Evaluating Tactile Feedback in Graphical User Interfaces

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Abstract

Tactile feedback is a modality that has become more common in user interfaces due to overall development of haptic feedback hardware. However, it is still not well understood how to get benefit from this modality in graphical user interfaces. Answering this need of knowledge we present two experiments on how tactile feedback could be used in target selection tasks when using a tactile mouse. In the first experiment twelve subjects tested four different feedback conditions: (1) mouse vibrates when the cursor is on the target, (2) mouse vibrates when the cursor is near the target so that tremble is more powerful when the mouse is near the target, (3) mouse vibrates when the cursor is far from the target so that tremble is more powerful when the mouse is far the target, and (4) normal feedback in which the mouse does not vibrate at all. In the second experiment we used the best method from the first experiment and had different target sizes. We did not find significant differences in selection times. However, we got interesting results on how people liked to use tactile feedback.

Keywords: Tactile feedback, target selection, tactile mouse.

1. Introduction

Tactile feedback is weaker than force feedback in that it does not produce the same kind of forces in the user's hand and therefore cannot guide the user in the same way as force feedback can. The specific benefits of tactile feedback are related to using textures and tactile sense in addition to other ways of feedback in user interfaces.

The mouse is one of the most common input devices in graphical user interfaces. Computer interfaces that make use of tactile feedback have only recently become available for common users. Immersion Corporation has developed a technology called TouchSense [4] and, among other licensees, Logitech uses this technology in their iFeel mice [7] that we used. A TouchSense-enabled mouse allows users to engage their sense of touch in interacting with their desktops.

In this paper we present results on how to use tactile feedback in target selection tasks so that tactile feedback supports seeing. We aimed at finding out which way of using tactile feedback the users like to use in target selection tasks and what kind of tactile feedback gives best results in finding the target. In the experiment we used a simple target selection task in which a subject selected targets as quickly and accurately as possible. The use of normal mouse feedback served as a base-line condition, and to this we added three different ways to use tactile feedback as additional conditions. Selection times were measured and the subjects were also asked their opinions on, e.g., which of the feedback methods was most likeable and which was the most unlikable.

2. Previous work

Akamatsu, MacKenzie and Hasbrouq [2] studied target selection task in five different sensory feedback conditions. Those conditions were normal, auditory, color, tactile, and combined. In that study tactile feedback was implemented so that a pin under the fingertip pressed upwards generating a tactile sensation to the finger while the cursor was over the target. They did not find differences in overall response times, error rates, or bandwidths; however, significant differences were found in the final positioning times (from the cursor entering the target to selecting the target). For the latter, tactile feedback was the quickest, and normal feedback was the slowest.

Akamatsu and MacKenzie [1] studied target selection task in four feedback conditions: normal, tactile, force and tactile+force. They found that compared to normal feedback the error rate was higher with tactile and tactile+force conditions. The fastest movement time which includes approach time and selection time was using tactile+force feedback while tactile feedback decreased the selection time. Selection time included stopping time and clicking time and they both decreased when using tactile feedback. Akamatsu and MacKenzie found that tactile feedback offers the best potential reduces in target selection times and this effect becomes more pronounced as targets get smaller.

Oakley et al. [3] studied haptic effects in graphical user interfaces (GUI). They did two experiments that empirically tested the use of haptics to augment targeting in a standard GUI. In these tests force feedback, not tactile feedback, was used, and they used the PHANToM 1.0 device [5] in the experiment. Oakley et al. carried out a two-phase study. The first experiment compared the effect of four different haptic augmentations on usability in a simple targeting task. The effects used were texture, friction, recess and gravity well. Recess and gravity well were the most effective in the first experiment so they used those in the second experiment that involved a searching and scrolling task. Results indicated that the haptic effects did not improve the users' performance in terms of task competition time but it reduced number of errors.

3. Testing software

In this section we explain the software that was used in the experiments. We implemented three different dialogs (Figure 1) that made use of tactile feedback, and one similar dialog that did not use it to have a normal dialog to compare.

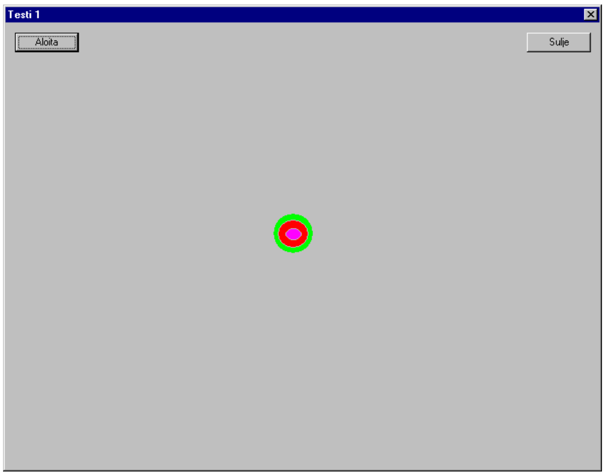

Figure 1. A test dialog, 'Start' button (Aloita) in top-left corner, 'Close' button (Sulje) in top-right corner. A 46 pixels wide target to be selected is in middle of the dialog.

All dialogs were otherwise the same but they made use of feedback in different ways. Every dialog had two buttons; a button started the test and another closed the dialog. In dialog one the tactile mouse gave feedback when the user moved the mouse on the target. In dialog two the tactile mouse gave feedback when the user moved the mouse near the target so that tremble was more powerful when the mouse was near the target. In dialog three tactile feedback worked opposite to dialog two: when the user moved the mouse tremble was more powerful when the mouse was far from the target. There were no other features in the dialogs to avoid unnecessary disturbance. The dialogs stored information on selection times and the accuracy of selections.

4. The first experiment: how to use tactile feedback?

In the first experiment we compared different ways of implementing tactile feedback in graphical user interfaces.

4.1. Subjects and apparatus

Twelve subjects participated in the first experiment. All subjects were regular users of mice in their daily work. The experiment was conducted using the Logitech iFeel Mouse [7].

4.2. Procedure

Before the experiment the subjects were told that in the test they use a tactile feedback mouse but they were not told which kind of data was gathered. They were told that the purpose of the experiment is to test few different ways to use tactile feedback and test, which one is the best. Before actual test situation, subjects were able to try out the dialogs and feel how tactile feedback was given. They were not told how tactile feedback was given or when the mouse should vibrate; so they needed to find out by themselves how tactile feedback worked in each dialog.

When the user pressed the start button the first target appeared in the dialog. In the test the user was asked to press that target and when the user had pressed the target, it was relocated. In the test situation the user pressed targets as quickly as possible.

The users were asked to select targets that were colorful circles of 46 pixels wide as quickly and accurately as possible. Precise aiming at the center of the target was not required. The selection was done by moving the cursor to the target and selecting the target by pressing the left mouse button. The first target appeared right after the subject pressed the start button, and the timing was started. When the subject pressed the target, it disappeared and appeared in another position in the dialog. The subjects selected the circle twenty times in each test case. When the subjects pressed the twentieth target, timing ended.

4.3. Design

In each test case the user selected the target twenty times. Every subject did every test case three times after trying out the all the test cases first. There were four different test cases, so every subject did the test twelve times. To counterbalance for learning effects, every subject made tests in different order. Every subject was also asked which kind of feedback they liked most and which kind of feedback they liked least and why they liked or disliked the chosen kind of test cases.

The dialogs were modal dialogs and the mouse vibrated as a warning when the user moved the mouse outside of the dialog. The subjects were also asked what they liked of this effect.

4.4. Results and discussion

Table 1 shows the means of total movement times for the four feedback methods. The mean movement time for all test cases was 15028 ms. The conditions from fastest to slowest were tactile feedback on the target (14868 ms), tactile feedback near the target (14891 ms), tactile feedback far from the target (15159 ms), and no additional tactile feedback (15195 ms). These results can be seen in Figure 2. The differences were not statistically significant, even though conditions “Tactile feedback on the target” and “Tactile feedback near the target” had a minor speed advantage to the other cases.

Table 1. Average movement times for each test case. Values in parentheses are percent changes relative to normal feedback.

Mean	Normal	Tactile feedback on the target	Tactile feedback near the target	Tactile feedback far from the target
15028 (ms)	15195 (ms)	14868 (ms) (-2.2%)	14891 (ms) (-2.0%)	15159 (ms) (-0.2%)

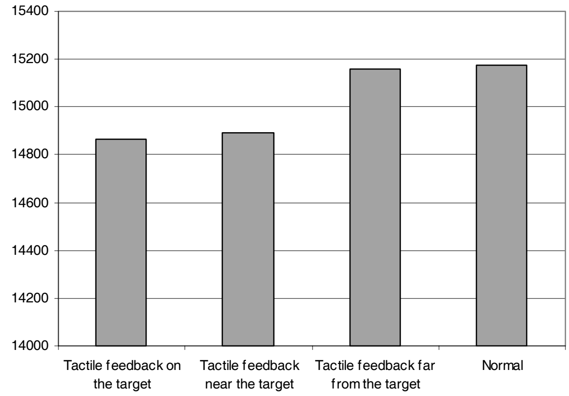

Figure 2. Average movement times for all test cases.

Thus, we did not achieve a significant improvement in movement times. However, when we look into the evaluations that the users gave after the experiment, there was clearly a different user response to different ways of using tactile feedback. In one of the questions the subjects were asked what kind of feedback they liked most and what kind of feedback they disliked most. Figure 3 shows what kind of feedback the subjects liked most. 75% of the users (nine out of twelve) liked best the feedback in which the mouse vibrated on the target. No one liked best the normal feedback.

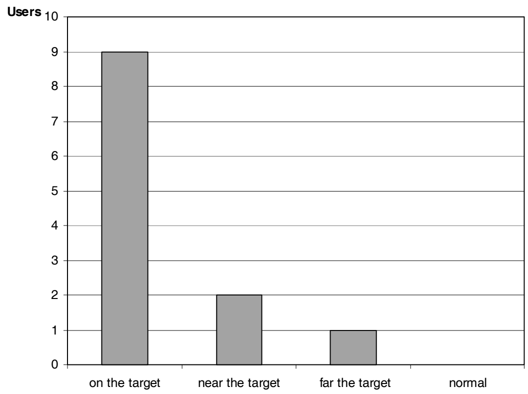

Figure 3. The most likeable feedbacks.

Figure 4 shows what kind of feedback the subjects disliked most. Most of the subjects (eight out of twelve) chose the feedback in which the mouse vibrated when the cursor was far from the target as the most unlikable feedback. This feedback method was clearly confusing, since when the mouse was getting closer to the target, the feedback disappeared. This caused the users to do more corrective gestures, and some of the users reported sudden lack of feedback to cause uncertainty.

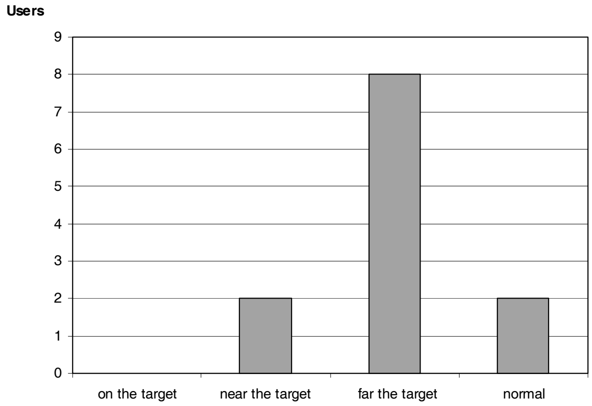

Figure 4. The most unlikable feedbacks.

The subjects were also asked to select which properties describe tactile feedback best. Subjects were given five property pairs and they had to select how well those describe tactile feedback. Table 2 shows how subjects answered. All the positive properties are left. Overall, the answers show that the subjects thought positively of tactile feedback.

Table 2. Subjective ratings for properties describing tactile feedback. A scale of 1–5 was used. The numbers show how many subjects answered that way.

	1	2	3	4	5	
Useful	2	7	2	1	0	Useless
Pleasant	1	8	1	1	0	Blunt
Eases working	1	2	7	2	0	Hinders working
Nice	1	5	4	2	0	Irritating
Tactile feedback is noticed clearly	6	5	0	1	0	Tactile feedback cannot be noticed

5. The second experiment: does size matter?

In the second experiment our focus was in testing effect of the size of the target, and finding out more subjective data on the use of tactile feedback.

5.1. Subjects and apparatus

Twenty subjects participated in the second experiment. Eleven of them had not used computer very much and nine were experienced computer users. None of the subjects had used a tactile mouse before. The experiment was conducted using the same Logitech iFeel Mouse as we used in the first experiment.

5.2. Procedure

In the second experiment the users were instructed to select the target that was a colorful circle in the dialog as quickly and accurately as possible by moving the cursor to the target and selecting the target by pressing the left mouse button. The dialog was like the dialog in the first experiment and it acted in the same way. The first target appeared right after the subject pressed the start button and timing started at the same time. Only the size of the target was changed between the test cases. Before the experiment the subjects were told that they test tactile feedback and they were told something about tactile feedback like what it means. Before actual test situation they were able to test how the testing software worked and what the tactile feedback felt like. They were not told which kind of data was gathered.

5.3. Design

The experiment was a 3x2 fully within-subjects repeated measures design. The independent variables are shown in Table 3.

Table 3. Independent variables

Target size	46, 21, 11 pixels
Feedback	normal, tactile

For the normal feedback condition, no additional feedback was provided in addition to the normal mouse cursor. For the tactile condition, the mouse vibrated when the cursor was on the target as found to be the best liked feedback method in our first experiment. The biggest target size (46 pixels) was used in the first experiment.

All subjects did every test case three times but only the data from the second and third cases were analysed. To counterbalance for learning effects, every subject made tests in different order. The subjects were also asked what they liked of tactile feedback.

5.4. Results and discussion

Table 4 shows the results of the feedback modalities on the movement time and error rate. These figures, while not significant, are consistent with the results by Akamatsu and MacKenzie [1] who found decrease in selection times and increase in error rates. They used force feedback in addition to tactile feedback, and this can be a reason for our results not to be significant.

Table 4. Average movement time for both test cases. Values in parentheses are percent changes relative to normal feedback.

Dependent	Mean	Normal	Tactile
Movement time (ms)	21958	22036 -	21877 (-0.7%)
Error rate (%)	2.8	2.6 -	2.9 (+10.9%)

Although tactile feedback did not decrease movement times and increased errors, 17 of 20 users answered that they felt it decreases both movement time and errors particularly when targets were small. When the users evaluated the statement "There is advantage in tactile feedback" (Figure 5), most users (14 of 20) thought that there is advantage. It seems that experienced users thought a little more positively about tactile feedback than inexperienced users. None of the experienced users disagreed the statement but two of inexperienced users did. Also, none of the experienced users agreed the statement “There is disadvantage in tactile feedback” (Figure 6) but two of inexperienced users partially did. Many subjects suggested that tactile feedback can be beneficial for vision-impaired users. One reason that we did not get significant results on that tactile feedback accelerates movement times can be that users are so used to use vision when they work with computer. It may not be able to speed up these rapid movements that rely on eye-hand coordination.

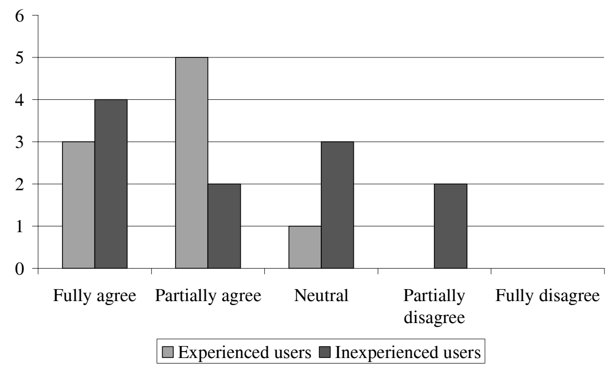

Figure 5. The subjects’ answers to the statement: "There is advantage in tactile feedback".

Figure 6 shows how subjects answered statement "There is disadvantage in tactile feedback". Many users said that at first they could not take advantage of tactile feedback but in the end that benefits a lot.

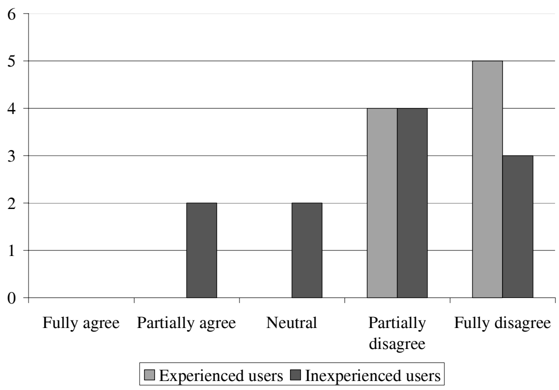

Figure 6. The subjects’ answers to the statement: "There is disadvantage in tactile feedback".

Following statements were also given to users to consider: “Tactile feedback irritates” and “Tactile feedback is fun”. 4 of 20 users agreed the statement “Tactile feedback irritates” and 15 of 20 users agreed the statement “Tactile feedback is fun”. Experienced users answered also these statements a little more positively than inexperienced users.

Figure 7 shows how subjects answered statement "Tactile feedback irritates". Users reported that mostly the sound of the mouse irritates. Thus, the irritation was more due to the way of implementing tactile feedback in iFeel mice, since it causes additional sounds with the motors. Also the users in the first experiment in which the participants used tactile feedback mouse said the same thing. Some users also reported that they could not take advantage of tactile feedback at first and before they could, it irritated them.

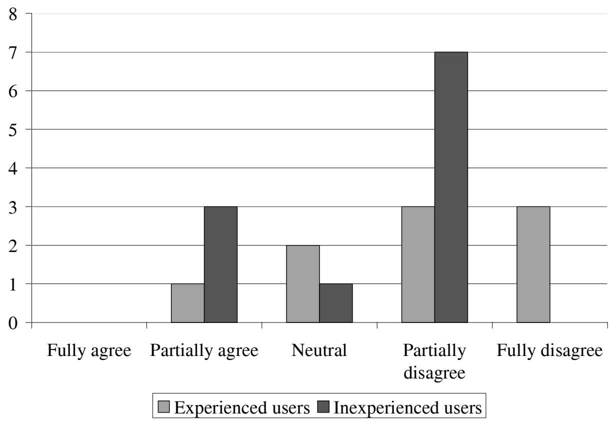

Figure 7 The subjects’ answers to the statement: "Tactile feedback irritates".

Figure 8 shows how subjects answered statement "Tactile feedback is fun".

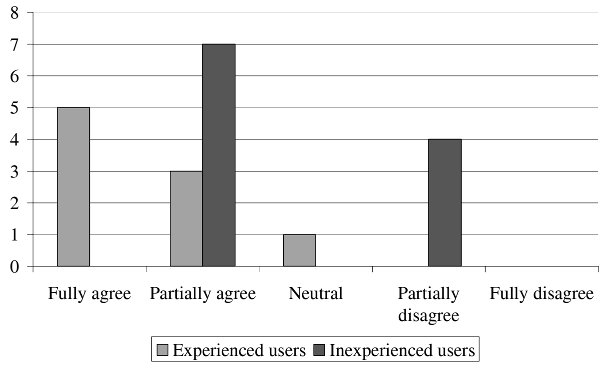

Figure 8 The subjects' answers to the statement: "Tactile feedback is fun".

The subjects also answered the question "Which properties describe tactile feedback best?" They were given the same five property pairs as in the first experiment. Table 4 shows how the experienced users answered. It can be seen that user thought quite positively about tactile feedback. Table 5 shows how the inexperienced users answered the question.

Table 4. Subjective ratings of the experienced users for properties describing tactile feedback. The numbers show how many subjects answered that way.

	1	2	3	4	5	
Useful	2	7	2	1	0	Useless
Pleasant	1	8	1	1	0	Blunt
Eases working	1	2	7	2	0	Hinders working
Nice	1	5	4	2	0	Irritating
Tactile feedback is noticed clearly	6	5	0	1	0	Tactile feedback cannot be noticed

Table 5. Subjective ratings of the inexperienced users for properties describing tactile feedback. The numbers show how many subjects answered that way.

	1	2	3	4	5	
Useful	2	7	2	1	0	Useless
Pleasant	1	8	1	1	0	Blunt
Eases working	1	2	7	2	0	Hinders working
Nice	1	5	4	2	0	Irritating
Tactile feedback is noticed clearly	6	5	0	1	0	Tactile feedback cannot be noticed

6. Conclusions and future work

In this paper we described two experiments that were aimed at finding out how to use tactile feedback. We were interested in potential differences in efficiency and user satisfaction. We did not find statistically significant differences in efficiency, but user opinions strongly supported the method "tactile feedback on the target".

The experiments described in this paper are more like pilot tests than rigorous empirical experiments. Therefore, we did not use a Fitts' law task [6] nor did we record detailed data on the trajectories of the selection movements. The tasks used in this experiment were simple pointing tasks. It is possible that statistical differences might be found if the tasks were more difficult or required more precise aiming. The pointing tasks are, however, often so quick that tactile feedback with a tactile mouse may not be able to help in these rapid movements.

The subjective data we collected gives guidance for the designers of software that makes use of tactile feedback. The benefits of tactile feedback with the present low-end hardware seem to be in enriching interaction and providing a more satisfying interface for the user, and not providing more efficiency in these interfaces.

7. Acknowledgments

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8. References

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