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Ergonomic design of electric vehicle instrument panel: a study case on Universitas Indonesia's national electric car

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Abstract. An electric car is an environmentally friendly car that becomes an alternative substitute for a conventional car. Similar to a conventional car, it is also completed with an indicator panel on its dashboard which is a display to present information to connect machine and human on a real time. However, there are some differences information required between electric car's indicator panel and the conventional car's indicator panel. This research is conducted to find the proper design and also to complete information requirements of indicator panel of an electric car, and the object of this research is The Universitas Indonesia's National Electric Car. This research conducted based on two major aspects, that is consumer's preferences, using conjoint analysis to obtain top three design, and also ergonomic, by testing three combinations of indicator panel design which produced by conjoint analysis using eye tracking method, in order to enhance the value of indicator panel for Universitas Indonesia's National Electric Car and also to meet consumer's preferences and needs. This research found the best design combination that has the least number of fixations and saccades eye movement, also the least response time.

1. Introduction

Indonesian society is currently very dependent on the motor vehicle to make the shift from one place to another. Based on data derived from the Traffic Police Corps of the Republic of Indonesia in 2014, the population of motor vehicles in Indonesia increased from 94.2 million units in 2012 to 104.2 million units in 2013. Motor vehicles passenger cars occupy the second position as where the largest population increase in the amount of 9.77% over the last five years [1].

The transport sector is the sector of final energy user after the second largest commercial industrial sector. Almost all energy consumption in the transport sector in the form of fuel oil (BBM). Fuel consumption during the years 2000-2012 increased by 1.9% per year. Approximately 89% of fuel consumption in the transport sector is the consumption of road transport sub-sector. The high level of fuel consumption is due to the high rate of fuel consumption of private vehicles [2].

Side effects that occur due to the high number of motor vehicle-based fuel is air pollution. One of the exhaust emissions of conventional vehicles are carbon monoxide (CO) gas which is toxic to human health. Based on reports from the WHO, from 5 cities in Indonesia, such as Jakarta, Surabaya, Bandung, Pekanbaru, and Medan, observed, only the city of Pekanbaru, at 11 ug / m³, which has an average pollution standard per year below the WHO standard, that is equal to 20 ug / m³ [3].



See from the above explanation, some of which promote the need for a solution in the form of alternative energy that replaces the fuel as the fuel is more environmentally friendly. In 2012, the President launched the National Electric Car Program (Molina) as electric cars would reduce dependence on oil and to support the Low Carbon Emission Program Project (LCEP) due to the electric car is a vehicle that does not produce the same emissions once (zero emission).

Higher Education appoint the Universitas Indonesia (UI) as one of the university that is assigned to participate in the development program of the National Electric Cars. According Baskoro (2015), development is still focused on the development of the engine alone. Universitas Indonesia are now replacing conventional car engine in accordance with the needs of electric cars, to test the machine, as well as data collection to determine what improvements are needed. However, from the exterior and interior of the National Electric Cars UI still uses the original design that exist on the old car, the Nissan March.

Just like a conventional car, the electric car is also equipped with an indicator panel which is an important part as a source of information that communicates between the actual condition of the vehicle's engine with the driver so that the driver can take action quickly and responsive when there is something happened on the vehicle [4].

With the existence of some differences in the indicators is needed, should the indicator panel design were developed as possible in order to provide comfort to the driver. Because of the importance of the indicator panel for comfort and safety of the driver in driving should be designed indicator panel allows the driver to read the information on the display (Buhr et al., 2003). Poor indicator panel design can cause interference receipt of information to the driver that it cannot respond quickly and responsiveness. The design forms the indicator panel also aims to decimate the risk of driver error in reading and understanding the information on the display panel indicators [5].

In doing designing a product, of course, we design according to desired by consumers. So that the products made will indeed be able to meet the needs of the market. But it would be nice if in designing a product we add the human factor. Because with the addition of human factors in the design of a product can make the products used into ergonomic [6]. Results from the design of the product will also become more effective and efficient, improve safety and comfort, as well as increase the level of satisfaction of consumers.

From all the explanation above, conducted research focused on designing the display panel Electric Car dashboard indicators to the National Universitas Indonesia on the basis of consumer preferences by using conjoint analysis and the additional side of ergonomics by using eye tracking is that the proposed design better meet the needs of consumers.

2. Methodology

2.1. Interviews with Expert

Before doing this research needs to be done interviews with experts who are involved in the process of making the National Electrical Drives, Universitas Indonesia. This interview was conducted to determine the condition of existing indicators panel display at the National Electrical Drives, Universitas Indonesia today as well as key indicators to know what needs to be displayed on the indicator panel of the electric vehicle.

2.2. First Questionnaire

In the first stage questionnaire survey conducted early to determine the general knowledge of respondents about electric vehicles, especially with regard to the indicator panel. Additionally, at this stage to identify the shape attributes desired by consumers and will serve as a reference to create a combination of attributes is done in phase 2 questionnaire.

2.3. Attribute Determination

Attributes in this case a variety of specific factors which have an influence on the needs of the display panel indicators on the dashboard of electric vehicles. These attributes are determined through the study of literature, benchmarking with the indicator panel design electric vehicles that exist abroad, the interview and questionnaire results support data from phase 1.

2.4. Second Questionnaire

Phase 2 questionnaire compiled to determine consumer preferences on the design of the indicator panel on the dashboard. At this stage the attributes and levels will be combined into a single unit and formed several design options that will each design options will be assessed by the respondents using a scale rating (metric) is a Likert scale of 1 to 5 where higher values indicate higher preference. Results of the questionnaire stage 2 will be processed using conjoint analysis method with SPSS Statistics 17.0 in the treatment process.

2.5. Design Testing Using Eye Tracking Method

Testing combinations indicator panel design using eye tracking method aims to see which combinations are most comfortable, easy to understand and informative for respondents (ergonomic). It will be analysed in terms of response time is the respondent in finding the quickest icon and the number of fixations and saccades the least, because the number of fixations and saccades are much less efficiency indicates a display [7].

At this stage the respondents will be paired eye tracker tool, to detect eye movements and asked for driving using a driving simulator for 5 minutes in which every one minute will be given orders to look for the icons on the panel indicators mentioned verbally and respondents were asked to respond verbally.

Respondents for testing the indicator panel design using eye tracking method is the respondent who is also a respondent in the questionnaire stage 1 and stage 2. The number of respondents who would be tested as many as 10 people aged 20-25 years with a composition of 5 male and 5 female sex, where it adjusts from the highest percentage of respondents, i.e. by 53%, which is at the vulnerable age of 20-25 years and to adjust the composition of the sex composition percentage of respondents by sex on stage questionnaire respondent 2. Other criteria should also be able to drive and has a driving License A, because in this test will be required for driving using a driving simulator.

3. Discussion

3.1. Conjoint Analysis

The data generated from data processing using methods such as conjoint analysis utility values (utilities) and the value of interest (importance value). Utility value is the value that indicates the level of consumer preferences of each level where if a level more preferably it will be worth more positive. While the value of the benefit is the most important value of an attribute that has an influence on the decision of the respondent and taken into account in selecting the design of the indicator panel tested. Assessment given of respondents to any combination indicator panel design is based on comfort level and ease of reading and design that attracted the attention of the respondents.

Can be seen in Table 1, the highest utility value for the attribute layout is the layout of A with a value of 0.163, to attribute speedometer is digital type, text, numbers, graphics with a value of 0.259, for the battery capacity is analogue type, text, symbols with a value of 0.056, for the driving range are digital type, text, numbers, symbols with a value of 0.066, to ready-to-drive is a digital type, text and symbols, with a value of 0.032, and for Eco meter is digital type and text with a value of 0.006.

In selecting three best combination of attributes, then the value of each existing utility on the results of phase 2 questionnaire summed. The amount of the highest utility value indicates that the combination is most preferred by respondents. Conversely, if the total value of the combination of low utility the least preferred by respondents. Based on the sum of the value of the attribute utility, obtained three panel design combination of the best indicators that can be seen in Table 2.

Table 1. Result of Utility Value

Attributes		Utility Estimate	Std. Error
Layout	A	.162	.042
	B	-.142	.042
	C	-.020	.051
Speedometer	Analogue numeric text	-.005	.042
	Digital numeric text	-.254	.042
	Digital graph text	.259	.051
Battery Capacity	Analogue numeric text	-.010	.046
	Analogue symbol text	.056	.058
	Digital text	-.040	.058
	Digital numeric symbol	-.007	.058
Driving Range	Analogue numeric text	-.050	.042
	Digital numeric text	-.016	.042
	Digital symbol text	.066	.051
Ready to Drive	Digital box	.008	.042
	Digital text	-.039	.051
	Digital symbol text	.032	.042
Ecometer	Analogue graph text	-0.024	.042
	Digital text	.006	.042
	Digital symbol text	-.018	.051
Constant		3.233	.039

Table 2. The third best combination of indicator panel

Card ID	Layout	Speedo meter	Battery Capacity	Driving Range	Ready to Drive	Ecometer	Total	Rank
14.	0.163	0.259	0.056	0.066	0.032	0.006	0.582	1
28.	0.163	0.259	-0.04	0.066	0.032	0.006	0.486	2
9.	0.163	0.259	-0.007	-0.016	0.008	0.006	0.413	3

3.2. Eye Tracking

The number of fixations and saccades describe the movement of the eye in looking icons. The more the number of fixation or saccade in search icon, then the indicator panel design is less efficient because the respondent had to do a great effort and much longer in his quest. Figure 1 displays the scan-path pattern that consists of data fixation (blue circle) and saccades (orange arrows) on the indicator panel design combination of 14, 28 and 9.



Figure 1. (a) Scan-path Graphic of Design 14; (b) Scan-path Graphic of Design 28; (c) Scan-path Graphic of Design 9. The details of the difference between this 3 designs explained in Table 2.

3.2.1. Analysis Based on Total Fixation. Fixation is the focal point of a view when respondents observe the target. In this study, the data used is the total fixation of each indicator panel design was tested using eye tracker. Data ANOVA total fixation have been tested to see how much significance mean the total fixation on the design 14, 28 and 9.

Processing results of ANOVA shows a significant difference between the mean of the total fixation on the design of 14, 28 and 9 (p value <0.05). If seen from the bar chart in Figure 2, the design of which has the fewest number of fixation is 14 design, i.e. a number of 30. This indicates that at the time of testing eye tracking respondents easier to find the icons according to the command so that the design of the 14 design. The most efficient, this statement is consistent with previous research that indicates the number of fixations that much less efficient [7].

3.2.2. Analysis Based on Total Saccade. Saccade is a fast eye movement between the fixations. In this study, the data used is total saccade to see which design most efficiently by looking at the amount of at least of the total design of the indicator panel on saccade 14, 28 and 9. Total data to be tested using the method will be saccade ANOVA to see its significance between the mean of the total design on each saccade panel indicators to find out whether the existence of a significant difference between the mean of the total design on saccade 14, 28 and 9. The results show that the existence of significant difference between the mean value of the saccade (p -value <0.05)

Bar chart in Figure 3 indicates that the average of the total design of the indicator panel on saccade 14 totalled at least, that a number of 31.6. These results indicate that in the design panel indicator 14, respondents did a little movement of the eyes in the search for icons during testing using eye tracker. So the combination of these three designs are tested, the design of the indicator panel 14 is the most efficient design because it has the fewest number of saccade which is in accordance with statement of Goldberg and Kotval (1999) that the number of saccade which many records indicate less efficient [7].

3.2.3. Analysis Based on Response Time. During testing using eye tracker, respondents were asked to drive a car on the simulator and the minute predetermined respondents were asked to look for indicators according to the instructions. Fastest response time for searching for icons that indicate that the respondent was ordered to be easy to do a search. Data on average of the response time will be tested using ANOVA test to see if the difference between the averages of the response time on the design of the indicator panel 14, 28 and 9.

Research on human factors have shown that the average time to see the display panel indicator is 2.7 seconds which is the time when the maximum permissible safety when driving at a speed of 30 km/h. In the bar chart shown in Figure 4, the average response time on the design of the indicator panel 14 is the fastest response time, i.e. at 2.44 seconds. It can be concluded that the design includes a safe design for the driver because the average time of less than 2.7 seconds.

3.2.4. Final Recommendations Design of Indicators Panel. Taking into account the total of the number of fixations and saccades value of currency movements as well as the response time, the combination of the best design is a combination that has a total value of at least fixations and saccades and the fastest response time on the search icon on the indicator panel. The combination of the best designs that satisfy both a combination of design 14 (Figure 5), where the average value of the total fixation of 30, the average value of the total saccade 31.6, and for the average value of a response time of 2, 44 sec.

Analysis of eye movement that shows the most efficient display produces a combination of 14 as the best combination. The election of a combination of the designs can be caused by the shape of the icon located on the panel of more use than the symbolic form of text. Symbol can be more quickly and accurately to be seen by men as compared with writing or text [8].

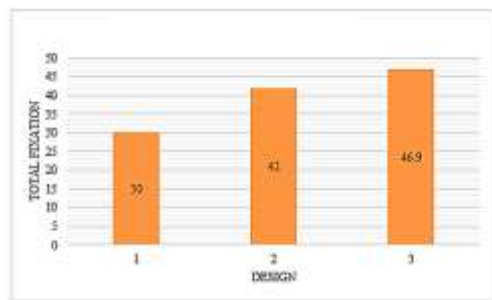


Figure 2. Average Value of Total Fixation (Design 14, 28 and 9)

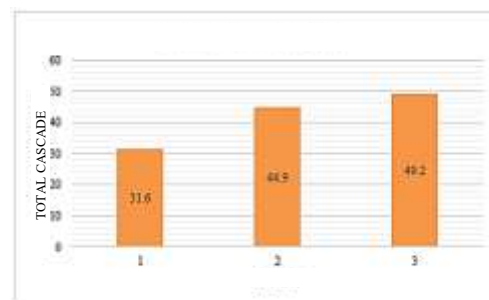


Figure 3. Average Value of Total Saccade (Design 14, 28 and 9)

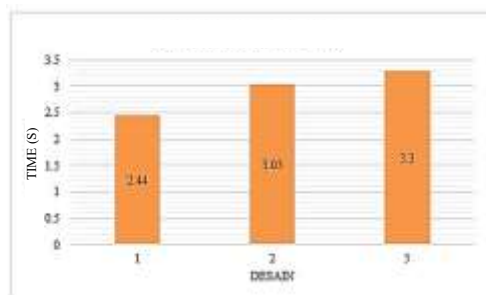


Figure 4. Average Value of Response Time (Design 14, 28 and 9)



Figure 5. Design Recommendation for Panel Indicator

4. Conclusion

From the analysis of the total of the number of fixations and saccades eye movement and response time in finding the icons on the display panel indicators, it was found that the combination of 14 is the best combination, both in terms of consumer preferences and in terms of the efficiency of eye movement (ergonomics). 14 comprises a combination of the layout types A, speedometer with digital type, text, numbers and graphics, battery capacity with analogue type, text and symbols, driving range with digital type, text, numbers and symbols, ready to drive the digital type and symbol, as well as Eco meter with digital type and text.

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