Academic Journal of Science and Technology
ISSN: 2771-3032 | Vol. 2, No. 3, 2022

Human Factors in Automotive HMI Design

Sihan Chen

Jiangxi University of Finance and Economics, Jiangxi, China

Abstract: Driving is an information processing activity. In the process of driving, the driver constantly obtains and processes information from various sensory channels to make decisions and take appropriate actions to control vehicle movement. This paper will discuss four parts: sensory, cognition, decision making and automation.

1. Sensory Senses

1.1. Visual

1.1.1. Vision

The ability of the eye to distinguish objects is called vision, which is divided into static vision and moving vision. Static vision is the driver's vision when he is still, and dynamic vision is the driver's vision when the car is moving. When people with normal vision observe distant objects, their dynamic vision decreases rapidly with the increase of speed. For example, when the vehicle speed is 60km/h, they can see the traffic sign at 240m.When the vehicle speed is 80km/h, it can only see the traffic sign at 160m.In addition, according to NHTSA2010-0053, drivers should not take their eyes off the road in front of them for too long. Two seconds is the recognized safe time limit.

1.1.2. Visual Field

The visual field refers to the range that can be seen on both sides of the fixation point when the two eyes gaze at a certain target. The size of the visual field is related to the speed of the vehicle. With the increase of the speed, the driver's visual field becomes significantly narrower. For example, when the vehicle speed is 40km/h, the visual field is 90° ~ 100°;When the vehicle speed is 80km/h, the field of view is 60°.Useful Field of View (UFOV) refers to the interval diameter of continuous eye movement between different fixation centers. Within this range of View, all existing targets can be seen. UFOV has been shown to be associated with the risk of vehicle collision, obstacle collision and propensity to fall.

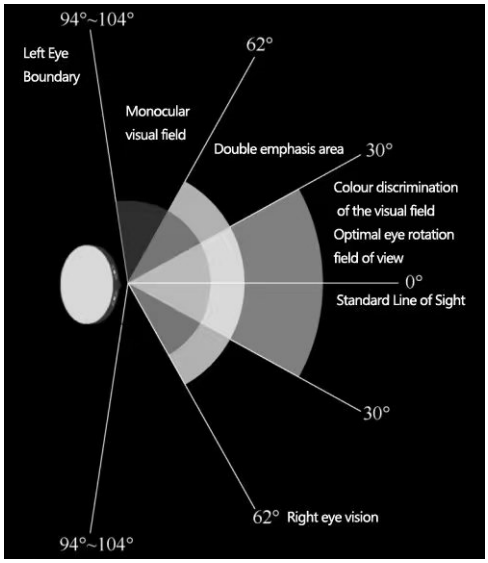


Figure 1. Visual field of human eye

1.1.3. Color

People's recognition and feeling of different colors is called color sense. People have different reactions to different colors, for example, red light visibility is high, strong stimulation, make people alert; The highest brightness of yellow light, reflected light intensity is the largest, easy to arouse people's attention; Green light is relatively soft, giving people a sense of calm and security. Therefore, traffic engineering will use red light as a no-traffic signal, yellow light as a warning signal, and green light as a traffic signal.

Figure 2. Visual specification of Baidu Internet of Vehicles

1.2. The Hearing

When the human driver's visual channel is occupied, auditory interaction is good at waking up and directing the driver's attention. The types of sound symbols can be divided into simple sounds, ear markers, symbolic sounds and speech information.

Display type	Type Specification	Illustrate
Simple Volume	One or a group of sound symbols of the same frequency presented simultaneously	Sine wave or square wave
Ear volume	A combination of abstract tones used in the presentation of auditory messages. Also called a composite tone	Jingling or chime bells
Indicative Sound	An environmental sound that represents an object or action and conveys the meaning of information visually	The sound of a car horn or braking crisis
Voice Message	A text message expressed by voice	danger

Simple sounds can attract the driver's attention, and their combination with visual communication can shorten the driver's reaction time. Ear subscripts are suitable for conveying suggestive information and can be used in less dangerous scenes. Simple sounds and ear subscripts need to be learned in advance by the driver, otherwise they may lead to wrong responses.

Symbolic sounds have contextual meaning and can promote drivers' understanding of unexpected situations, but they are highly intrusive and less friendly. The voice information carried by the voice message will lead to slow response speed, but with the improvement of vehicle intelligence, the voice message can meet the high demand for information detail transmission.

Figure 3. Xiaopeng car voice assistant Xiao P

1.3. The Sense of Touch

In the car, most of the operation, information input and so on before the full popularity of voice interaction, are done by hand. The design of many keys on the car is also to facilitate the driver to "blind operation" : without eyes to see, just touch the hand can complete the input of information. At present, with the trend of large-screen intelligent cockpit, many manufacturers are adding tactile click feedback to touch screens.

In addition, as a warning, compared with visual and auditory prompts, some studies have shown that visual prompts are the least intrusive, while tactile prompts are more intrusive. Therefore, in very urgent driving scenarios, tactile cues can be used to maximize the alertness of drivers.

2. Cognition

2.1. Attention 1.

Driver attention is a critical factor in safe driving. A new concept, Area of Interest (AOI), is needed in visual attention. AOI refers to an external physical area in which people can find information relevant to the corresponding task. The distance between two AOIs determines the amount of visual Effort, which is called Information Access Effort (IAE).In the actual driving scene, the advantage of the head-up display HUD is to shorten the distance between the road AOI and the center control screen AOI.

Figure 4. AR-HUD

Our vision usually has two parallel processes: automatically grouping similar content in the external environment and using selective attention to pick out the information we want to focus on. Therefore, when presenting information, it is important to combine relevant information organically for more effective visual search.

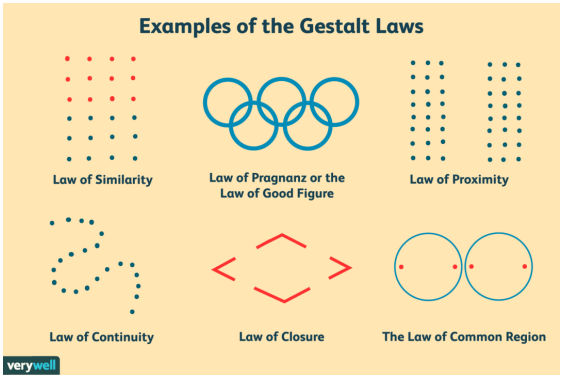


Figure 5. Gestalt Principle

The perception of sound is governed by two types of attention: one is differentiated attention, such as when a person hears different sounds at the same time; And selective attention, such as when we focus our attention on a certain sound. People generally distinguish (recognize) sounds by several different sound elements, including syllable, pitch, timbre, spatial location, and timing. The sound design in the cockpit should clearly distinguish primary and secondary information for the driver.

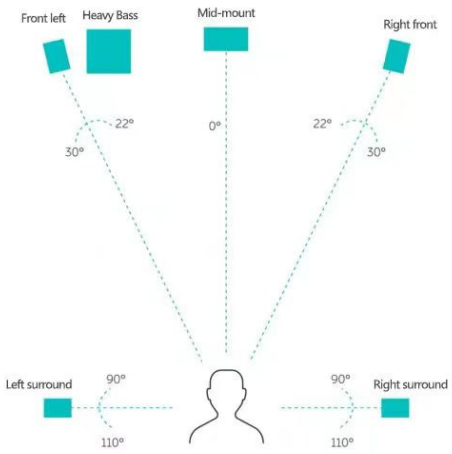
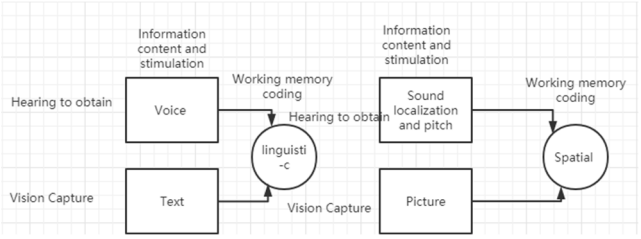


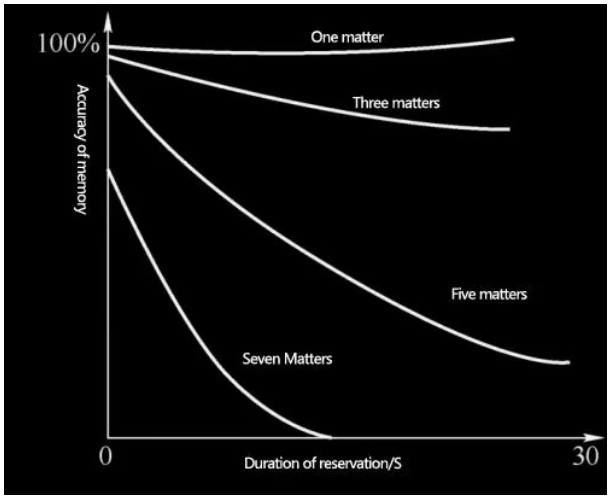
Figure 6. Nextev 5.1 speaker configuration

2.2. The Memory

Your memory can be divided into working memory and long-term memory. Working memory is a kind of active memory that is temporary and used to store new information, and it requires a lot of attention. Long-term memory is when we store knowledge about the world and how we do things for long periods of time. Working memory is even more important when it comes to safe driving.



In working memory, verbal information is stored in words and speech; Spatial information is stored in the form of sound spatial localization and images. When a short text information needs to be conveyed to the driver, the best way is through speech, so that the information will not be lost in the auditory sense when the information is received. The time of sound retention in the auditory sense is 3~ 4S, which is longer than that of visual retention. But if it is a longer message, then it can stay longer in the way of text writing, or repeat the speech information.

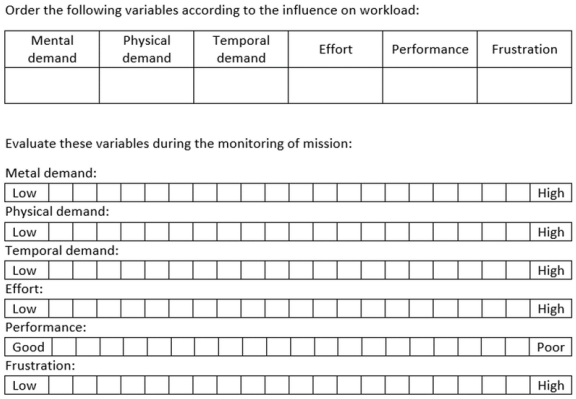


How many items a person can remember simultaneously is also related to the amount of time each item takes up. Never design to require the user to remember more than five numbers or letters at a time.

2.3. Work Load

Workload, "Workload," refers to the amount of work the human body can handle per unit of time. Driving workload refers to the driver's information processing ability under the influence of road, traffic and environment, and more importantly, it refers to the driver's psychological load.

For a skilled driver, highway driving is a scene that he is comfortable with, in which he has excess psychological resources to complete other tasks, such as making phone calls and operating the vehicle-machine interface. However, if there is an accident or road construction ahead and he needs to change lanes or drive off the highway, the demands on his mental load will reach a critical point. At this time, if there is a call, the driver may not answer.


Order the following variables according to the influence on workload:

Mental demand	Physical demand	Temporal demand	Effort	Performance	Frustration

Evaluate these variables during the monitoring of mission:

Metal demand: Low — High

Physical demand: Low — High

Temporal demand: Low — High

Effort: Low — High

Performance: Good — Poor

Frustration: Low — High

Figure 7. Nasa-tlx Workload Scale

3. Decision Making

3.1. SRK Behavioral theory

Skills-rule-knowledge based behavioral models (which classify people's work into three different levels according to the complexity of their cognitive engagement. Skill-based Behavior (SBB) operations are very skilled, almost subconscious operations, which can also be called instinctive operations.

For example, an old driver can drive a vehicle proficiently, and the eyes, hands and feet cooperate well. The corresponding interface is mostly state-type interface, such as the safety state and speed of the vehicle. Rule-based Behavior (RBB) operations that operate according to various rules, such as maintaining lanes and obeying traffic laws, belong to this type of operations. Guided interfaces can be used, such as driving prompts and the status of collision times.

Knowledge-based Behavior (KBB) operation, facing relatively complex problems, need a lot of Knowledge, analysis and judgment. In interface design, it is necessary to provide as much useful information as possible to assist the driver's thinking.

Figure 8. Ar-Hud RBB Guides Information

3.2. Situational Awareness

Situational Awareness (SA) is when the driver is aware of what is happening around him, understands the significance of relevant information, and what that information means for the future.

Situational awareness is divided into three stages: perception, understanding, and anticipation. The perception stage can provide basic information about the current state, goal, intention and plan to the driver. The understanding stage should reveal the reasoning process and the constraints and options considered. In the prediction stage, the driver is

provided with information about his prediction of the future state, the consequences of the prediction, and the likelihood of success or failure.

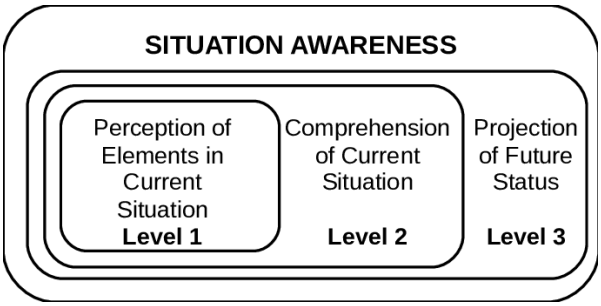


Figure 9. Three stages of situational awareness

4. Automation Automation

4.1. A distraction

Driving distraction is when the driver's attention is diverted from safe driving activities to other competitive activities, which can easily occur under assisted driving conditions.

When the level of automation is L3, the driver does not need to supervise the road situation, and the driver can participate in some non-driving sub-tasks, such as chatting on the mobile phone, watching videos, etc.This will reduce the situational awareness of drivers, and they need to understand the current situation before they can take countermeasures, which leads to a long time to take over and a decline in decision-making ability, a great challenge to the safety of driving, and a loss of trust in the automation system and a poor sense of autonomous driving experience.

When designing take-over behavior in the context of autonomous driving, designers need to focus on the situation when the driver is not in the out-of-the-loop driving.

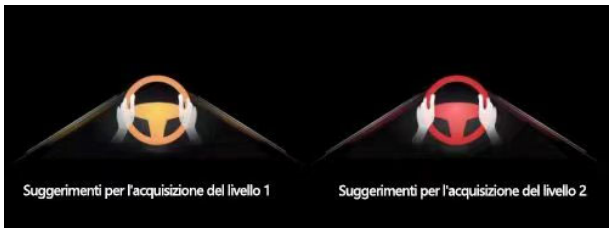
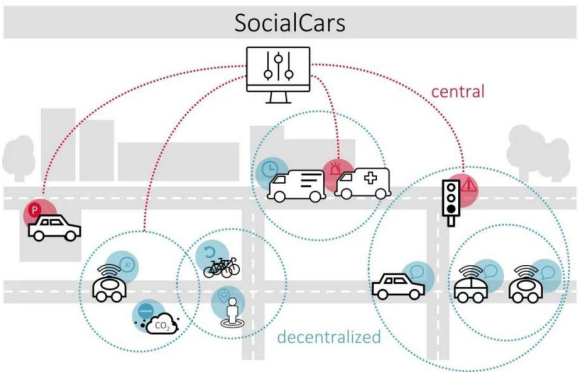


Figure 10. Autopilot assistance system takes over cue

4.2. Division of 2.

Automated systems need to define their divisions of labor in their interactions with people. What tasks can be done by people and what tasks can be done by the system. If the information processing and decision-making processes of automated systems are not communicated with people, people will be in the dark, scratching their heads. Therefore, the feedback design of automated systems is very important.

In addition, the division of labor can be between road users. With the development of vehicle-to-vehicle (V2V) communication technology, it is possible to understand each other's intentions through Vehicle communication. For example, when ramps merge, they can connect and avoid each other better.



4.3. Trust

In automated human-computer interaction, "trust" is important. There are three relative relationships: appropriate trust, insufficient trust and excessive trust. Appropriate trust refers to that the subjective trust level of the driver is consistent with the objective trust level of the system. Under-trust refers to that the subjective trust level of the driver is lower than the objective trust level of the system. Over-trust usually means that the driver overestimates the ability of the autopilot system and abuses the automation function.

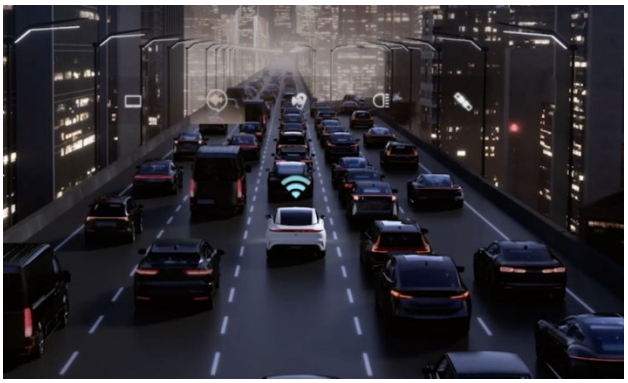


Figure 11. Zhiji car confidence signal

4.4. Acceptance

Acceptance is a lower level factor than trust. Trust is built on acceptance. Acceptance refers to people's willingness to use new information technology. Specifically, it can be understood in terms of usefulness and ease of use. Usefulness is a measure of how useful the driver is to the automated system, while ease of use is how easy the driver thinks the automated system is to use. One of the ways to increase acceptance can be achieved through anthropomorphic and emotional appearance features to provide natural and emotional interaction feelings.

Figure 12. NOMI, NIO's voice assistant

5. The Summary

Intelligent cockpit provides abundant functions and convenient operation for drivers and passengers. It is very important to understand the underlying human factors. The influence of human factors is always implied in the design of automobile HMI.

References

[1] Gao Zaifeng, Li Wenmin, Liang Jiawen, Pan Hanxi, Xu Wei, Shen Mowei. Human-computer trust in autonomous vehicles [J]. Advances in psychological science,2021,29(12):2172-2183.

[2] Wang Gao Fei, Liu Song. [2] study on urban road capacity evaluation based on ahp [J]. Henan science and technology,2020,39(31):128-130.]

[3] SHEN Yichuan. Correlation Analysis between highway Visual environment and vehicle operation Characteristics [J]. Traffic and transportation,2021,37(04):90-94.]

[4] Qin Yaqin, Zhao Pengyan, Xie Jiming, Wang Jinrui. [4] Review on Drivers' Visual Load [J/OL]. Journal of Kunming University of Science and Technology (Natural Science Edition):1-17[2022-09-03].DOI:10.16112/j.cnki.53-1223/ N.2022.06.481.

[5] HAN Jiayi. Research on Human-machine Tactile Interactive Cooperative Steering Control of Intelligent Vehicle based on Driver's behavior understanding [D]. Jilin university, 2022. DOI: 10.27162 /, dc nki. Gjlin. 2022.001199.

[6] XU Tao. Research on Human-computer interaction Interface Design in the context of autonomous driving takeover [D]. Southwest university of science and technology, 2022. DOI: 10.27415 /, dc nki. GXNGC. 2022.000665.

[7] XU Wei. User-centered design: from automation to intelligent aircraft cockpit [J]. Applied Psychology, 222,28(04):291-313.

[8] Manchon J.-B.,Bueno Mercedes,Navarro Jordan. How the initial level of Trust in Automated Driving Impacts Drivers' [8] behaviour and early trust construction[J]. Transportation Research Part F: Psychology and behaviour,2022,86.

[9] Jens Kotte,Johanna Josten,Adrian Zlocki,Lutz Eckstein. Impact of a Visual and Haptic Driver Advice and Preview System [9] on a Range Optimized Way of Driving in Electric Vehicles[J]. Transportation Research Procedia,2016,14(C).

[10] Zhang Xiaoying,Chang Ruosong,Sui Xue,Li Yutong. Influences of Emotion on Driving Decisions at Different Risk Levels: [10] Frontiers in Psychology, 2002,13. (in Chinese with English abstract)

[11] Cao Yaoguang,Chen Yuyi,Liu Lu. Research prospect of autonomous driving decision technology under complex traffic Scenarios [J]. MATEC Web of Conferences,2022,355.

[12] Xie Yongquan,Murphey Yi L.,Kochhar Dev. Personalized Driver Workload Estimation Using Deep Neural Network Learning from Physiological and Vehicle Signals[J]. IEEE Transactions on Intelligent Vehicles,2020.