive appraisal of a system's external attributes (e.g., an unprecedented visual style), which aligns more with a passive "experience." In contrast, self-expression is an active, volitional behavior—an exercise of agency—aimed at manifesting one's personal identity and individuality. Consequently, merely presenting a novel design to a user does not, in itself, constitute a complete act of self-expression. This interpretation is

strongly supported when we contrast the non-significant result of H2 with the significant findings for H4 and H6. Personalization affordances demonstrated the strongest predictive power on self-expression (H4: $\beta = 0.540$), illustrating that the crux of self-expression lies in whether the system grants users the power to choose and define. The intrinsic motivation for self-expression is to satisfy the user's need for uniqueness (Tian et al., 2001). Therefore, passively experiencing a novel interface provided by the system is insufficient. A valid act of self-expression is only completed when users can autonomously select a unique option that they desire. This powerfully explains why personalization affordances strongly predicts self-expression while perceived novelty does not: personalization affordances empowers users to fulfill their need for uniqueness, whereas perceived novelty merely offers a novel experience.

Finally, aesthetic quality had a significant direct impact on both perceived enjoyment and self-expression (H5 and H6 were supported), though this influence was not as strong as that of perceived novelty and personalization affordances. On one hand, semiotics and cockpit ergonomics research has proven that users can readily grasp and use infotainment in-car interface features with reasonable icon styles, colors, locations, and spacing. The strong association between colors and emotional value has been confirmed by many studies (Hsiao and Tsai, 2015; Issa and Isaias, 2022). On the other hand, Professionally developed interfaces are consistent, have a coherent visual appeal, have fine details, and have outstanding overall texture. And interfaces with varied styles or themes provide interactive effects and aural feedback to enhance the user's emotional experience. Researchers have found that visual quality increases cognitive, emotional, and behavioral involvement with items (Bazi et al., 2023). Thus, even if drivers don't notice every element, these design features enhance user experience by evoking emotional resonance (Jiang et al., 2024).

The significant positive impact of aesthetic quality on self-expression may be due to the fact that high aesthetic quality content can enhance users' momentary experience in the corresponding context, triggering situational interest (Brom et al., 2018; Harackiewicz and Hulleman, 2010; Wong and Adesope, 2021). Consequently, users are inclined to choose certain interfaces to express their emotions in that context. Viewed this way, what drives user self-expression is not how novel the interface is, but rather the process through which users autonomously select an aesthetically pleasing interface to manifest their sense of self. In essence, perceived novelty serves as a catalyst for creating an enjoyable experience, whereas the realization of self-expression is more dependent on the empowerment afforded by personalization and an identification with aesthetic value.

5.2 Emotional value and user's behaviour

The analysis of the direct impact on continuance intention reveals that both perceived enjoyment and self-expression have significant effects, supporting H7 and H8. However, perceived enjoyment has a more substantial impact ($0.473 > 0.456$). This finding aligns with the understanding that emotional experiences can significantly influence how humans use technology or products (Hassenzahl, 2018; Lu et al., 2019).

Self-expression has a relatively small direct effect on the intention to continue using compared to perceived pleasure, probably because passengers pay less attention to the interface design and drivers lack an audience that appreciates their personalized expression. However, just as people like to have different wallpapers on their phones or computers, personalization features can satisfy users' self-expression needs and provide them with hedonic value.

Perceived enjoyment, or hedonic value, is highly correlated with the continuance intention to use a specific product (Hong et al., 2017). This observation is consistent with previous research by Hung et al. (2016), which asserts that perceived enjoyment positively influences users' attitudes toward using technology.

Finally, regarding perceived enjoyment and self-expression, which both contribute to emotional value, they are distinct in nature yet complementary. Perceived enjoyment pertains to the pleasure of experiencing the product, serving the user's hedonic needs, whereas self-expression serves the user's perception of self through the product, belonging to the eudaimonic dimension centered on meaning and identity construction. A synergistic effect may also exist between them: an interface that facilitates a high degree of self-expression might, in turn, be perceived as more enjoyable, thereby enhancing perceived enjoyment. Conversely, a highly enjoyable interface could motivate users to invest more time in exploration, particularly of its personalization capabilities, thus fostering self-expression. It is also plausible that perceived enjoyment and self-expression jointly enhance user stickiness: perceived enjoyment provides immediate gratification that encourages continued use, while self-expression helps forge a unique connection between the user and the system. A minor limitation of our model, however, is that it did not quantify the influence and relationship between perceived enjoyment and self-expression.

5.3 Design Implications

In our research model, personalization affordances have the most significant positive impact on self-expression, a finding that is widely supported across numerous digital interaction domains. From the customization of social media profiles and the creation of avatars in online games to the personalization of themes and layouts on smartphones, users consistently leverage personalization options to construct and express their digital identities. The intimate relationship between product personalization and self-expression is a universal phenomenon (Grant et al., 2013; Shi et al., 2024). For the design of personalization affordances in in-vehicle HMIs, future efforts should move beyond merely allowing users to select from predefined themes. Instead, a more intelligent personalization system should be constructed, particularly one that leverages artificial intelligence to deliver personalized experiences based on the user's perceived emotional state (Chen et al., 2025). This system could offer deeper, more modular customization options to satisfy users' finer-grained needs for self-expression, for example, by allowing users to independently modify various interface modules—akin to assembling LEGO bricks—including instrument cluster modes, color schemes, and information widgets. The interface could also dynamically adapt to the external environment or user state, making the personalized interface feel more alive, and could even permit users to integrate personal elements, such as their own photos, into the HMI. Furthermore, optimizing the user experience during the personalization setup process is another

crucial aspect of fulfilling these needs. For instance, incorporating multimodal interactions, such as voice and gestures, could lower the operational cost of customization; users could be allowed to browse, design, and configure their HMI via a companion mobile app, which then syncs with the in-vehicle system; and with the aid of AI, the system could learn user preferences and proactively offer personalized recommendations. Moreover, a future personalization system could even enable users to create and save their own multi-sensory scenario modes. For example, users could design a mode that includes their favorite music, lighting, and fragrances. This form of holistic, multi-modal customization that creates an overall atmosphere—going beyond just the visual interface—has already been implemented in features like BMW's "Caring Car" and Mercedes-Benz's "Energizing" functions (Braun et al., 2021).

The finding that aesthetic quality has a significant positive impact on both perceived enjoyment and self-expression aligns with established principles in UX/UI design. Beyond the automotive cockpit, interfaces with a high standard of aesthetic quality—whether in web design, mobile apps, or wearable devices—consistently elicit more positive emotional feedback and are often perceived by users as an extension of their personal taste. In his work, Hassenzahl (2018) distinguishes between the pragmatic and hedonic qualities of a product, where aesthetics are a key component of hedonic qualities capable of enhancing the user experience.

Although in-vehicle HMIs are continually evolving, their core function remains that of a tool for accomplishing the driving task. Driving is a safety-critical activity that demands significant cognitive resources. Unlike platforms such as social media, which afford long-term, immersive content creation, interaction in the automotive context is often fragmented and shallow. In such a scenario, the primary objectives of user-interface interaction are efficiency and safety. While a novel interface can enhance perceived enjoyment, the additional cognitive effort required to interpret and adapt to it may inhibit deeper, more reflective self-expression activities. The role of novelty in design elements, therefore, likely tends more towards servicing the user experience—that is, making the tool more enjoyable to use—rather than facilitating the user's identity construction. The review by Braun et al. (2021) also notes that the goal of influencing user emotions is to restore a safe driver state, not to satisfy their desire for self-expression. Ultimately, therefore, both aesthetic quality and perceived novelty should be constrained by personalization affordances; the degree of freedom and diversity in an HMI's aesthetic quality and novelty must be reasonably controlled. This is key to ensuring that the final personalized HMI is both safe and usable.

6 Limitations

This study makes valuable theoretical contributions; however, it has several limitations. First, all participants are mainland Chinese users in this regional study. Future research should move beyond mere cross-regional comparisons and adopt a more theoretically grounded research design. For example, by adopting the theoretical lens of Hofstede (2001), a comparative study could be conducted between users from a collectivist culture (such as the Chinese sample in this study) and those from an

individualist culture (such as the United States or Western European countries). Expanding the sample size accordingly would enable a more comprehensive examination of how user experiences with entertaining in-vehicle HMI systems vary across different cultural and ideological backgrounds. Such research is poised to reveal the cultural contingency of self-expression within the automotive HMI context. Secondly, this study operates at a macro level. While we examined the influence of high-level constructs like aesthetic quality and personalization affordances on continuance intention, our work does not delve into the granular level of specific design details. For instance, we did not investigate how low-level design attributes—such as specific color combinations, information density, or graphical styles—affect users' emotional value and continuance intention. Finally, our sample was skewed towards experienced drivers, with 77% of participants possessing three or more years of driving experience. This potentially limits the generalizability of our findings to novice drivers or users in regions with lower exposure to advanced vehicle technologies. This highlights that a comparative study on HMI design for experienced versus novice drivers remains a valuable avenue for future research.

Nevertheless, this study opens up several promising avenues for future investigation. We suggest that future work should extend beyond the current focus on "static" interface styles to investigate dynamic and adaptive interfaces; develop methodologies and evaluation metrics to quantify the cognitive load imposed by highly stylized, novel, or dynamic interfaces; and explore how the user needs for personalization and self-expression might evolve in the context of highly automated driving.

7 Conclusion

The results of this study reveal that perceived novelty, personalization affordances, and aesthetic quality all influence users' emotional experiences with entertaining in-vehicle HMI applications, particularly in terms of perceived enjoyment and self-expression. Personalization affordances had the strongest effect on both perceived enjoyment and self-expression, whereas perceived novelty did not significantly affect self-expression. In predicting continuance intention, perceived enjoyment showed a slightly stronger effect than self-expression. Perceived enjoyment significantly mediated the effects of perceived novelty, personalization affordances, and aesthetic quality on continuance intention, whereas self-expression mediated the effects of personalization affordances and aesthetic quality, but not the effect of perceived novelty.

Declarations

Competing interests

The authors declare no competing interests.

Ethical statements

This study was conducted in accordance with applicable ethical standards and relevant national and institutional regulations. All participants were appropriately informed of the study's purpose, procedures, voluntary nature, anonymity, and intended use of the data. Electronic informed consent was obtained from all participants before they completed the online questionnaire. Ethical approval was obtained from the Institutional Review Board for Human Research Protections of Shanghai Jiao Tong University under reference number 20260032I. All research was performed in accordance with the Declaration of Helsinki and all applicable ethical guidelines.

Author Contribution

Conceptualization, B.L. and X.M.; methodology, B.L., X.W. and X.M.; formal analysis, B.L., X.W. and X.M.; investigation, B.L., X.W. and X.M.; writing—original draft preparation, B.L., X.W. and X.M.; writing—review and editing, X.W., J.Y., L.D. and J.Z.; supervision, J.Y., L.D. and J.Z. All authors have read and agreed to the published version of the manuscript.

Data Availability

All de-identified data and documentation underpinning the findings are provided to the editors and reviewers as the Supplementary Data package accompanying this revised submission. The package contains: (i) the raw survey dataset (208 records); (ii) the processed dataset (198 records); (iii) the final 174-case dataset containing the 21 measurement items used for SmartPLS model estimation; (iv) the questionnaire items, scale sources, variable definitions, coding and data-processing documentation; (v) the SmartPLS project, settings, PLS algorithm, bootstrapping and PLSpredict output files; and (vi) the common-method-variance analysis output. Recruitment, the attention check and exclusion criteria are described in Section 3.2. The shared files contain no directly identifying personal information.

References

1. Ajamieh A, Benitez J, Braojos J, Gelhard C (2016) IT Infrastructure and Competitive Aggressiveness in Explaining and Predicting Performance. J Bus Res 69(10):4667–4674
2. Bagozzi RP, and Youjae Yi (1988) On the Evaluation of Structural Equation Models. J Acad Mark Sci 16:74–94
3. Bazi S, Filieri R, and Matthew Gorton (2023) Social Media Content Aesthetic Quality and Customer Engagement: The Mediating Role of Entertainment and Impacts on Brand Love and Loyalty. J Bus Res 160:113778
4. Bhattacherjee A (2001) Understanding Information Systems Continuance: An Expectation-Confirmation Model. MIS Q, 351–370
5. Braun M, Weber F, and Florian Alt (2021) Affective Automotive User Interfaces–Reviewing the State of Driver Affect Research and Emotion Regulation in the Car. ACM Comput Surv (CSUR) 54(7):1–26

6. Brom C, Starkova T, Sidney K, D'Mello (2018) How Effective Is Emotional Design? A Meta-Analysis on Facial Anthropomorphisms and Pleasant Colors During Multimedia Learning. Educational Res Rev 25:100–119
7. Byun K-A, Kay RP, Jones, and Barbara Ross Wooldridge (2018) It Is Not Always about Brand: Design-Driven Consumers and Their Self-Expression. J Retailing Consumer Serv 43:296–303
8. Chen X, Wang X et al (2025) Cong Fang,. Emotion-Aware Design in Automobiles: Embracing Technology Advancements to Enhance Human-Vehicle Interaction. *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, 1–18
9. Chin WW, Barbara L, Marcolin, Peter RN (2003) A Partial Least Squares Latent Variable Modeling Approach for Measuring Interaction Effects: Results from a Monte Carlo Simulation Study and an Electronic-Mail Emotion/Adoption Study. Inform Syst Res 14(2):189–217
10. Cimini C, Freti E, and Alexandra Lagorio (2024) Design and Test of a Human-Machine Interface for Assembly Lines in a Learning Factory. IFAC-PapersOnLine 58(19):73–78
11. Cleridou K, and Adrian Furnham (2014) Personality Correlates of Aesthetic Preferences for Art, Architecture, and Music. Empir Stud Arts 32(2):231–255
12. Codish D, and Gilad Ravid (2014) Academic Course Gamification: The Art of Perceived Playfulness. Interdisciplinary J E-Learning Learn Objects 10(1):131–151
13. Çöteli S (2019) *The Impact of New Media on the Forms of Culture: Digital Identity and Digital Culture*
14. Cronbach LJ (1951) Coefficient Alpha and the Internal Structure of Tests. Psychometrika 16(3):297–334
15. Csikszentmihalyi M (1990) and Mihaly Csikzentmihaly. *Flow: The Psychology of Optimal Experience*. Vol. 1990. Harper & Row New York
16. Cui J, Wang Y (2024) and Hongwei Xiao. Research on HMI Interaction Design Scheme Based on Multimodal. *2024 International Conference on Electronics and Devices, Computational Science (ICEDCS)*, 919–24
17. Cyr D, Head M, Ivanov A (2006) Design Aesthetics Leading to m-Loyalty in Mobile Commerce. Inf Manag 43(8):950–963
18. Davis FD (1989) Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Q 319–340. https://doi.org/10.2307/249008
19. Davis K (2013) Young People's Digital Lives: The Impact of Interpersonal Relationships and Digital Media Use on Adolescents' Sense of Identity. Comput Hum Behav 29(6):2281–2293. https://doi.org/10.1016/j.chb.2013.05.022
20. DuFord R (2017) An Expanded Conception of Sentimental Value. J Value Inq 51:1–11
21. Fan H, and Marshall Scott Poole (2006) What Is Personalization? Perspectives on the Design and Implementation of Personalization in Information Systems. J Organizational Comput Electron Commer 16(3–4):179–202

22. Fang Y, Chen J (2021) and Zaixing Liu. Research on Emotional Interaction Carriers of Driving Assistants in Service Scenarios of Self-Driving Automobiles. *2021 International Symposium on Artificial Intelligence and Its Application on Media (ISAIAM)*, 36–42
23. Fiore AM, Jin H-J, Kim J (2005) For Fun and Profit: Hedonic Value from Image Interactivity and Responses Toward an Online Store. Psychol Mark 22(8):669–694
24. Florentino André, Luiz (2025) and Plinio Thomaz Aquino-Junior. Adaptive Human-Machine Interaction for Autonomous Passenger Vehicles: Towards Personalization and Enhanced User Experience. *2025 Brazilian Conference on Robotics (CROS)* 1: 1–6
25. Fornell C, Fred LB (1982) Two Structural Equation Models: LISREL and PLS Applied to Consumer Exit-Voice Theory. J Mark Res 19(4):440–452
26. Fornell C, David FL (1981) Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. J Mark Res 18(1):39–50
27. González-Cutre D, Álvaro, Sicilia AC, Sierra R, Ferriz, Martin SH (2016) Understanding the Need for Novelty from the Perspective of Self-Determination Theory. *Personality and Individual Differences* 102: 159–69
28. Grant K, Straker K, Muller C, and Cara Wrigley (2013) The Search for Individualism: Self-Expression Through Product Personalisation. Int J Designed Objects 6(1):17–29
29. Grobelna I, Mailland D, Mikołaj, Horwat (2025) Design of Automotive HMI: New Challenges in Enhancing User Experience, Safety, and Security. Appl Sci 15(10):5572
30. Hair F Jr, Tomas G, Hult M, Ringle C, Sarstedt M (2016) A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM) Sage Publications. *Thousand Oaks, CA, USA*
31. Harackiewicz JM, Chris SH (2010) The Importance of Interest: The Role of Achievement Goals and Task Values in Promoting the Development of Interest. Soc Pers Psychol Compass 4(1):42–52
32. Hassenzahl M (2018) The Thing and i: Understanding the Relationship Between User and Product. Funology 2: Usability Enjoyment, 301–313
33. Hekkert P (2006) Design Aesthetics: Principles of Pleasure in Design. Psychol Sci 48(2):157
34. Henseler Jörg, Ringle CM, Rudolf RS (2009) The Use of Partial Least Squares Path Modeling in International Marketing. In New Challenges to International Marketing. Emerald Group Publishing Limited
35. Hofstede G (2001) Culture's Consequences: Comparing Values, Behaviors, Institutions and Organizations Across Nations. Int Educational Prof
36. Hong J-C, Lin P-H, and Pei-Chi Hsieh (2017) The Effect of Consumer Innovativeness on Perceived Value and Continuance Intention to Use Smartwatch. Comput Hum Behav 67:264–272
37. Hsiao S-W, Cheng-Ju Tsai (2015) Transforming the Natural Colors of an Image into Product Design: A Computer-Aided Color Planning System Based on Fuzzy Pattern Recognition. Color Res Application 40(6):612–625. https://doi.org/10.1002/col.21929

38. Hsu M-H, Chao-Min C (2004) Internet Self-Efficacy and Electronic Service Acceptance. Decis Support Syst 38(3):369–381. https://doi.org/10.1016/j.dss.2003.08.001
39. Hu Li-tze, Peter MB (1999) Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. Struct Equation Modeling: Multidisciplinary J 6(1):1–55
40. Hung S-Y, Tsai JC-A, Shin-Tzu Chou (2016) Decomposing Perceived Playfulness: A Contextual Examination of Two Social Networking Sites. Inf Manag 53(6):698–716. https://doi.org/https://doi.org/10.1016/j.im.2016.02.005
41. Huo F, Zhao Y, Chai C, Fang F (2023) A User Experience Map Design Method Based on Emotional Quantification of in-Vehicle HMI. Humanit Social Sci Commun 10(1):1–10
42. Issa T, and Pedro Isaias (2022) Usability and Human–Computer Interaction (Hci). Sustainable Design: HCI, Usability and Environmental Concerns. Springer. https://doi.org/10.1007/978-1-4471-6753-2_2.
43. Jiang Q, Liyuan Deng, and, Zhang J (2024) How Dose Aesthetic Design Affect Continuance Intention in in-Vehicle Infotainment Systems? An Exploratory Study. Int J Human–Computer Interact, 1–16
44. Jiang Q, Deng L, Zhang J (2025) How Does Aesthetic Design Affect Continuance Intention in in-Vehicle Infotainment Systems? An Exploratory Study. Int J Human–Computer Interact 41(1):429–444
45. Kemeny A (2023) On-Board Virtual Reality and Applications. Autonomous Vehicles and Virtual Reality: The New Automobile Industrial Revolution. Springer
46. Lambillotte L, Magrofuoco N, Poncin I, and Jean Vanderdonckt (2022) Enhancing Playful Customer Experience with Personalization. J Retailing Consumer Serv 68:103017
47. Lee J, Chen C (2025) and Aryabrata Basu. From Novelty to Knowledge: A Longitudinal Investigation of the Novelty Effect on Learning Outcomes in Virtual Reality. *IEEE Transactions on Visualization and Computer Graphics*
48. Legaard J, Falck et al (2020) Designing Aesthetics for Play (Fulness). *DS 101: Proceedings of NordDesign 2020, Lyngby, Denmark, 12th-14th August 2020*, 1–12
49. Liu H, Shao M, Liu X, and Li Zhao (2021) Exploring the Influential Factors on Readers' Continuance Intentions of e-Book APPs: Personalization, Usefulness, Playfulness, and Satisfaction. Front Psychol 12:640110
50. Long, Tao KI, Gero, Lydia BC (2024) Not Just Novelty: A Longitudinal Study on Utility and Customization of an AI Workflow. *Proceedings of the 2024 ACM Designing Interactive Systems Conference*, 782–803
51. Lowry PB, and James Gaskin (2014) Partial Least Squares (PLS) Structural Equation Modeling (SEM) for Building and Testing Behavioral Causal Theory: When to Choose It and How to Use It. IEEE Trans Prof Commun 57(2):123–146
52. Lu Y, Papagiannidis S, and Eleftherios Alamanos (2019) Exploring the Emotional Antecedents and Outcomes of Technology Acceptance. Comput Hum Behav 90:153–169

53. Luo Y, Yang L, Ye Q, and Qichen Liao (2023) Effects of Customization and Personalization Affordances on Perceived Value and Continuance Intention of Smartwatch Use. Technol Forecast Soc Chang 194:122752. https://doi.org/10.1016/j.techfore.2023.122752
54. Ma J, and Zaiyan Gong (2024) Aesthetics. Automotive Human-Machine Interaction (HMI) Evaluation Method. Springer
55. Mekler ED, Hornbæk K (2019) A Framework for the Experience of Meaning in Human-Computer Interaction. *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, 1–15
56. Moshagen M, and Meinald Thielsch (2013) A Short Version of the Visual Aesthetics of Websites Inventory. Behav Inform Technol 32(12):1305–1311. https://doi.org/10.1080/0144929X.2012.694910
57. Myszkowski N, Storme M, Zenasni F, and Todd Lubart (2014) Is Visual Aesthetic Sensitivity Independent from Intelligence, Personality and Creativity? Pers Indiv Differ 59:16–20
58. Pantano E, and Loredana Di Pietro (2012) Understanding Consumer's Acceptance of Technology-Based Innovations in Retailing. J Technol Manage Innov 7(4):1–19
59. Podsakoff PM, Scott B, MacKenzie J-Y, Lee, Nathan PP (2003) Common Method Biases in Behavioral Research: A Critical Review of the Literature and Recommended Remedies. J Appl Psychol 88(5):879
60. Rauschnabel PA, Alexander Rossmann, Claudia tom M, Dieck (2017) An Adoption Framework for Mobile Augmented Reality Games: The Case of Pokémon Go. Comput Hum Behav 76:276–286. https://doi.org/10.1016/j.chb.2017.07.030
61. Roca JC, Chiu C-M, Francisco JoséMartínez (2006) Understanding e-Learning Continuance Intention: An Extension of the Technology Acceptance Model. Int J Hum Comput Stud 64(8):683–696. https://doi.org/10.1016/j.ijhcs.2006.01.003
62. Sarstedt M, Ringle CM, Joseph FH (2021) Partial Least Squares Structural Equation Modeling. In Handbook of Market Research. Springer
63. Schumacker RE, Richard GL (2004) A Beginner's Guide to Structural Equation Modeling. Psychology
64. Sergueeva K, Shaw N, and Seung Hwan Lee (2020) Understanding the Barriers and Factors Associated with Consumer Adoption of Wearable Technology Devices in Managing Personal Health. Can J Administrative Sciences/Revue Canadienne Des Sci de l'Administration 37(1):45–60
65. Shi Y, Peng Y, Dang S, Zhao N (2024) and Nan Cao. Personalizing Products with Stylized Head Portraits for Self-Expression. *Proceedings of the CHI Conference on Human Factors in Computing Systems*, 1–18
66. Sosa-Tzec O (2019) Design Delight: An Experiential Quality Framework. *UNIDCOM/IADE International Conference Senses & Sensibility*, 169–80
67. Talukdar N, and Shubin Yu (2021) Breaking the Psychological Distance: The Effect of Immersive Virtual Reality on Perceived Novelty and User Satisfaction. J Strategic Mark, 1–25

68. Talukdar N, and Shubin Yu (2024) Breaking the Psychological Distance: The Effect of Immersive Virtual Reality on Perceived Novelty and User Satisfaction. J Strategic Mark 32(8):1147–1171
69. Tarafdar P, Leung ACM, Yue WT (2019) and Indranil Bose. Impact of Immersive Interface Design on Consumer Perceptions During Online Product Presentation. *ICIS*
70. Terras MM, Ramsay J, Boyle EA (2015) Digital Media Production and Identity: Insights from a Psychological Perspective. E-Learning Digit Media 12(2):128–146
71. Tian K, Tepper WO, Bearden, Gary LH (2001) Consumers' Need for Uniqueness: Scale Development and Validation. J Consum Res 28(1):50–66
72. Urbach N, and Frederik Ahlemann (2010) Structural Equation Modeling in Information Systems Research Using Partial Least Squares. J Inform Technol Theory Application (JITTA) 11(2):2
73. Wang J, Yang J, Fu Q, Zhang J, Zhang J (2024) A New Dynamic Spatial Information Design Framework for AR-HUD to Evoke Drivers' Instinctive Responses and Improve Accident Prevention. Int J Hum Comput Stud 183:103194
74. Wang Z, and Jian Wang (2023) Do the Emotions Evoked by Interface Design Factors Affect the User's Intention to Continue Using the Smartwatch? The Mediating Role of Quality Perceptions. Int J Human–Computer Interact 39(3):546–561
75. Wells JD, Damon E, Campbell JS, Valacich, Featherman M (2010) The Effect of Perceived Novelty on the Adoption of Information Technology Innovations: A Risk/Reward Perspective. Decis Sci 41(4):813–843. https://doi.org/https://doi.org/10.1111/j.1540-5915.2010.00292
76. Wold H (1975) Soft Modelling by Latent Variables: The Non-Linear Iterative Partial Least Squares (NIPALS) Approach. J Appl Probab 12(S1):117–142
77. Wong RM, Olusola OA (2021) Meta-Analysis of Emotional Designs in Multimedia Learning: A Replication and Extension Study. Educational Psychol Rev 33(2):357–385
78. Wu L, Lei T, Li J, Li B (2015) Skeuomorphism and Flat Design: Evaluating Users' Emotion Experience in Car Navigation Interface Design. *Design, User Experience, and Usability: Design Discourse: 4th International Conference, DUXU 2015, Held as Part of HCI International 2015, Los Angeles, CA, USA, August 2–7, 2015, Proceedings, Part i*, 567–75
79. Xi T (2018) and Xiaoli Wu. The Influence of Different Style of Icons on Users' Visual Search in Touch Screen Interface. *Advances in Ergonomics in Design: Proceedings of the AHFE 2017 International Conference on Ergonomics in Design, July 17–21, 2017, the Westin Bonaventure Hotel, Los Angeles, California, USA 8*, 222–32
80. Yan M, Filieri R, and Matthew Gorton (2021) Continuance Intention of Online Technologies: A Systematic Literature Review. Int J Inf Manag 58:102315
81. You F, Liang Y, Fu Q, Zhang J (2025) Exploring the Role of AR Cognitive Interface in Enhancing Human-Vehicle Collaborative Driving Safety: A Design Perspective. Int J Human–Computer Interact 41(1):115–135
82. Yu C-Y, Po-Ching W (2018) Aesthetic Experience Anchors Ego Identity Formation. Sustainability 10(8):2596

83. Zhou S, Lan R, Bai XSJ, Zhang Y, Jiang X (2022) Emotional Design for in-Vehicle Infotainment Systems: An Exploratory Co-Design Study. In *HCI in Mobility, Transport, and Automotive Systems*, edited by Heidi Krömker. Springer International Publishing

Figures

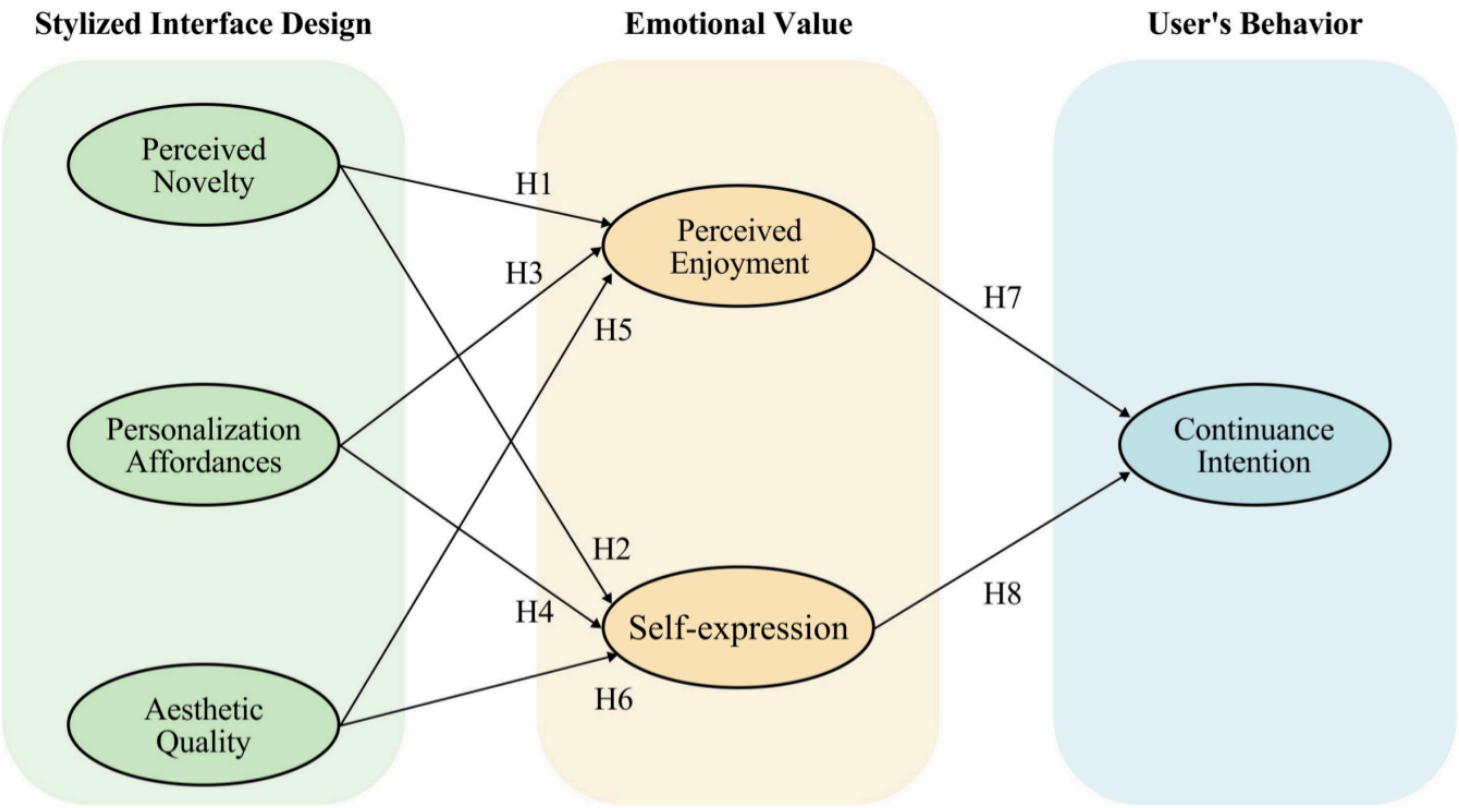


Figure 1

Research framework. This study proposed eight research hypotheses: perceived novelty, personalization affordances and aesthetic quality positively affect perceived enjoyment and self-expression, while perceived enjoyment and self-expression positively affect continuance intention. The two emotional-value variables were hypothesized to mediate the relationships between stylized interface design features and continuance intention.

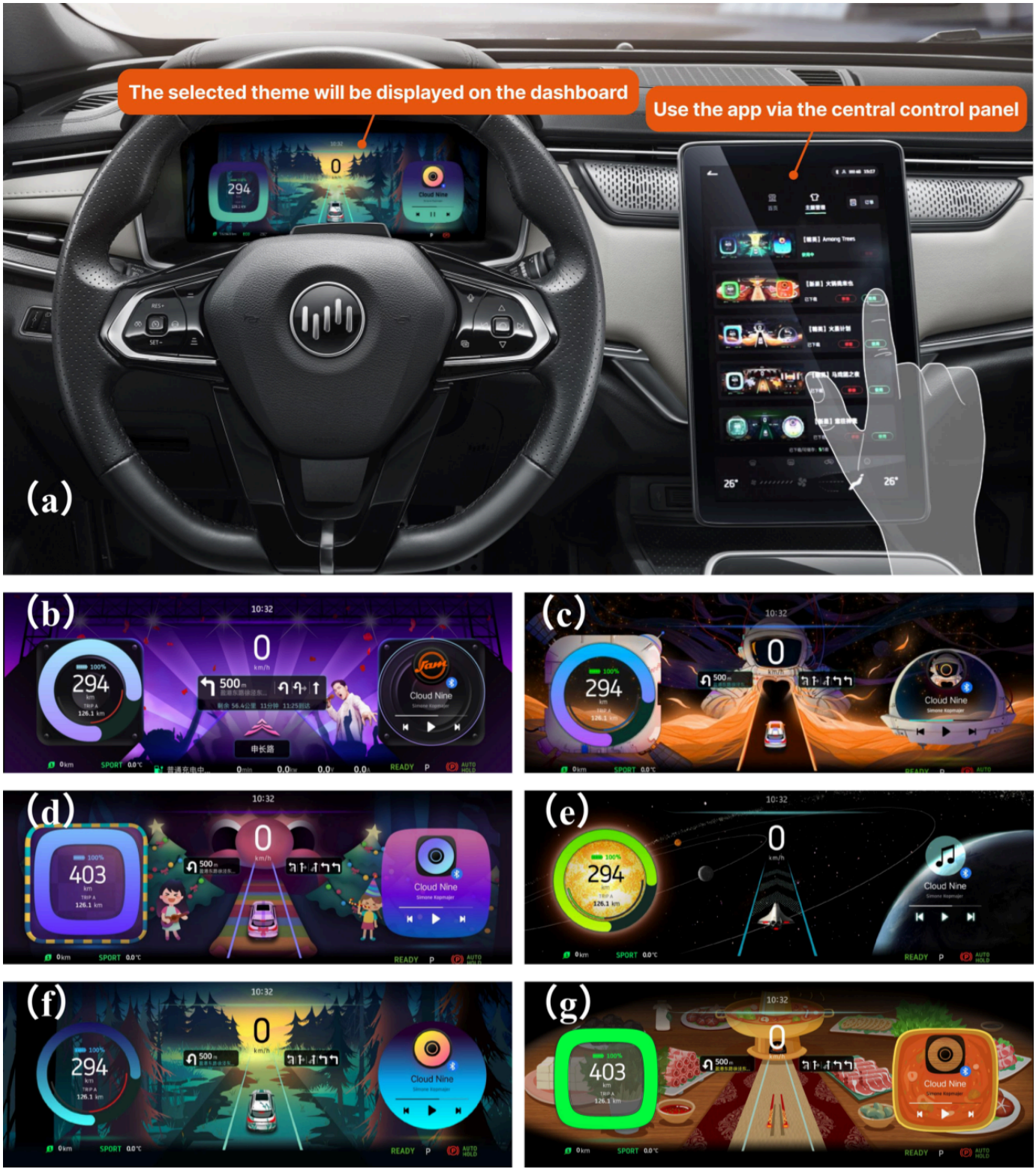


Figure 2

HMI presets. (a) In-vehicle HMI application operation scenario. (b) Music-themed interface design. (c) Interface design for the moon travel theme. (d) Interface design with a Christmas and children's theme. (e) Interstellar voyage-themed interface design. (f) Forest-themed interface design. (g) Hotpot-themed interface design.

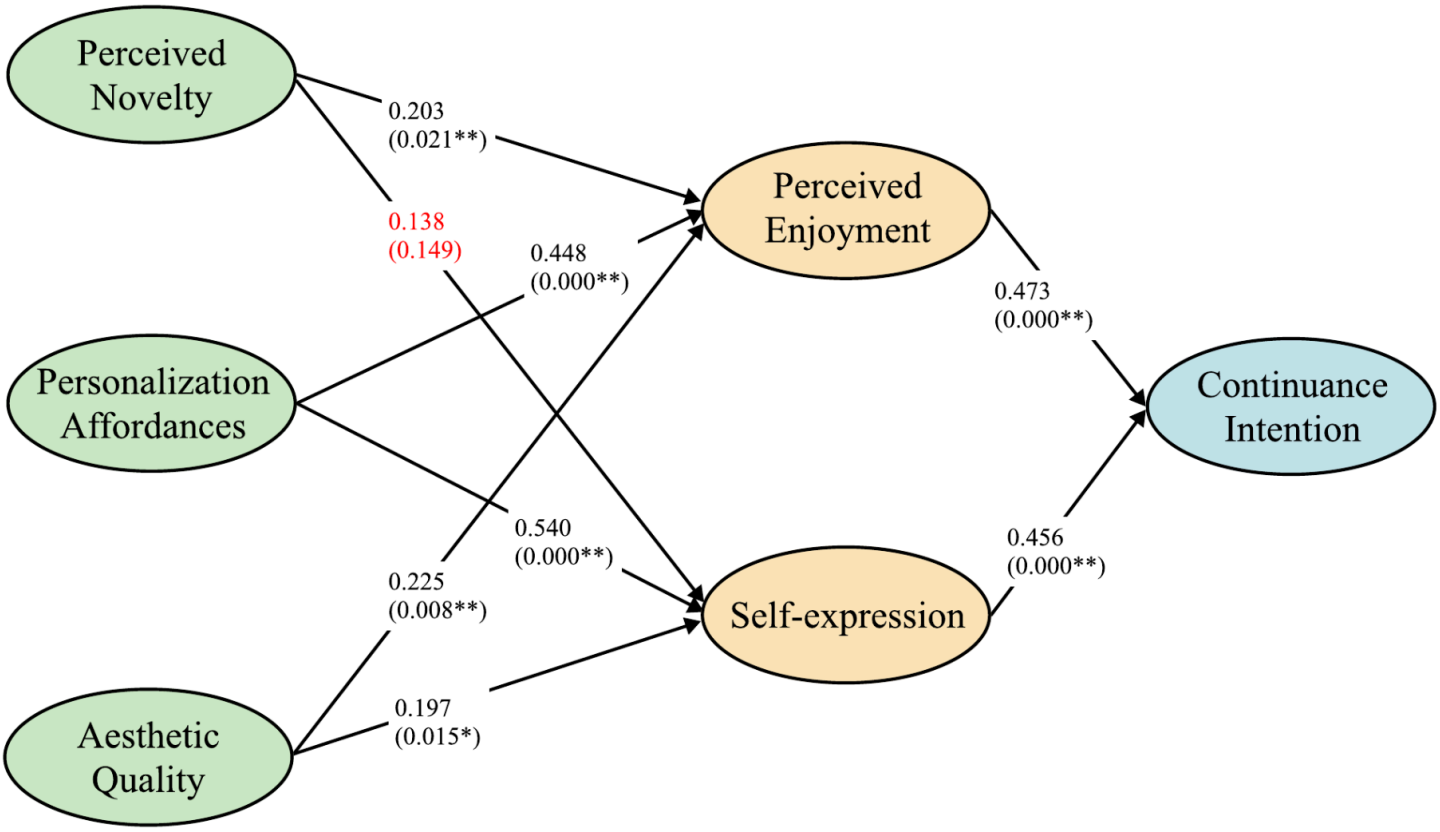


Figure 3

Results of structural model hypothesis testing. All hypotheses were supported except H2. Perceived enjoyment and self-expression were influenced by perceived novelty, personalization affordances and aesthetic quality. Perceived novelty had no significant effect on self-expression, while personalization affordances had the strongest impact on both perceived enjoyment and self-expression. The effect of perceived enjoyment on continuance intention was slightly stronger than that of self-expression. Note: * = $p < 0.05$; ** = $p < 0.01$; n/s = not significant.