Menu Selection with a Rotary Device Founded on Haptic and/or Graphic Information

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Abstract

The purpose of the study reported in this paper was to compare three different types of interfaces providing: haptic information, graphic information, or combined haptic and graphic information in an easy menu selection task. The results suggested that the combined haptic and graphic interface was preferable to the graphic interface regarding accuracy, while both interfaces were fundamentally equal concerning completion time. The results also indicated that the combined haptic and graphic interface was less mentally demanding than either the graphic or the haptic interface. Solely haptic feedback obtained, without exception, worse results than the other cases.

1. Introduction

In-vehicle Human-Machine Interaction (HMI) is becoming increasingly computerized and complex by providing driving assistance as well as information and improved comfort [1]. Although not impinging on the driving task, the overwhelming functionality might cause safety critical mental workload and distraction. Furthermore, the operation of all new in-vehicle functions demands numerous manual controls. To deal with the problem, auditory and haptic in combination with visual HMI are being used in vehicles. The issue of how to combine haptic and graphic interfaces, and their relative advantages, have been studied in various ways [2] [3]. The main focus in the studies has been on analysing how new types of graphic and haptic interfaces improve performance in steering tasks by providing guiding help.

In the study, described in this paper, different ways of providing information in an interface, either haptically, graphically or both haptically and graphically, was studied. The purpose was to evaluate and compare how well participants could discriminate a target through the different interfaces in a simple

menu selection task. The evaluation was based on completion time, error rate and mental workload.

2. Method

30 engineering students participated in the study. The haptic interface used in the experiment was a rotary device that could be turned and pushed. It was connected to a laptop computer displaying a graphical interface. The experimental task was to repeatedly find and select a target in a menu with five functions. The functions were described differently for the participants depending on which cases they were assigned to.

Figure 1 shows the information provided in the *haptic* case, "Case H". The functions in Case H could only be distinguished through haptic feedback, e.g. by different textures that are described in the lower part of the figure. As illustrated in the upper part of Figure 1, the functions were all identically displayed as blank areas in the graphic interface.

Figure 2 shows the information given in the *graphic* case, "Case G". The functions in Case G were discriminated by means of graphic feedback, as illustrated in the upper part of the figure. All functions were haptically represented by the same smooth texture, as presented in the lower part of Figure 2.

Finally, a consistent *haptic and graphic* case, "Case HG," offered a combination of the haptic effects in Case H with the corresponding graphic representations in Case G (Figure 3). Hence, in this case everything that was felt could also be seen.

The haptic effects described in the lower parts of figures 1-3 was not displayed to the participants.

During the test the *task completion time* and *turn errors* were measured. If the target was passed without being selected, the action was recorded as a turn error. Furthermore the participants perceived mental workload was measured with the NASA-TLX questionnaires [4].

Figure 1. Case H with functions described haptically.

Figure 2. Case G with functions described visually.

Figure 3. Case HG with functions described both visually and haptically.

3. Results

The data was analyzed with t tests (two tailed) for independent groups with the significance level set at 0.1. Analysis of the measured *task completion times* showed that the participants that used Case H performed notably worse than the participants that used Case G and HG ($p < 0.001$, in both instances). However, between Case G and Case HG there existed no significant difference.

Case H yield significantly more *turn errors* than the other two cases ($p < 0.001$, in both instances). Furthermore, Case HG proved better than Case G regarding turn errors, though not as marked ($p < 0.1$).

The *mental workload* results showed most evident differences for the criterion Mental Demand. Case HG yielded significantly lower mental demand than Case G ($p < 0.02$) and Case H ($p < 0.01$). Concerning the workload criterion Performance, the participants believed they performed worse with Case H than with Case G ($p < 0.05$). Finally, Case H was reported to demand more effort than Case HG ($p < 0.05$).

4. Discussion

The results suggest that a combined haptic and graphic interface was preferable to a graphic interface regarding accuracy, i.e. fewer turn errors, while both interfaces were fundamentally equal concerning completion time.

The results from the NASA-TLX measurement indicated that a combined haptic and graphic interface is less mentally demanding than either a graphic or a haptic interface. This could possibly be due to the use of multidimensional stimuli which is found efficient in data processing [5].

Solely haptic feedback obtained, without exception, worse results than the other two cases. The longer task completion times could be explained by the fact that visual feedback was obtained by merely taking a glance at the display, meanwhile haptic feedback required hand motion. Haptic feedback is also rarely used in today's interfaces, in comparison with visual feedback, which may have influenced the haptic results negatively. Moreover, in car driving situations where the visual sensory channel is occupied by the on-road situation, haptic information might have a natural advantage. A natural continuation of this study would be a distraction study where a menu selection task with a haptic interface serves as a secondary task in a driving situation.

References

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