Auditory Interface Improvement of In-Vehicle Speech Interaction System

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ABSTRACT

According to a previous study, current Talking Car system has some defects on control button and guiding sentence for beginners. Therefore, the purpose of this study aimed to improve and analyze the usability of the Talking Car system. For the first part, control button data from five brands which are the most popular cars in the market were gathered and analyzed. Then, cooperated with expert advices the control button was redesigned. In the guiding sentence part, an experiment was conducted to realize the misunderstood and annoying degree of current guiding sentences, and to modify the guiding sentences. After all improvement, another driving simulation experiment was conducted. Based on the objective statistic data, the result indicated that task finished time has been decreased significantly. The shorter task finished time proved the system is more convenient and easier to use. With regard to evaluation of safety, react on times of emergency brake were decreased. Times of unsafe driving behavior like exceeding the speed and lane departure were decreased. In consequence, the system is more suitable using in driving. And in the subjective part, subjects are more satisfied with guiding sentence of beginner and control button. After improvement, Talking Car is easier to use and more fit to the beginners.

Keywords: auditory interface, guiding sentence, ergonomics design

INTRODUCTION

With recent advances in technology, there is a wide range of infotainment systems available inside vehicles. In despite of convenience all these technology bring, the safety of users is the most important subject we focused on. As we know, in term of safety and efficiency, auditory interface was better than the visual interface because visual interface strongly distracted the user's attraction while driving (Sodnik *et al*., 2007). Therefore, there are more and more auditory-only interface to be developed and used inside vehicles.

Because use of auditory-only interface differ from use of visual interface, to the people not get used to it, auditory interface present challenges in eliciting novice to use. To avoid unsafe behavior by novice operating inappropriately, the auditory interface with Novice Elicitation Function (Wei, 2013) has been developed. However according to the study (Chen, 2014), the inadequate interface of full voice-based design may cause user's error and then influence user's safety.

In order to make the interface to be provided with security and convenience, it's necessary to redesign an auditory interface more fit in with users. This research aimed to conduct a series of user interface improvement against an in-vehicle full voice-based interface named Talking Car and to verify the result of improvement by conducting driving simulation experiments.

BACKGROUND

System Sentences with Elicitation

System sentences with elicitation play an important role of user performance, what too fast presentation rate why make user difficult in comprehension. On the other hand, too slow presentation rate why make user bored in waiting information. Research for user preferences in auditory system (Eiriksdottir *et al*., 2006) showed that the inter-item gap should be between 1 to 2 seconds for novice is most comfortable and efficient. And the appropriate inter-item gap for people after practice is 0.73 seconds.

Control Button on Steering Wheel

While driving a vehicle, the posture that two hands separately put on the left side and the right side of steering wheel is the most natural one to controlling steering wheel. For this posture, using the thumb to press the control button can fit driving action and reduce operational errors of controlling auditory system. According to the research of ergonomically design (Chung, & Rantanen, 2010), the control buttons should be set in the area of 2.3 in long and angle of 80° from horizon.

Sign of Control Button on Steering Wheel

Although auditory system doesn't have any visual display that distracts user attention, the sign on control button will help the user to understand the system. For novices, the sign of control button make them easy to remember the function of buttons or to find out the position of control buttons. Users more familiar to the auditory system, number of operation errors will be decreased more. In the market, there are many control buttons designed by well-known vehicles, so we collect several brands that are most popular in the market.

METHOD

Experimental Ⅰ Design

To fully find out defects of system sentences with elicitation, the first experiment was conducted to examine totally 19 system sentences with elicitation. For simulating real driving activity, experiments were done in a driving simulator composed by solid steel construction, steering wheel and numeric keyboard. The special numeric keyboard was made to simulate the control buttons on the steering wheel for this experiment. Totally 16 subjects was recruited to conduct this experiment, numbers of female and male are equally in one half.

Experimental Ⅰ Procedure

Subjects were requested to listen to system sentences and answer some questions for each sentence while driving. Order of system sentences follows the order of task that was assigned to subjects. For each sentence, subjects answer several questions about degree of understanding, degree of elicitation, and degree of bored. There are five level of degree that subject can choose, from level one means totally agree to level five means totally not agree.

Result of The Experimental Ⅰ

Experiment Ⅰ was aimed to observe if subjects can use less attention to understand the system sentences while focusing on driving. As the result of data analysis, we can conclude several system sentences that have lower understanding level, elicitation level and higher bored level. These system sentences that have lower satisfaction will be redesign by following principles.

i. Adjust the intern gap of system sentences with elicitation.

Some subjects indicated that some intern gaps of system sentences were too long, and it leads them feel bored with. Although subjects can stop the system sentences if they feel bored, it may cause some miss of important information for them.

ii. The important information should be broadcasted earlier in a system sentence

For novices to use to auditory system, they need to get enough information to get into the next step. If the important information is in the end of sentences, they will be tired to wait for so long and so many times until get the function they need.

iii. Add some keywords with elicitation.

The result shows that some system sentences are too brief to understand by users, and it may create many operation errors. To avoid this, we review all system sentences and redesign them to be more completed and understandable.

Redesign Control Button of Steering Wheel

Although the buttons on the steering wheel are very helpful, it does not mean that more buttons are the better. In fact, the more buttons will let users feel confused about the buttons and correspond functions. Before improvement, the Talking Car system has 5 control buttons, including one voice activation button, two option change button and two break off buttons. To add new function that make system more convenient and decrease numbers of buttons with same function, the buttons on the steering wheel were designed.

Experiment II Design

After improving system sentences elicitation and control buttons on steering wheel, an experiment was conducted to verify the improvement. Numbers of 16 subjects need to finish tasks by controlling the Talking Car system while driving simulator. The subjects are with average of 3 years driving experience. The subjective questionnaire that is about satisfaction level and guiding level of Talking Car system would be filled out after finishing the tasks.

Experiment II Procedure

It took 5 minutes to introduce the driving simulator and the Talking Car system, and then the subjects practiced driving on the simulator for 10 minutes. The subjects spent around 20 minutes to complete all the simulated tasks. Once the task failure occurred, the subjects were asked to try again until they did it right to make the experiment carry on. After the test, the subjects took 20 minutes to fill out the subjective questionnaire and attended an interview.

RESULTS

Total Finish Tasks Time

The mean of tasks finfish time of subjects is 13mins 36secs that is much shorter comparing to the mean of experiment conducted by Chen, 2014 (18mins 48secs). According to the statistic test, there is significant difference between the results of two experiments.

Task Failure Rate

Table1 shows the results of two experiments before and after improvement. The failure rates of most of the task have decreased significantly after improvement. Specially, the failure rate of the forth task that has reduced the most (56.25%); the next ones were the first task and the 12th task (43.75%).

Subjective Questionnaire

The result has shown in Table2 that all average has decreased after improvement. The scores present how much the subjects agree with each question, and the scores ranges are from 1(not agree) to 5(highly agree) except fifth question that is from 1(not satisfy) to 100(highly satisfy). By statistic test examination, barely all point of question has significant difference except one. Compare to the result before experiment the average point of second question has difference but not significant. Table 4 shows the difference of two experiment result.

Table1: Failure rates of each task.

	Task	Failure rate	
		Before improvement	After improvement
1.	Start the function	50%	6.25%
2.	Listen to the assigned song	31.25%	0%
3.	Answer a phone call	0%	0%
4.	Change function to music	12.5%	0%
5.	Search for a the assigned song	12.5%	0%
6.	Cancel the result of speech recognition	81.25%	25%
7.	Favorite music	12.5%	12.25%
8.	Use help function	37.5%	6.25%
9.	Change function to radio	18.75%	6.25%
10.	Listen ICRT	43.75%	12.25%
11.	Listen FM96.1	43.75%	12.25%
12.	Change function to text message	12.5%	0%
13.	Listen a text message	31.25%	25%
14.	Change function to radio	62.5%	18.75%
15.	Favorite radio channel	37.5%	25%
16.	Close Talking Car	31.25%	12.50%

Table2: Result of subjective questionnaire.

	Question	Average	
		Before improvement	After improvement
1.	Without the manual, I don't know how to use the Talking Car system.	3.63	2.56
2.	I thinks I am familiar the Talking Car system after the experiment.	3.31	3.75
3.	I think control buttons is easy to be used.	3.13	4.06
4.	I think the configuration of control buttons is good.	3.19	3.92
5.	Satisfaction scores	71.25	81.19

CONCLUSIONS

Nowadays, many speech systems have provided by some vehicles. However, most of speech system or auditory interfaces didn't use ergonomics techniques in Chinese language. Under this condition, different point of view is used to develop more suitable system. Therefore, this study is performed to improve and analyze the usability of the Talking Car system. Though the experiments, the Talking Car system has performed more ergonomics and suitable for the novices.

In the result, the final task finish time has decreased significantly; new control button with new function may help a lot with it. Because the novices no longer get to other function though the long operating process that makes the task become easier and saving times. The improvement of system sentences with elicitation also makes the system easy to understand and control. Therefore, the Talking Car system has progressed to be a mature system that has more practical function.

Finally, Speech systems are playing an important role nowadays, and still have lots of potential possibilities that can be discovered. Although the Talking Car system is in experimental process now, we hope it can be used and become good tools while people driving.

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