Interactive Design of Digital Car Dashboard Interfaces

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Abstract. The effects of digital car dashboard interface factors on driving experience were studied. Specifically, representative car dashboard interface design elements were analyzed and five representative samples were selected. Four aspects were explored, including dashboard design style, interface layout, information framework, and hierarchical table. The color proportions and shape division of dashboards were analyzed both longitudinally and transversally. By studying and analyzing the five samples, we find to design digital car dashboards, designers have to obey the rules of simple layout, color precision and experience richness. This study has high practical significance and values.

Keywords: Digitization · Automobile instrument panel · Interface · Experience design

1 Research Background

The car dashboard is a bridge for information exchange between the driver and the vehicle. Owing to the high contrast and glaring colors of the thin-film transistor (TFT) liquid crystal display (LCD), the digital dashboard will become the information and control center of future vehicles. Thus, studying the effects of digital dashboard interface design factors on safety driving is of high significance and contributes to improving the driving experience. So far, the dashboard of a passenger car mainly consists of the main dashboard facing the driver and the auxiliary dashboard beside the driver. In particular, the main dashboard contains all instruments on the car that monitor the rotating speed, speed per hour, oil mass and water temperature. Great achievements have been made in research on car dashboard interfaces.

Many efforts have been devoted to combatant instrument layout, lens hood, vision blind field, light reflection, glare, pointer, colors, characters and sound, and to the proposal of optimized design. For instance, a dashboard surface designed as a large semicircle satisfies the requirements of most dashboards. Designing the same characteristics of dashboard interface elements can save driver much time in information processing, but otherwise, it would prolong the driver's exploration. As for old drivers, females depend more on information acquisition than males, so a suitable reduction of interface contrast can improve the driving behaviors of old drivers. Meanwhile, along with the development of new energy, the design of car dashboards will be targeted at interaction, automation, synthesization and diversification. As reported, a digital dashboard with identifying ability is capable of on-line information collection,

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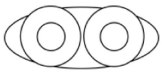
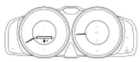
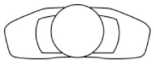
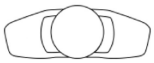
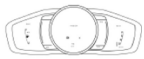
targeting at resource management and share. However, in China, relevant research is focused on electronic instruments, which fail to meet the increasingly intensified requirements for driving. In this regard, we selected five representative dashboards from the 2014 World Automobile Safety Ranking, which was jointly worked out by US Insurance Institute for Highway Safety (IIHS) and US National Highway Traffic Safety Administration (NHTSA). We analyzed and studied the interface designs of these five dashboards.

2 Longitudinal Analysis of Car Dashboard Interfaces

With the Volvo S60 dashboard as example, the longitudinal analysis covered four aspects (dashboard pattern, overall layout, information framework, basic information list) as well as the color ratios. The results are listed in Table 1.

Table 1. The vertical analysis of the instrument panel interface of the Volvo S60

Time	Dashboard style	Layout	Information architecture
First Generation 2013			
Second Generation 2013-2014			
Third Generation 2014-Now	  		

2.1 Structural Simplification

Information During the transition from G1 to G2, the dashboard has changed largely from a dual-dial shape to a mono-dial shape, but it reserved the traditional dial pointer pattern (Table 1). From G2 to G3, the shape has changed very little, but the TFT-supported G3 S60 dashboard adopts full-animation and its dials have changed along with the driving speed, which contributes to safe driving. Due to the decrement of dial, the overall layouts of both G2 and G3 have been simplified, as the central display screen mainly exhibits the speed per hour and range, but other information including rotating speed, oil mass and temperature is concentrated on the bilateral

histograms, which save the occupied space and highlight the important information, thus contributing to the driver's cognition.

2.2 Framework Hierarchy

The information framework is the carrier of visual information expression, including contents, layout and hierarchy. It focuses on the expression and transfer of information. The vehicles have brand-related information framework patterns and obvious family characteristics. The information framework of a Volvo S60 dashboard is showed in Fig. 1. The basic contents displayed include vehicle speed, rotating speed, time, temperature, driving range, gears, oil mass and indicator lamps. These contents are not largely different among the three generations, except for layout and hierarchy. The G1 dashboards adopted two-dial layout and two-level hierarchy. The speed per hour and rotating speed were at the parallel layer, or the first level, and the contents displayed on the controlled zone also belonged to this level. Other information displayed on the dashboard belonged to the second level. In particular, the first level contains rich information about driving, which is hard to be differentiated and thus prolongs the driver's time in information processing.

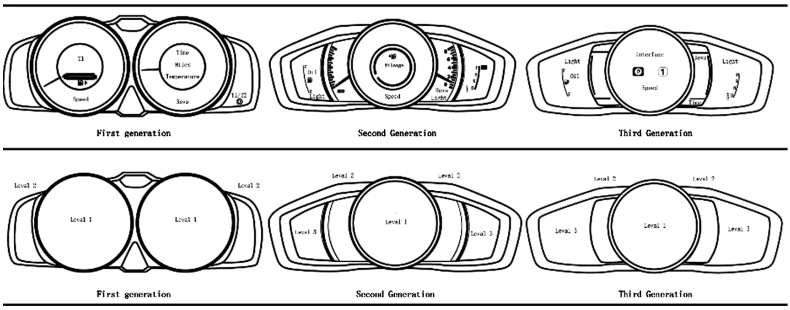


Fig. 1. The family dashboard information architecture

The major difference of G2 from G1 is the single-dial layout, which directly affects the design style of dashboard interfaces and contains three levels of information. The central dial mainly displays vehicle speed and continuous range, which belong to the first level. Information including rotating speed and oil mass is mainly displayed on the bilateral histograms of the large dial and belongs to the second level. Secondary information including gears and indicator lamps is mainly displayed on the bilateral dashboards of the histograms and belongs to the third level. Such three-level information management is divided into obviously primary and secondary parts and saves the driver's time in information processing. The information hierarchy of a Volvo S60 dashboard is showed in Fig. 1. G3 dial inherits from G2, and neither their overall layouts nor hierarchies are largely different, except that the ratio design is more humanistic. The ratios of first level to second level are largely different, which helps the driver with information identification.

Generally, the evolution of the information framework of Volvo S60 dashboards shows that the overall dashboard design becomes increasingly simplified and the driving information management becomes more humanistic, which provide more values for reference.

2.3 Color Diversification

G1 dashboards met the basic driving requirements and their traditional pattern of red pointers and yellow caution icons attracted the driver's attention within short time. In comparison, G2 dashboards had more colors. The newly-added green danger zone indicates the colors are worth of reference, but this half-animatic display has some limitations, as it is unable to display the complete information. Moreover, the exposed dials tend to cause visual fatigue. The patterns of G1 and G2 Volvo S60 dashboards are showed in Fig. 2.

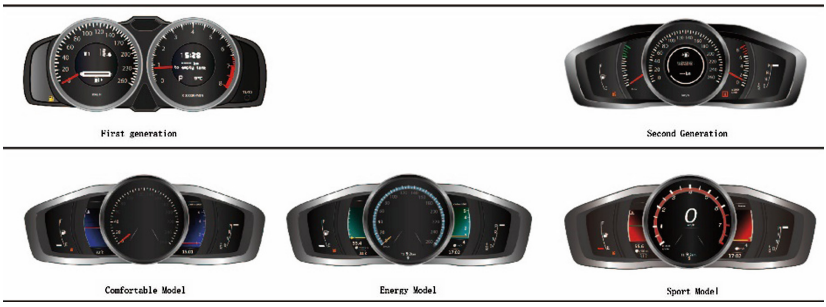


Fig. 2. The family dashboard information architecture (Color figure online)

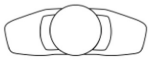
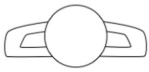
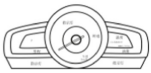
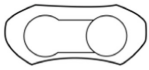
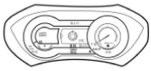
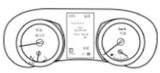
The design of G3 dashboard has been significantly improved, as the TFT high-resolution screen is fine and textural and displays concise information. Such design is fully human-oriented and has inherited the conventional Scandinavian style. The three patterns of elegance, ecology and optimization have enriched the driver's driving experience. Meanwhile, the proportion of colors is obviously increased, which improves the human-machine affection and reflects the principle of personal experience. With the dazzling pattern as example, the single-circular main dashboard displays both speed per hour and rotating speed, and the large-area red color is regarded as generality and naturalness, which brings the driver with infinite dynamic experience. The pattern of a Volvo S60 G3 dashboard is showed in Fig. 2.

By studying the characteristics of Volvo S60 G3 dashboards, we find the general design has been gradually improved with innovations. The dashboard shape and information framework become increasingly simplified and the colors are gradually enriched. The use of TFT increases the storage of dashboard information and largely improves the driver's driving experience. Clearly, an appropriate layout directly affects the information framework, promotes the hierarchical management of driving information and plays an unignorably role in safe driving.

3 Transversal Analysis of Car Dashboard Interfaces

Here the top five dashboards from 2014 world vehicle safety ranking were selected and used into transversal analysis, which covered six aspects: dashboard pattern, overall layout, information framework, basic information list, color collocation ratio, and styles. The results are listed in Table 2.

Table 2. The horizontal analysis table of five sample instrument panel

Dashboard style	Layout	Information architecture	Information list
			Speed Revs Time Temperature Miles Oil Light
			Revs Time Temperature Miles Oil Light
			Speed Revs Time Temperature Miles Oil Light
			Speed Revs Time Temperature
			Speed Revs Time Temperature

3.1 Obvious Brand-Related Characteristics

The five dashboards have different patterns and obvious brand-related characteristics. The Volvo S60 single-dial dashboard has a simple layout and inherits the previous Scandinavian style. Subaru Legacy has a circular or semi-circular collocation dial, and the overall layout is significantly different. Meanwhile, the double "cannon-typed" dial is matched with a red pointer, which improves the attention and indicates a sense of activity and vitality. Mazda 3 Axela barrel-shaped single-dial has a layout with a red remarkable zone, which conveys an "active" style of both passion and strength. Lincoln MKZ adopts a circle and large-semicircle combined pattern for information display, which is unique and brightly-colored. This layout inherits the Ford style with obvious American elements and a strong sense of scientificness. The Infiniti Q50 dashboard, known for its sensibility, obeys the traditional overall layout, but the "double-wave" strength aesthetic design integrates both functionality and visual aesthetics from the field ergonomics. The seemingly traditional layout embodies a detailed design, and the wave-shaped frillings with remarkable and fresh blue color express the flexibility and softness of sea elements.

3.2 Information Framework Personalization

By analyzing the information frameworks of Volvo S60 dashboards, we find the information framework would directly promote the hierarchical management of driving information and save the driver's time in information processing. The information frameworks of the five tested dashboards are showed in Fig. 3, including the frameworks and contents in Table 2. These five dashboards basically have the same contents, including vehicle speed, rotating speed, time, temperature, gears, driving range, oil mass, water temperature and indicator lamps, but they are different in layouts. The information management is divided into three levels of "large, small, large", indicating a trend of individuation, except Infiniti Q50, whose layout is very traditional (two-level). These four dashboards all place the first-level information into the central part with a large area in the dial. The second-level information is only after the first level and accounts for a smaller area, while the third level occupies the remaining area, which is very large. The second-level information attracts the driver's attention through

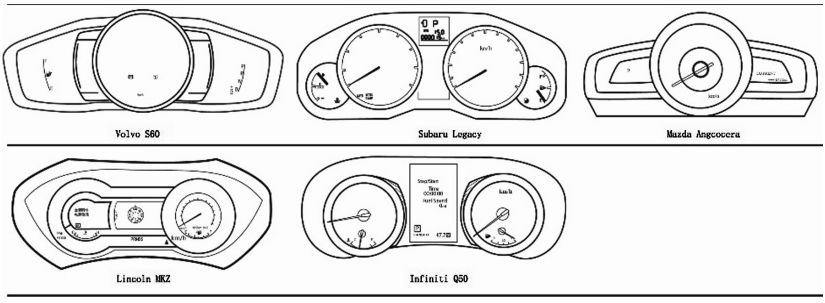


Fig. 3. The information architecture of five sample instrument panel

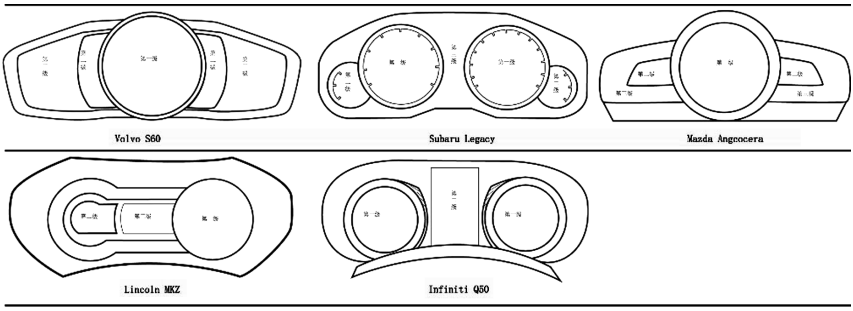


Fig. 4. The layout and information level of five sample instrument panel

a very special shape. For instance, the Volvo S60 is cylinder-shaped; the Subaru Legacy is a 3/4 circle; Mazda 3 Axela is wing-shaped; Lincoln MKZ has a very special shape in both the second and third level information, which deserves further analysis. On this basis, the personalized hierarchical information management is mainly manifested as the shape and ratio of the second level information. The layouts and information hierarchy of the five samples are showed in Fig. 4.

3.3 Rich Interface Vision Elements

The final trait is the effects of frills on the dashboard. Frills play a highlighting role in dashboard shapes, but may be easily ignored. Of the five dashboards, frills were only done by Infiniti Q50. Specifically, it inherited the sea elements, as the wave-shaped design strengthened the style of strength esthetics and showed a strong feeling of perceptual design.

By analyzing these five dashboards, we find the dashboards have obvious brand-related characteristics and their information frameworks indicate a trend of individuation. Specifically, hierarchical information management is accompanied by special shape elements, which contribute to the driver's height identification. Moreover, as for design of interface vision elements, the number of dials also affects the trend of dashboard shapes. Frills, as a part of detailed design, frills play a highlighting role and contribute to the driver's driving experiences. Among the five dashboards, the biggest breakthrough is from the digital hidden design of Volvo S60, which improves the driver's perception accuracy and largely contributes to safe driving.

The interface visual elements of a car dashboard include size, shape and color of graphs, and in particular, the elements that should be displayed on media, including texts, graphs, insets, pics, tables, frills and color blocks. During interface design, the use of visual elements affects the direction of interface styles.

First, we selected five dashboards and adopted the display pattern of TFT animation. The five dashboards are illustrated in Fig. 5. The difference is that the Volvo S60 adopts a TFT intellectual multi-pattern digital dashboard that is fully created by liquid crystal screen, while the other four dashboards only use local liquid crystal effect and reserve the characteristics of physical dial meters. Based on the advantages of TFT, the Volvo

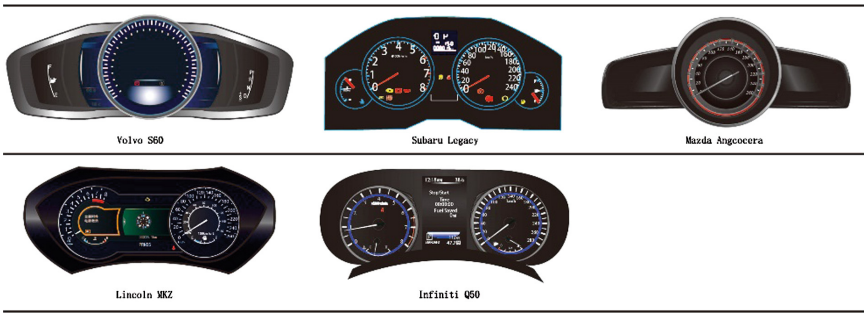


Fig. 5. The style of five sample instrument panel (Color figure online)

S60 dashboard has an outstanding trait – digital hidden design. The data vary along with the change of speed, and the match of striking colors could improve the precision.

The second trait is the effects of shape and colors on the whole dashboard. Of the five dashboards, the dial has a significant effect on the shape of the whole dashboard. The single-dial dashboards represented by Volvo S60 and Mazda 3 Axela have significantly different shapes from the other three double-dial dashboards. The single-dial shape is narrower and longer and shows a feeling of flexibility, while the double-dial shape is thicker and expresses a feeling of heaviness. Color is a key influence factor on the pattern of the whole dashboard, and the design of large-area color blocks interferes with user experience. With the middle display zone of Lincoln MKZ as example, based on its entertainment function, this zone has rich colors and enhances the feeling of driving experience.

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4 Rules in Digital Car Dashboard Interface Design

4.1 Concise Layout

During dashboard interface design, the key information is displayed on the first level and should be conveyed to the driver as soon as possible, while the supplementary

information is exhibited at the second and third levels or the interactive sub-interface. An efficient way is to provide such marking information on the start-up screen of the program, so that such information could be designed in a very attractive way and inform the driver they are entering the corresponding program [10]. Otherwise, the large amount of information puzzles a new user and reduces the speed of a mature user, as well as increases the possibility of wrong operation. Thus, the layout information hierarchical management should be conducted at an appropriate way. Another way is the rule of "less is more". The Volvo S60 dashboard interface offers a good reference.

4.2 Color Appropriateness

Color is a key step during the user-dashboard interfacial interaction and should be used carefully. Jakob Nielsen proposed three rules for color use during interface design. First, do not use too many colors, and appropriately 5–7 colors. Also light-gray or soft colors are more suitable than bright colors for being used as background colors. Second, ensure the interface can be used in different colors, so that the user can use the interface if he/she is unable to differentiate colors, such as the blind people. Third, use colors only for differentiation and emphasization, rather than for provision of information, especially quantitative information. These three color use rules can be well validated by the five samples. As for selection of bottom color, we suggest black or gray, and the sample has 5–7 colors. Some important information colors, such as pointer, scale, character colors, and indicator light, can also be well redundantly indicated, ensuring it is accessible to special populations.

4.3 Color Appropriateness

Perception and experience are needed in cognizing higher-efficiency higher-level design. Research on perceptual experience is generally divided into two patterns. First, the Western emotional design or experience design is able to acquire user-related information about emotion or experience, through user participation in research or activities, and use into design. The other is the Japanese perceptual design, which focuses on the mapping between perceptual elements and design elements as well as algorithms, and its research method is more quantitative. From the perspective of experience design, the tested five dashboards all reserve the respective brand characteristics in style and type, and have brought users with different driving experiences. The most representative is still Volvo S60, which provides three patterns of ecology, elegance and optimization that promote the human-machine interaction and bring good news to the boring drive. This modern esthetics with strong human kindness has catered to the public.

The above design rules suggest that the dashboard interface should be designed to be concise and efficient (Fig. 6).

Fig. 6. Interface design of automobile instrument panel

5 Conclusion

Research on car dashboard interface design under the background of digitalization is a novel topic, which deserves systemic development from the perspectives of design contents, methods and flowchart as well as abundant experimental validation. With the popularization of the Internet+ technology, the car dashboards will bring new experiences in design contents and interactive technology, but are also faced with challenges. In this study, we selected only five dashboards for systematic research and proposed some design rules, which should be further explored. Nevertheless, with the technical progression, the human-dashboard interaction will become increasingly efficient under the premise of safe driving. Personalized driving experience is a key trend in the field of dashboard design.

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