On Feelings of Comfort, Motivation and Joy that GUI and TUI Evoke

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Abstract. New ways to interact with technology are gaining ground over the familiar Graphical User Interfaces (GUI). The Tangible User Interfaces (TUI) are one example of this. However, while it may seem intuitive that such interfaces should evoke rather positive responses from users – e.g. feelings associated with pleasure – little has been studied in this sense. In this challenge of understanding the feelings that GUI and TUI have the potential to evoke, we present our findings from a research that involved more than a hundred people. The research question that guided our endeavors was: What are the relations between the feelings of joy, motivation and comfort when using TUI and GUI? We analyze the results and discuss some hypotheses to explain the behavior observed.

Keywords: Feeling, Comfort, Motivation, Joy, TUI, GUI, Kodu, Scratch.

1 Introduction

Advances in research in Tangible User Interface (TUI) have inspired diverse researchers, who are trying to understand the differences in users' responses when they interact to TUI and to Graphical User Interface (GUI). While statistics on impacts on productivity and cognitive development are important information, a research opportunity that still offers ground for further investigation is related to the type of feelings that those interfaces can evoke. As Norman [13] argues, “attractive things work better”. Since usability and the efficacy of objects or systems are not always enough to determine their success or appreciation, we must also consider the affectability - i.e., the affective or emotional aspects of interaction [6]. In this sense, this work reports on our endeavors to understand the feelings of comfort, motivation and joy that the different interface styles TUI and GUI may evoke.

Xie et al. [19] have found that, although children's self-reports of enjoyment are similar for TUI and GUI, they took longer and had more difficulty completing puzzles when interacting with GUI. As Ishii et al [8] explain, GUIs can be powerful, but they are not consistent with our interactions with the rest of the physical world. The study from Patten and Ishii [15] suggest that TUI provides better opportunity, when compared to GUI, for task recall and problem solving.

Besides the work of Xu [20] comparing enjoyment in children when interacting with TUI and GUI, Horn et al. [7] investigated other facets of affectability aspects. They found that TUI was more inviting, more supportive of active collaboration, and more child-focused than the mouse-based interface. GUI and TUI were equivalently apprehendable and engaging. Those feelings, however, have been treated isolatedly in each separate research. This leads us to the research question that guided our study: what are the relations between the feeling of Joy, Motivation and Comfort when using TUI and GUI?

Historically, the Xerox Company introduced the first generation of Graphical User Interfaces (GUI) in 1981 [9]. The GUI allows the user to view digital information through one or more screens, and interact with it via remote controls such as keyboards, mouse and more recently through touch screens [8].

Ten years later, in 1991, Mark Weiser, employee of Xerox company, published an article with a new vision entitled "Ubiquitous Computing"; in this vision, he tries to make the computer, as it is traditionally known, hidden from the user, almost invisible. One way to achieve this invisibility of computers is with an interface type called Tangible User Interface (TUI), which has been investigated in deep by authors like Ishii [8, 9, 10]. The TUI allows users to manipulate physical objects, and through this manipulation the computer is able to change its internal state, subsequently causing a response or feedback to the user [4], [18], [19]. In other words, TUI makes a connection between physical objects with digital elements, thus providing the possibility of directly manipulating these elements [3].

We agree with the authors Doering et al. [3], who say that the TUI does not fit all situations; however, we also agree with the benefits that this type of interface may have in specific contexts, such as education. This idea is shared by authors such as: Garzotto and Gonella [5], Horn et al. [7], Strawhacker and Sullivan [17], Sylla[18] and Xu [20]. While many agree on the potential of TUI, there is still a great research opportunity on the investigation of the affective responses that GUI and TUI might evoke. In this sense, the research question that we presented and that guides our work should manage this opportunity.

The aspects of affective responses that we cover in our study are related to the feelings of Comfort, Motivation and Joy. Bernstein [1] defines Motivation as "an inner state that energizes an individual toward fulfillment of a goal". We understand that this should be an important response from users, as it should make the users continue using the application and fulfilling its tasks (e.g. an educational goal). Hence, motivation should not only stimulate users but also should indicate the success or failure of an application or type of application/interaction style.

Some authors (e.g. [2]; [16]) who study emotional responses adopt the PAD emotional state model. PAD stands for Pleasure, Arousal and Dominance. In our context we can associate arousal (excitement in the use of an application) with the Motivation of use. Pleasure could be associated with the feeling of Joy, as Joy is defined by the Oxford Dictionary [14] as "a feeling of great pleasure and happiness".

Another aspect of Dominance is the feeling of Comfort (e.g., when we dominate/feel powerful over an application, we usually feel comfortable in the use of it). For sake of

simplicity, we provided easier definitions for each of these feelings, as we show in the next section.

This work investigates the relations between the feelings of joy, motivation and comfort of different user profiles when using TUI and GUI. The paper is organized as follows: in section 2 we describe the study context and method. In section 3 we present the results and we discuss them in section 4. Section 5 concludes this paper.

2 The Study Context and Method

This research was conducted in the context of an HCI discipline in the University of Campinas (UNICAMP), in São Paulo State, Brazil. It occurred during two academic semesters in 2013 as part of the design and development of user interfaces projects, in which the students had the role of designers.

2.1 Participants

Besides the students enrolled in the discipline, we managed to include other participants, who contributed as end user evaluators of the projects. In total, we had one hundred and nine people participating.

In the first semester of 2013 (2013A) we had a total of 69 people involved, with an average age of 23 years old (a maximum age of 59 years old and a minimum age of 14). In the second semester of 2013 (2013B) there was a total of 40 people. The average age was of 23 years old (a maximum age of 52 years old and a minimum age of 15). The age distribution of the whole set can be seen in Figure 1.

Fig. 1. Age range of the participants

As can be seen in Figure 1, the data of each semester will be treated separately, although shown in the same graph, with the intention to compare and identify any indications of trends.

Figure 1 shows the distribution of the age of the participants: for the 2013A is 11 (15.94%) people aged between 14 and 19 years old, 30 (43.48%) people aged between 20 and 21, and 28 (40.58%) people aged between 22 and 59. For the 2013B, there are 14 (35.00%) people aged between 14 and 19 years old, 15 (37.50%) people aged between 20 and 21, and 11 (27.50%) people aged between 22 and 59.

2.2 Method

In both semesters, the students from the HCI course were asked to choose an existing GUI application and modify it in a way that it would receive external events as inputs. Such external events should be in the form of physical objects being presented to the camera. In other words, their primary task was to take a GUI application and develop its TUI version.

In one semester the students were invited to choose an application among the many available for the Scratch¹ platform. In the other semester, the students chose among the applications available for Kodu² platform. Both Scratch and Kodu offers mainly educational solutions and underneath both lays the purpose of bringing programming language closer to children's world. Our objective was to investigate the affective responses from users towards the GUI and TUI versions of a same application. The platform of the original GUI version should have no or little impact on the results. In order to control also this factor we had the two courses working with a different platform (Scratch and Kodu). After developing the TUI applications, the designers were asked to invite other end users to interact with both GUI and TUI versions. After interacting with both versions, designers and end users answered a questionnaire.

2.3 Materials and Procedure

As a result of the method described, for each GUI version of an application (be it from Scratch or Kodu), there was a correspondent TUI version of it.

After interacting with both versions, designers and end users answered a questionnaire composed by three questions (Table 1). The central idea of the questionnaire was to determine, if it existed, any difference between the two versions, GUI and TUI, with respect to the feelings that were evoked in relation to Motivation, Comfort and Joy.

In 2013A, the students, divided into 10 groups, had to select a Scratch 1.4 application from the projects repository of SAPOScratch³. In 2013B, the students were divided into 5 groups; they selected an application made in Microsoft Kodu to make the same procedure requested in the 2013A group.

¹ http://scratch.mit.edu/scratch_1.4/

² <http://research.microsoft.com/en-us/projects/kodu/>

³ SAPOScratch, is an educational program, product partnerships between "Portugal Telecom" and "Massachusetts Institute of Technology" (MIT) since 2008.
<http://kids.sapo.pt/scratch/channel/toploved>

Table 1. The questionnaire

<p>With which version did you feel more Comfortable? <i>(which application evokes a greater sense of comfort in use)</i> ☐ GUI ☐ TUI ☐ Indifferent ☐ None</p> <p>With which version did you feel more Motivated? <i>(which application evokes a greater desire to continue using it)</i> ☐ GUI ☐ TUI ☐ Indifferent ☐ None</p> <p>Which version caused more Joy? <i>(The application that evokes a greater sense of pleasure in use)</i> ☐ GUI ☐ TUI ☐ Indifferent ☐ None</p>

In both semesters, the groups should use the computer vision framework called ReacTIVision⁴ [11] to implement the TUI version. ReacTIVision is a framework for, among other things, the fast and robust tracking of Fiducial markers attached onto physical objects. This implies that with the TUI version, the user must use different Fiducial markers to associate objects to interact with the system (the markers must be attached to physical objects). Fiducial marks are figures that represent unique codes that can be identified by the computer.

Fig. 2. The codes to associate objects to interact with the system

Figure 2 illustrates this activity and depicts students interacting with physical objects to obtain a response from the application (either Kodu or Scratch) via a monitor. Of course, this output could be projected onto the glass table (shown in Figure 2b) where students interacted, but that was not a requirement of the project.

In 2013A, each group of students had to implement a Java application that communicates ReacTIVision Framework with Scratch 1.4, through the Scratch resource called "Remote Sensor". In 2013B, each group of students received a developed app, which communicated ReacTIVision Framework with Kodu, by sending keyboard events. An open source version of these applications is available on the website of our research group: <http://styx.nied.unicamp.br:8080/interhad/products>.

In the next section we present the results of answers to the questionnaire and discuss possible interpretation for them. In order to make it clearer to the reader, we will refer to the projects created in 2013A as "ScratchP", and the projects created in 2013B as "KoduP".

⁴ <http://reactivision.sourceforge.net/>

3 Results

The next three subsections present results of the questionnaire regarding the focus on each of the feelings of our interest (Comfort, Motivation, and Joy). For each feeling we present four graphs which show the data: (a) From all participants of that semester; (b), (c), and (d) separated by the different age groups. In the sequence we discuss the relationship observed between these feelings.

3.1 Comfort Feeling

For the sake of simplicity, the questionnaire defined to the users the feeling of comfort as: “The application that evokes a greater sense of comfort in use”. Surely it is a simplistic definition for a feeling, but this provides a common basis to all users. Our intention is to align participants’ idea on the feeling of comfort when making a decision regarding the application that best evokes that feeling.

Fig. 3. Comfort feeling per age

Figure 3 shows the percentage values of the number of people who felt more comfortable with each option (GUI, TUI, Indifferent and None) in each project; Figure 3a shows the results associated with the feeling of comfort considering all users who

participated in the study. In the project with Scratch (ScratchP), 34 (49.28%) users considered the GUI version as the version that evokes a greater sense of comfort. In the project with Kodu (KoduP) 27 (67.50%) users felt more comfortable using the GUI version. That is, the two groups considered the GUI version as the version that evokes greater sense of comfort. If we analyze the TUI version, we see that 20 (28.99%) and 7 (17.50%) people considered it to be the most comfortable, in the projects with Scratch and Kodu respectively. The reason for this preference may be related to the previous exposition of users to the amount of movement required by GUI, in comparison with the TUI versions, which require different physical interaction.

More important than indicating the percentage values or the number of people for each option, we want to highlight the options movement along the three graphs (Figures 3b, 3c, and 3d). These Figures show the behavior of the “feeling of comfort” for each different age ranges. The three charts are on the same scale in both axes, so it is possible to make some observations visually. It is true that we cannot generalize this behavior; however some aspects are evidenced. The GUI version remains the version that best evokes the feeling of comfort. When we look at the older age groups, we can see that the GUI version loses ground to the TUI version and to Indifference. One possible explanation for this latter behavior is that the younger participants in this research are very familiar with computers and their predominant model of user interaction today is through GUI. In contrast, the older participants seem to feel less comfortable with these versions and begin to see the TUI versions as more natural for them.

3.2 Motivation Feeling

The questionnaire defined the feeling of motivation as: “The application that evokes a greater desire to continue using it”, for the sake of simplicity.

As we can see in Figure 4a, the results of motivation presents a different picture compared to the results regarding comfort. The TUI version was selected in the project with Scratch by 44 (63.77%) of the people, and in the project with Kodu by 20 (50.00%) of people. In contrast, the GUI version was selected by 10 (14.49%) and 11 (27.50%) people in the two projects respectively, not far from the results shown by the Indifference option, 7 (10.14%) and 9 (22.50%) respectively.

With respect to the behavior of different ages people, we can see that the TUI version was always selected as the version that best evokes the feeling of motivation, for all age ranges. The GUI version seems to lose its ability to motivate groups of older participants. The option of Indifference starts among the least preferred choices (Figure 4b) but gains space and even surpasses the GUI version (Figure 4d). Looking at Figures 4b, 4c and 4d we can observe the opinion of the different age groups about the feeling of motivation for both ScratchP and KoduP applications. First consider the x axis, which represents ScratchP: the TUI version remains more or less stable, being the preferred choice for the first two groups (age groups between 14-19 and 20-21).

Fig. 4. Motivation feeling

However, it falls 22.7% for the older group. Regarding the y axis - KoduP - the percentage value decreases less abruptly, but is still visible in the graphs. The biggest change is between the first age group and the second (10.48%). A possible explanation may be the need of physical activity required by the TUI version, which encourages them to continue using the application while the GUI version does not present novelty. It is worth noticing the decrease in the last three figures, where the GUI version remained the option that least evokes the feeling of motivation. Regarding the decline of TUI option in the last two figures, one might speculate that this is due to the inability of younger people to be as effective with the required physical activity as they are with the keyboard.

3.3 Joy Feeling

For simplicity, the questionnaire defined the feeling of Joy as: “The application that evokes a greater sense of pleasure in use”. With regard to the feeling of joy, we can observe that the TUI version has shown a greater ability to evoke this feeling, 31 (44.93%) people and 17 (42.50%) in the two projects respectively, selected the TUI version; in contrast with 14 (20.29%) and 7 (17.50%) people who selected the GUI version, in the same two projects. In general terms (Figure 5a) the number of people who marked the Indifferent option exceeds the number of people who select the GUI version. People who marked the Indifferent option are 19 (27.54%) and 16 (40.00%) in the two projects respectively.

(a) Joy feeling

(b) The age range of 14-19

(c) The age range of 20-21

(d) The age range of 22-59

Fig. 5. Joy feeling

Another interesting result is observed when we look the option of Indifference in the other age groups. Figure 5b shows the Indifference option has the same percentage of choices the TUI version has, in relation to the project with Kodu. However, the difference in the percentages between Indifference and TUI are greater in relation to the project with Scratch. A possible explanation may be found in the applications environments (Kodu and Scratch). The Kodu environment is visually more appealing than Scratch, and may invite interaction with it.

In the next age group (Figure 5c), the Indifference option exceeds the option of TUI version; 46.67% and 33.33% respectively in KoduP.. While for KodyP the distance between “Indifference” and TUI is small, for ScratchP the distance between the same two is bigger. Although there are percentage differences, the behavior and the explanation may be similar for the younger group. Finally in the older age group (Figure 5d), the situation changed drastically, the TUI version options with 54.55% far exceeds the other options (Indifference 27.27%, 18.18% GUI version, and None 0.00%) in the project with Kodu, while the option of Indifference (35.71%) narrowly exceeds the other options (28.57% in the TUI version, GUI version 21.43% and None 14.72%) in the project with Scratch. In other words, the result indicates that for the older group - compared to other age groups - the TUI version is the one that least evokes the feeling of joy when using Scratch.

4 Summarized Discussion

In the previous section, we examined each of the three feelings separately; now we want to see the relationship between these selections on two or three feelings simultaneously. Figure 6 shows these relationships. The purpose of this figure is to observe the combinations of options that are clearly protruding.

Fig. 6. Relationship of the three feelings

Figure 6a shows the combination of options with greater selection with respect to the feelings: Motivation, Comfort and Joy. Note that the order, in which the feelings were cited, should be the order in which the options on each circle in the figure should be interpreted (e.g: TUI-GUI-TUI, The version that best evokes Motivation feeling is TUI, the Comfort feeling is GUI, and the Joy feeling is TUI). Observing this same combination, we have: 15 (21.74%) and 9 (22.50%) of the people involved in projects with Scratch and Kodu, agree on three things: a) TUI version evokes the greatest motivation, b) the GUI version evokes greater comfort, and c) the TUI version causes the greatest joy. As we can see in Figure 6a, there are no other combinations that stand out from the other options. In Figure 6b, we see that there are two other options that attract attention: a) relative only to ScratchP is TUI-TUI, which tells us that 13 (18.84%) of the participants in the first semester agree that the second version that best evokes the feeling of Motivation and Comfort is the TUI version;

b) in relation only to KoduP is GUI-GUI, which tells us that 10 (25.00%) of the participants of the second semester agree that the second version that best evokes these feelings is the GUI version. But independent of the application, the best combination is TUI-GUI, with more than 31.00% of the participants in each semester. In Figure 6c and 6d, we can see the Indifferent option between the combination that is highlighted, and it appears replacing the TUI version (i.e. Figure 6c: the best combination TUI-TUI, the following TUI-Indifferent; Figure 6d: the best combination GUI-TUI, the following GUI-Indifferent).

5 Conclusion

The research question we wanted to answer was: what are the relations between the feelings of Joy, Motivation and Comfort when using TUI and GUI? In this sense, our objective in this research was to better understand the relationships between the feelings of Comfort, Motivation and Joy evoked in users when interacting with GUI and TUI applications. In order to achieve this objective, we gathered the participation of more than one hundred people over the period of two semesters experimenting applications developed in educational contexts. The paper investigated affective responses with regard to two different interaction types: GUI and TUI.

The results were analyzed both in a general view and also in the perspective of different ages groups. Under the general view, the interaction type to evoke most Comfort was GUI, but TUI seems to be the preferred type in regards to Motivation and Joy (although sometimes Indifference was also chosen in relation to Joy). The analyses among different age groups provide us with some insights on what can be considered as relevant to these groups.

We are aware of the need to extend the study to other contexts; however, the evidence shows a greater sense of motivation and joy related to the TUI versions. This leads us to believe in the potential of TUI to be used in educational contexts. Further work involves a deeper investigation using different TUI architectures (e.g. different sensors, objects) in order to have other combination types of interaction.

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