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Evaluation of the usability of certain symbols indicating automobile lighting status

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A R T I C L E I N F O

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A B S T R A C T

The research presented in this document addresses the ability of drivers to understand what information has been presented by symbols that are used to indicate certain status of vehicle lights. The concept known as usability can be applied extensively to ergonomic design and testing of a wide range of products and systems, including cars. In order to assess drivers' understanding of what information is exactly presented by symbols that are used to describe the state of the lighting system of an automobile, a usability test was designed. The test included 4 symbols, three of which were ISO-approved symbols. This study of usability of symbols on a sample of drivers showed that understanding of information represented by symbols is relatively low, ranging from 41.93% to 61.29%. Certain statistical tests allow for prognosis results on a population level, using the data based on a sample. For that purpose, we used the Z-test of a sample proportion. Testing of statistical hypotheses yielded even lower values of symbols understanding at the population level, for each tested symbol. Suggestions have been made to improve the usability of this type of symbol.

1. Introduction

A symbol is a visual image or sign representing an idea or universal fact (Harrison et al., 2008). By means of marks, signs, or words, symbols represent ideas, objects, and relationships. Symbols, according to (Rusiñol, 2010), are graphical entities with semantic meaning in a particular domain that convey the minimum amount of information necessary. Modern automobile dashboards can display a wide range of symbols. Nowadays, an increasing amount of information in vehicles is presented on small screens (Čičević et al., 2017; Liu et al., 2022). Also, the communication between the driver and the vehicle is directed through the touch screen (Pitts et al., 2012; Tao et al., 2021). The interaction between the driver and the symbol can be viewed as a two-step process. The driver should first determine what the symbol indicates, i.e., whom or what it stands for. The driver subsequently needs to comprehend the information conveyed by the symbol in connection to the entity it stands for. However, the design of some symbols makes it impossible to make such a difference, leading to a simultaneous process of comprehension and recognition of the symbols' meaning.

It is difficult to discover such studies on the symbols used on car displays in the literature. One technical paper (Saunby & Farber, 1988) about this kind of research from 1988 was found through our search. Despite relatively high levels of recognition, low levels of understanding of car display symbols were observed in this study.

2. Goal of the Research

There are many different symbols on modern cars that provide the driver with information about the vehicle, the driving mode, or the road conditions. However, some drivers fail to make adequate use of all the information available to them. This can be because of a misunderstanding of the information represented with the aid of using the displayed symbol.

For testing whether drivers understand the displayed information, four symbols representing automotive lighting were selected. However, even if the driver is unfamiliar with the meaning of the symbols, a properly designed symbol should convey the information.

3. Method

In order to verify the quality of design solutions for car display symbols, four symbols representing car lighting were selected. The names of these symbols are:
1. Tail light out
2. Front fog light (according to ISO 7000-0633 standard)
3. Headlamp levelling control (warning purpose), (according to ISO 7000-0151 standard)
4. Daytime running lights (application of ISO 7000-2611 standard).

A concept known as usability can be applied extensively to the ergonomic design and evaluation of a variety of products and systems (Zunjic & Leduc, 2018). A variety of usability testing methods has evolved from strict experimental psychology methods to less controlled and more qualitative ones today (Fox, 2015). Research methods such as classical experiments are the foundation of usability testing. Tests can take many forms, from large-scale classical experiments to very informal qualitative studies conducted with only one participant (Rubin & Chisnell, 2008). Below, we will describe a usability experiment that was used to determine the usability of 4 symbols, which are used on car displays.

Table 1. Symbols used in the research, offered answers related to their meaning (function) and correct answers

Ordinal number of symbols	Symbol	Answers offered	Correct answer
1		a) Failure of any headlight b) Tail light out (failure) c) Turn signal malfunction	Tail light out
2		a) High beam b) Daytime running light c) Front fog light	Front fog light
3		a) Faulty headlight leveling system b) Headlight leveling system activated c) Headlight leveling system off	Faulty headlight leveling system
4		a) Daytime running light b) Fog lights c) High beam	Daytime running light

Table 1 displays the symbols in the order they are listed. The basic function of the first symbol is to convey information that the tail light is not in function. The purpose of the second symbol is to indicate the activation of the front fog light. The function of the third symbol is to indicate the malfunction of the headlight leveling system. The purpose of the fourth symbol is to indicate the activation of the daytime running light. As can be seen, the use of symbols 2, 3 and 4 is recommended by the ISO (International Standard Organization).

The survey was completed by 31 respondents, 24 of whom were men and 7 of whom were women. The average age of respondents was 22.67 years (standard deviation 2.49 years). The respondents all had valid driver's licenses. Other demographic data were also collected from respondents.

Despite selecting younger drivers, the sample was random within that group. Choosing the younger drivers was based on the assumption that the training's instructions and content were still fairly fresh as well as the fact that these respondents had taken more recent driving courses (modern ones). Respondents participated voluntarily.

The purpose of the test was explained to the participants at the outset. They were then given forms to fill out on their own. For each symbol, three answers were given, but only one was correct. The provided answers are listed in the third column of Table 1. The correct answer is shown in the fourth column of Table 1. The respondents were asked to circle the option (a, b, or c) that they thought was the correct answer. Also, respondents were required to circle a number on a five-point scale corresponding to their belief that the rounded answer was correct (1 - not sure at all, 5 - completely sure) for each answer given (whether correct or incorrect).

There was an additional goal in mind when selecting options for offered responses. As opposed to most other symbol-based research, which offers names that have nothing to do with the symbol (or have relatively few touchpoints) in addition to the correct name (meaning) of the symbol, this research, in addition to the correct meaning of the symbol has primarily offered those options that have something common with the symbol, but do not match to the exact meaning of the symbol. The goal was to see how accurately a specific symbol could convey targeted information and whether the respondent could incorrectly interpret a specific function of a symbol.

4. Results

The percentage of correct answers for each symbol tested is shown in Table 2. In this table, the column "average" refers to the average value of the respondents' answers on a scale of 1 - 5 regarding their belief that they provided the correct answer, i.e. that the presented symbol has the meaning that they rounded off in the test form. The table's standard deviation column shows the standard deviation in relation to the respondents' self-reporting that they provided the correct answer.

Table 3 shows the percentage of incorrect answers for the first incorrect choice. In this case, the first wrongly chosen option is the wrong answer with a higher error rate than the error rate associated with the other wrong answer given as a possibility. In this table, the column "average" denotes the respondents' average response on a scale of 1 to 5 regarding their belief that they provided the correct answer (despite the fact that such an answer is incorrect), i.e., that the displayed symbol has the meaning they rounded out in the test form. The table's standard deviation column refers to the standard deviation for respondents' estimates of their confidence in providing the correct answer (regardless of whether the answer is wrong).

Table 2. Percentage of correctly recognized symbols, average and standard deviation of respondents' belief that the symbol has the meaning given in their answer

Symbol	Percent of correct answers (%)	Average	Standard deviation
	58.06 %	3.39	1.037
	61.29 %	4.5	0.901
	41.93 %	3.07	1.656
	41.93 %	3.46	1.127

Table 3. The percentage of incorrectly recognized symbols for the first incorrectly chosen option, average and the standard deviation of the respondents' belief that the symbol has the meaning given in their response (regardless of the fact that the answer is inaccurate)

Symbol	Percent of incorrect answers for the first incorrectly chosen option (%)	Average (for the first incorrectly chosen option)	Standard deviation (for the first incorrectly chosen option)
	22.58 % (a)	3.71	1.253
	25.81 % (a)	3.25	1.388
	38.71 % (c)	3.083	1.676
	35.48 % (b)	4.09	1.136

The percentage of incorrect answers for the second incorrectly chosen option is shown in Table 4. In this case, the second incorrectly chosen option is the incorrect answer with a lower error rate than the error rate associated with the remaining incorrect option offered as a possible answer. The "average" column in this table refers to the average value of respondents' responses on a scale of 1 to 5 regarding their opinion of having given the correct answer (regardless of whether such an answer is incorrect), i.e., that the presented symbol has the meaning that they have rounded in the test form. The table's standard deviation column refers to the standard deviation for respondents' belief in having given the correct answer (regardless of the fact that the answer is also wrong).

Table 4. The percentage of incorrectly recognized symbols for the second incorrectly chosen option, average and the standard deviation of the respondents' belief that the symbol has the meaning given in their response (even though such a response is inaccurate)

Symbol	Percent of incorrect answers for the second incorrectly chosen option (%)	Average (for the second incorrectly chosen option)	Standard deviation (for the second incorrectly chosen option)
	19.35 % (c)	3	1.095
	12.90 % (b)	3.75	0.957
	19.35 % (b)	3.5	1.048
	22.59 % (c)	3.714	1.253

5. Analysis

From table 2 it can be seen that for no symbol, the percentage of correct responses did not exceed 61.3 %, while for symbols 3 and 4 percent of symbol recognition is at the level of about 42 %. These are the values obtained on the selected sample. However, if we are interested in the situation on this issue at the population level, it is necessary to test certain statistical hypotheses.

For the "tail light out" symbol, the following null and alternative hypotheses for the population proportion need to be tested:
H_0: $p \le 0.44$
H_a: $p > 0.44$

This corresponds to a right-tailed test, for which a z-test for one population proportion will be used. The significance level is $\alpha=0.05$, and the critical value for a right-tailed test is $z_c = 1.645$. The rejection region for this right-tailed test is $R = \{z: z > 1.645\}$. The z-statistic is computed and it is $z = 1.58$. Since it is observed that $z = 1.58 \le z_c = 1.645$, it is then concluded that the null hypothesis is not rejected. If we use the P-value approach, the p-value is $p = 0.0574$, and since $p = 0.0574 \ge 0.05$, it is concluded again that the null hypothesis is not rejected. Therefore, we can conclude that there is not enough evidence to claim that the population proportion p is greater than 0.44, at the $\alpha = 0.05$ significance level.

For the "front fog light" symbol, the following null and alternative hypotheses for the population proportion need to be tested:
H_0: $p \leq 0.47$
H_a: $p > 0.47$

This corresponds to a right-tailed test, for which a z-test for one population proportion will be used. The significance level is $\alpha=0.05$, and the critical value for a right-tailed test is $z_c = 1.645$. The rejection region for this right-tailed test is $R = \{z: z > 1.645\}$. The z-statistic is computed and it is $z = 1.59$. Since it is observed that $z = 1.59 \leq z_c = 1.645$, it is then concluded that the null hypothesis is not rejected. If we use the P-value approach, the p-value is $p = 0.0555$, and since $p = 0.0555 \geq 0.05$, it is concluded again that the null hypothesis is not rejected. Therefore, we can conclude that there is not enough evidence to claim that the population proportion p is greater than 0.47, at the $\alpha = 0.05$ significance level. In both previous calculations have been satisfied conditions for sample size that $np > 5$ and $n(1-p) \geq 5$ ($n \geq 30$).
In an identical way, for the "headlamp levelling control" symbol, it was tested hypothesis H_0: $p \leq 0.29$, which is not rejected ($p = 0.0563 \geq 0.05$). Therefore, we can conclude that there is not enough evidence to claim that the population proportion p is greater than 0.29, at the $\alpha = 0.05$ significance level for this symbol. For the "daytime running lights" indicator, it was tested hypothesis H_0: $p \leq 0.29$, which is also not rejected ($p = 0.0563 \geq 0.05$). Therefore, we can conclude that there is not enough evidence to claim that the population proportion p is greater than 0.29, at the $\alpha = 0.05$ significance level for the daytime running lights symbol.

6. Conclusion

Based on the results of this research, it can be concluded that the percentage of correctly understood symbols is surprisingly low, especially if we take into account that these are symbols that are often used in vehicles. The symbol that was best understood is the front fog light. The least understood symbols were headlamp levelling control and daytime running lights (equal performance of understanding). However, it can be assumed that participants mixed answers because options of names of the offered symbols were mainly connected with the symbols, but they did not represent the exact meaning (except the option for exact meaning offered for each symbol).

It is important to emphasize how the values for p_0 were chosen when testing statistical hypotheses. The stated values for the proportion p_0 (0.44, 0.47, 0.29 and 0.29) were obtained for each symbol individually based on the calculation. This means that the z-test for one population proportion was applied iteratively, until a limit value of p_0 was reached for each symbol, at which the set null hypothesis cannot be rejected. In other words, it means that in the population, statistically viewed, the percentage of correct understanding of the symbol "tail light out" cannot be expected to be higher than 44 %, as well as that the percentage of correct understanding in the population for the symbols "front fog light", "headlamp levelling control" and "daytime running lights" cannot be expected to be greater than 47 %, 29 % and 29 % respectively.

The obtained results cannot be considered satisfactory. As a result, it is important to take the necessary steps to improve users' understanding and recognition of symbols displayed on car displays. This can be accomplished in two ways: education and redesign. Driving schools should pay special attention to this aspect of education when training future drivers. Furthermore, new design solutions for symbols that indicate vehicle lighting state could improve the ability to recognize this type of symbol, which is important for preventing possible accidents.

References

[1] Čičević, S., Trifunović, A., Mitrović, S., & Nešic, M. (2017). The usability analysis of a different presentation media design for vehicle speed assessment. In *Ergonomic Design and Assessment of Products and Systems*.

[2] Fox J E. (2015). *The Science of Usability Testing.* Proceedings of the 2015 Federal Committee on Statistical Methodology (FCSM) Research Conference, Washington Convention Center, Washington, DC

[3] Harrison I. et al. (2008). *Signs & symbols*. Dorling Kindersley Limited, London.

[4] Liu, X., Sun, H., Gao, Y., Zhang, W., Ge, Y., & Qu, W. (2022). Exploring the performance of click and slide gestures on large in-vehicle touch screens. *Applied Ergonomics*, 99, 103613.

[5] Pitts, M. J., Burnett, G., Skrypchuk, L., Wellings, T., Attridge, A., & Williams, M. A. (2012). Visual–haptic feedback interaction in automotive touchscreens. *Displays*, *33*(1), 7-16.

[6] Rubin J., & Chisnell D. (2008). *Handbook of Usability Testing* (second edition). Wiley Publishing, Inc., Indianapolis, Indiana.

[7] Rusiñol M., Lladós J. (2010). *Symbol spotting in digital libraries: focused retrieval over graphic-rich document collections*. Springer, London.

[8] Saunby, C. S., & Farber, E. I. (1988). *Driver understanding and recognition of automotive ISO symbols* (No. 885182). SAE Technical Paper.

[9] Tao, D., Zeng, J., Liu, K., & Qu, X. (2021). Effects of control-to-display gain and operation precision requirement on touchscreen operations in vibration environments. *Applied Ergonomics*, *91*, 103293.

[10] Zunjic A., & Leduc S. (2018). *Readability as a Component of the Usability of a Web Presentation - A Case Study from the Banking Sector*. Advances in Intelligent Systems and Computing 822, Proceedings of the 20th Congress of the International Ergonomics Association (Vol.5), Bagnara S., Tartaglia R., Albolino S., Alexander T., Fujita Y., Springer, pp. 441-456.