WEP Warwick Evans Publishing

International Journal of Global Economics and Management

ISSN: 3005-9690 (Print), ISSN: 3005-8090 (Online) | Volume 4, Number 1, Year 2024
DOI: https://doi.org/10.62051/ijgem.v4n1.74
Journal homepage: https://wepub.org/index.php/IJGEM/index

Research on the Subjective and Objective Evaluation Strategy of the Intelligent Vehicle Cockpit Based on the User Experience

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ABSTRACT

The trend of intelligent networking in automobile industry is developing in full swing, with more and more functions. But feature richness does not necessarily reflect user needs. In order to perfect the evaluation system in the field of automobile intelligent cockpit, this paper constructs the subjective and objective evaluation strategy and tests the function of automobile intelligent cockpit. By building evaluation strategy, standardizing the tester, testing process pole test dimension, combining with subjective evaluation and eye movement, EEG device objective data, clear model and algorithm. Finally, the feasibility of the modified strategy is verified by a practical case.

KEYWORDS

Visual cognition; Brain cognition; Subjective and objective evaluation; Intelligent cockpit

1. INTRODUCTION

At present, the automobile industry is undergoing profound changes of electric, networked and intelligent. This trend has not only reshaped the pattern of China's automobile industry, but also profoundly changed the car habits and thought mode of users. As the car gradually evolves into an intelligent mobile space, users' expectations for vehicles are far beyond the scope of traditional transportation vehicles, and they are eager to enjoy a more convenient, intelligent and personalized experience in the car [1].

The rapid progress of computer technology is the key force to promote the continuous improvement of the intelligent and networked level of automobiles. In this context, users have put forward higher level requirements for the design of intelligent connected vehicles, and expect that the vehicle can provide more advanced, rich and rich functions close to the actual use scenarios. However, it is worth noting that there are still some problems in the development process of many on-board intelligent network functions in the current market, such as too much pursuit of advanced technology and ignoring the optimization of user experience, resulting in some functions, although seemingly powerful but are difficult to really meet the actual needs of users [2].

2. TECHNICAL ROUTE SCHEME

The whole evaluation strategy and technical route is carried out according to the research work of subjective and objective information characteristics, experiment collection and result analysis.

2.1. Research on Subjective and Objective Information Characteristics

This research work is carefully planned as two core links: first, "in-depth feature analysis based on multi-dimensional element information", followed by "strategy formulation for accurately matching personnel and trial design".

In "based on the depth of the multidimensional element information characteristics analysis" link, we focus on the features of intelligent made car, which not only covers the user direct experience level of subjective evaluation —— through exquisite questionnaire, depth interview, accurate capture the user for car intelligent snatched function of subjective feelings and expectations, also into the technology to achieve the objective level —— through professional test methods, quantitative analysis of information content of richness, information processing efficiency (i. e., information density) and other key indicators. This process aims to build a panoramic view of the features of intelligent connected vehicles from two dimensions of user perception and technology realization [3-4].

Next, in the link of "accurately matching personnel and trial design", take the above subjective and objective analysis results as the core input, carefully select the tester with relevant background knowledge, skills and experience, to ensure that they can not only accurately understand the user needs, but also efficiently perform the technical test. Subsequently, according to the specific test purpose and content, tailored a set of scientific and reasonable test program. The scheme aims to comprehensively verify the practicability and user experience of various functions of intelligent and connected vehicles through well-designed test scenarios and tasks, so as to provide solid data support and direction guidance for the subsequent optimization and improvement.

2.2. Test Acquisition of the Evaluation Strategies

Guide the tester according to the test tasks, and perform the corresponding operations one by one. At the same time, with the help of advanced test equipment, the multi-dimensional information of the tester in the execution process is fully captured and recorded. This information not only covers the cognitive details at the visual level, such as gaze trajectory and pupil changes, and deeply reveals how users interact with the intelligent connected car interface through the visual system; but also touches the deep level of brain cognition, such as attention allocation and decision-making process, providing us with valuable insight into the user's brain when dealing with complex intelligent functions.

In addition, teare encouraged to give subjective quantitative evaluation scores on the performance and ease of use of intelligent connected vehicles based on their true feelings. This subjective information, complementary to the above objective data, jointly build a comprehensive and three-dimensional evaluation system. In this way, it can not only accurately grasp the users' intuitive feelings of intelligent connected vehicles, but also deeply understand the cognitive mechanism behind it, so as to provide richer and more detailed feedback for the design and optimization of intelligent connected vehicles [5-6].

3. TEST COLLECTION

By formulating a detailed test process, collect the test data, and explain the purpose, basis and scale of the collected data.

3.1. Define the Test Process

The test process follows a series of logically clear steps for data acquisition. First, the task environment is presented one by one (such as task 1, task 2...) Give the tested personnel, and reserve sufficient time for their adaptation and preparation. Subsequently, the instruction for the execution of the task is clearly issued, and after the tested personnel confirm the readiness, the task execution is officially started. This process continues, ensuring that every task is examined in meticulous detail [7-8].

The whole test process consists of a series of carefully designed scene tasks and independent hardware operations interwoven, aiming to fully cover the functional characteristics of intelligent connected vehicles. Each scene task, such as the vehicle atmosphere of immersive experience, entertainment video enjoy moment, multitasking flexible switch, navigation to explore unknown location, car personalized setting of sweet atmosphere, music and radio free control, game entertainment experience, and the precise adjustment of air conditioning system, as an independent data acquisition unit, to ensure that each function can get independent and in-depth analysis [9-10].

At the same time, intelligent driver assistance functions such as automatic following and lane keeping were also included in the test category to evaluate the performance of intelligent connected vehicles in autonomous driving mode. During each task execution, we use advanced test equipment to capture and record the visual cognitive information, brain cognitive activity and subjective evaluation feedback of the subjects in real time, as a valuable input for the subsequent model calculation and data analysis. Such test process design aims to provide solid data support for the performance evaluation and optimization of intelligent connected vehicles through multi-dimensional and all-round data collection [11-12].

3.2. Test Case of Objective Data of Intelligent Cockpit

Before the test, the test should be ensured that the test object is familiar with the basic physical keys in the car, the test auxiliary personnel should provide the equipment harmless explanation to the tester, calibrate the equipment, ensure the smooth signal connection, at the same time, keep the car clean and adjust the air conditioning to the appropriate temperature in advance.

The test type includes two parts: static test and dynamic test. During the execution of each task, the test engineer should explain the test task first, and the user will operate after the "start" instruction from the engineer. In this strategy introduction, observing the vehicle atmosphere, watching entertainment videos, and opening three programs are switched to sequence. Table 1 shows the test case of the objective data of the intelligent cockpit [9].

Table 1. Test cases of objective data of intelligent cockpit

Task / evaluation items	Interface layout	Interface color	Overall cockpit layout	Interface density
The vehicle is divided into observations			•	
Watch entertainment videos	•	•		
Open program switch	•			•

3.3. Test Execution

The test was carried out in Nanjing, starting from Beijing, with complete office, business, home, entertainment, education and medical attributes, large traffic flow and complex road conditions. Collect the information of 30 users from the four models.

4. RESULTS ANALYSIS

4.1. Data Collation and Analysis

4.1.1. Eye movement part

The data analysis of eye movement includes five parts: data extraction, outlier proposal, data merger by task and model, data standardization and normalization, and dimension reduction analysis. Analytical data results are shown in Table 2:

Table 2. Eye movement indicators

Eye movement index	mean	standard deviation
Blink times	92	103
frequency of wink	0.95	0.35
Average blink time	3.12	7.22
Blink range	5.43	1.53
fixation time	11.32	6.23
The number of gaze	21.23	21.90
Mean pupil diameter	5.15	0.83
Scan the time	3.93	5.87
Number of saccades	24	11.32

Data extraction means that the collected data is extracted according to the required characteristics. This test involves 30 respondents, 4 test vehicles, and 3 tasks for each vehicle, and the required data is extracted and summarized.

The elimination of outlier values is to average or eliminate the missing values, and to test the effectiveness of conventional indicators. The evaluation method of outlier value is as follows. To the quartile:

$$IQR = Q_3 - Q_1 \quad (1)$$

IQR is the interquartile distance, and Q_3 is the 75% quantile of the data (i. e., the third quartile), and Q_1 is the 25% quantile of the data (i. e., the first quartile);

The effective interval is:

$$Q_1 - 1.5IQR \le v \le Q_3 + 1.5IQR \quad (2)$$

v is the effective interval. After the cleaning, the data will be merged according to the test name, model and task number, and sorted into the corresponding documents according to the model, and the intermediate data will be saved.

In the data standardization and normalization section, the normalization method is: let, average the data within the task, then the variance:

$$\sigma = \sum_i^n (a_i - \bar{a})^2 \quad (3)$$

a_i is the i th value, and $\bar{a}$ is the average;

The threshold is normalized to:

Set the threshold, $h_{\max}$, h_{min}

Then

Dimensionality reduction analysis, or principal component analysis, reduces the data to a one-dimensional composite score, and the weights satisfy Eq. The formula is:

$$\max\ \boldsymbol{\alpha}_1^{\mathrm{T}} \boldsymbol{\Sigma} \boldsymbol{\alpha}_1$$

$$s.t.\ \boldsymbol{\alpha}_1^{\mathrm{T}} \boldsymbol{\alpha}_1 = 1 \tag{4}$$

The eigenvalues satisfy:

$$\mathrm{var}\left(\alpha_k^{\mathrm{T}} x\right) = \alpha_k^{\mathrm{T}} \boldsymbol{\Sigma} \alpha_k = \lambda_k,\ \ k = 1,\ 2, \cdots, m \tag{5}$$

To make the scores distributed in the [0, 1] interval, the weights were normalized according to the size.

4.1.2. The EEG part

The analysis of test results can be divided into four parts: one is the original EEG waveform; two is bad channel marking, interpolation and data segmentation; three is useful for ICA separation, which can see the activation features in the left frontal lobe, which can be used as reference; the messy signals are removed as action and other interference; and the processed EEG data is more stable than the original waveform and can be used for analysis. As shown in Figure 1,2,3 and 4:

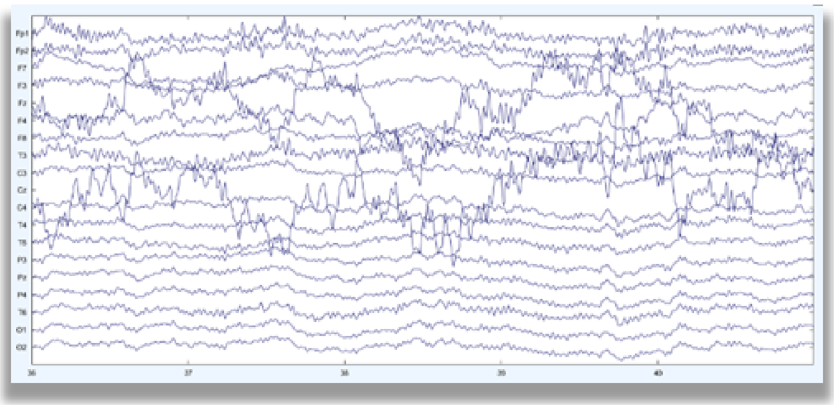

Figure 1. Raw brain waveform

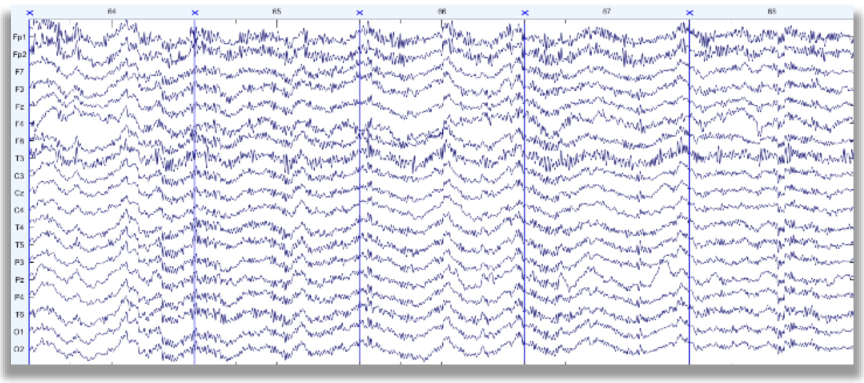

Figure 2. Bad channel annotation, interpolation and data segmentation

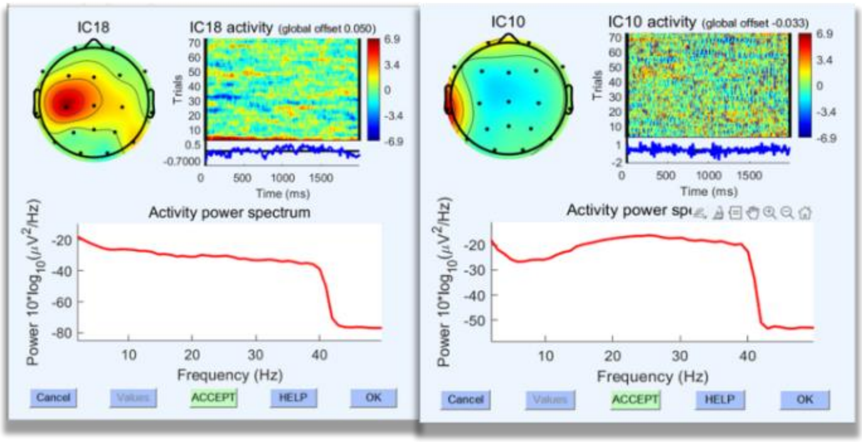

Figure 3. ICA separates the useful components

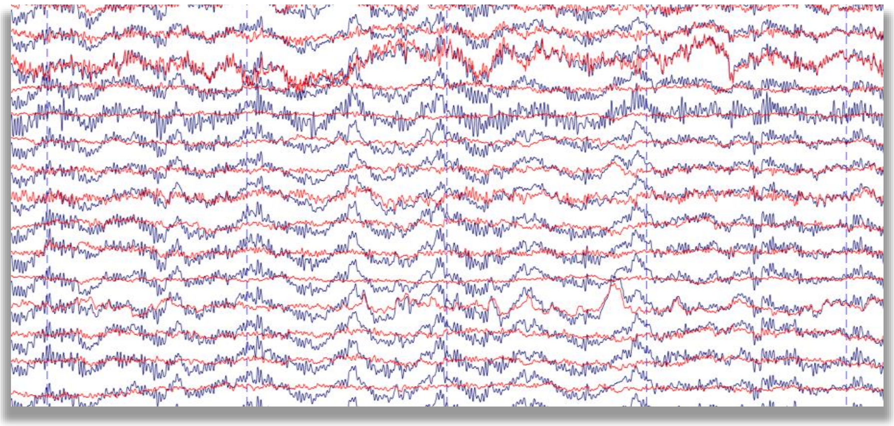

Figure 4. The processed EEG data

The EEG data analysis process is divided into four steps. The first step is the preprocessing part, including data reading, marking bad guides, extracting normal electrode data and dividing the data according to events.

The second part is data cleaning, according to the first step generation content, bandpass filtering, ICA principal component analysis, merge and generate the process file 1.

The third part is dimension reduction and calculation. According to the second part process file 1, the index system configuration file is generated and read. Calculate the dimension of the third-level index to the second-level index, clear the outlier, mark P200, P300 and N400 values, extract the value and output the image.

The fourth part is divided into data analysis. The results of the third part are cross-analyzed and the results are output, and classified according to vehicle models and tasks.

4.2. Analysis of the Results

4.2.1. Observation of the whole vehicle atmosphere

The test observed the vehicle atmosphere for the four models. The eye movement information of ABCD is shown in Figure 5, 6, 7 and 8 respectively.

Figure 5. Model A

Figure 6. Model B

Figure 7. Model C

Figure 8. Model D

The results show that the interior design of model A is novel, but for the subject, the observation elements are scattered; the interior of Model B is too simple. From the video observation of the eye tracker, the task completion time is the fastest and does not surprise the users; the interior design of Model C is classic, in line with the daily use habits of the subject, and obtains A high score; the key design of Model D is more convenient and comfortable, and the operation and learning cost is low, and has the best performance in the sense of dependence. The overall cockpit layout score and EEG score results of different models are shown in Table 3 and Table 4:

Table 3. Overall cockpit layout scores

	Overall cockpit layout	feeling of dependency	a sense of joy
motorcycle type A	0.39	0.44	0.37
motorcycle type B	0.22	0.38	0.26
motorcycle type C	0.45	0.43	0.41
motorcycle type D	0.40	0.48	0.37

Table 4. Task 1-EEG score

	N400	P200	P300
motorcycle type A	-0.66	-0.61	-0.21
motorcycle type B	0.12	0.17	0.19
motorcycle type C	-0.58	-0.64	-0.26
motorcycle type D	0.10	-0.01	-0.13

In conclusion, the novel design of the interior of model A brings certain visual impact to the subjects, and performs well in both pleasure and dependence; but the physical keys bring less operation and learning cost, and score low in the N400 band of EEG, as shown in Figure 9 and Figure 10, and the familiar operation mode will be improved in the future.

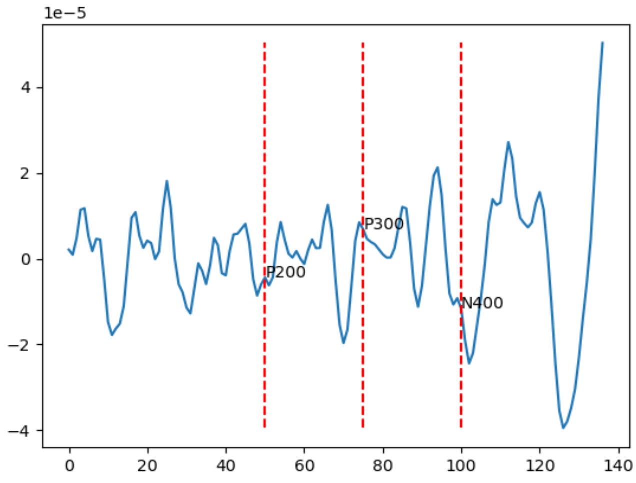

Figure 9. Model A-N400

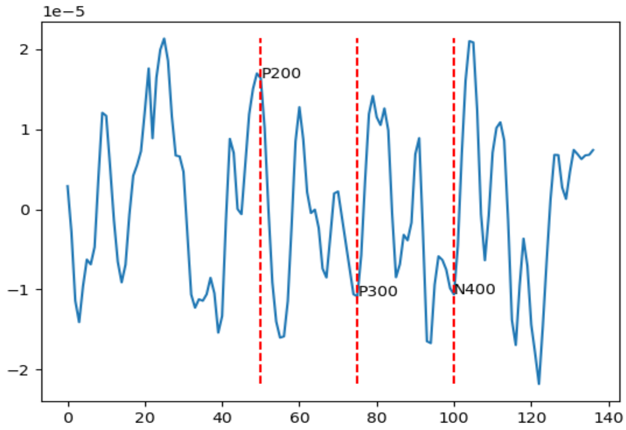

Figure 10. Model B-N400

5. SUMMARY OUTLOOK

Starting from the two aspects of user visual and intuitive perception and deep brain cognition, this paper combs a subjective and objective network of automobile intelligent network evaluation system. It is not only closely related to the subjective satisfaction evaluation of users, but also deeply explores the objective response of users in the visual receiving and brain processing information, realizing the comprehensive coverage and in-depth mining of the evaluation dimension.

Valuable objective evaluation data are obtained by capturing and parsing the subtle changes in users in visually contacting the intelligent connected vehicle interface, and the cognitive activity of their brains in processing complex intelligent functions. These data are like an accurate ruler, effectively improving the reliability and accuracy of the evaluation, and ensuring the solid credibility of the evaluation results. At the same time, it also provides a more scientific and objective basis for the design and optimization of intelligent and connected vehicles, and enhances the practical value of the evaluation.

In order to fully verify the feasibility and effectiveness of this strategy, many representative models are selected for practical evaluation and test. The test results show that this strategy can not only accurately reflect the performance of intelligent connected vehicles in different dimensions, but also can effectively guide the car enterprises to make targeted improvement and upgrade. This practice verification not only deepens the understanding of user evaluation of intelligent connected vehicles, but also provides useful reference for relevant research and application in the industry.

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