The Effects of User Adaptability to Automation for a Robotic Art Box

Linda Morales
Computer Science
Universidad Francisco Marroquín
lmoralesh@ufm.edu

Victor del Cid
Computer Science
Universidad Francisco Marroquín
victordelcid@ufm.edu

Carlos Morales
Computer Science
Universidad Francisco Marroquín
carlosmorales@ufm.edu

Sebastian Enríquez
Computer Science
Universidad Francisco Marroquín
enriquezs@ufm.edu

Juan López
Computer Science
Universidad Francisco Marroquín
juanllopez@ufm.edu

CHI'17 Extended Abstracts, May 06-11, 2017, Denver, CO, USA
ACM 978-1-4503-4656-6/17/05.
http://dx.doi.org/10.1145/3027063.3048433

Abstract
This experiment is looking to expand the knowledge about the idea that a robot can help increase the productivity of an individual performing a task, the robot's behavior can influence performance. This experiment uses a robot with remote controlled wheels that was hidden inside an art box.

The approach taken to test the hypothesis was to separate users in three groups, each of these characterized by a unique form in which the robot would interact with the subjects. The three groups were categorized by its interaction mode: Proactive, Reactive and Manual. The first group found a robot that interacted with them in an insistent way, the second one only when the subject completed a task and the third one when the user explicitly requested its assistance. The experiment results are meaningful, because although there´s no significant difference regarding quality of work between modes, there exists a difference in time of completion of the task, which is proof of a change in efficiency.

Author Keywords
Robot; Automation; Wizard of Oz; Art Box; Gesell dome; Interaction

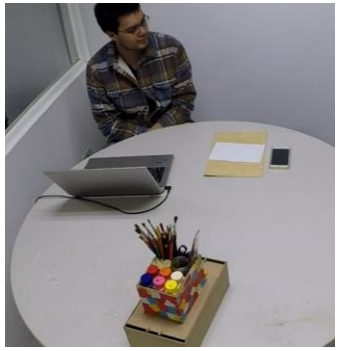

Figure 1: A participant starting the experiment.

ACM Classification Keywords
H.5.2 User Interfaces.

Introduction

Robotics is one of the most debated topics when it comes to human development since they can be really helpful in many day to day tasks. Two very important factors that will influence the future of commercial robots are receptivity and adaptability of the user to the device, and the effects that the last may have or not in the efficiency of the task that the human is pursuing. There is a big amount of investigation on this subject and a useful technique for the purpose is Wizard of Oz method, which makes use of supervised experiments where the subject is presented with an apparently automated device.

There exist various modes in which an automated device can interact with the user. While technology by itself is very important, the way in which it is presented to the user has direct and transcendent influence in receptivity and adaptability that the person will have to it [1]. Receptivity and adaptability, either instant or long term, depend at the same time of how friendly and effective the system is.

Commercial robotics presents challenges when it comes to human-computer interaction, because it should have an optimum mix between those factors mentioned before (receptivity and adaptability). A valid focus of automation that can be applied to robotics is to distinguish the forms of interaction that trigger the robot to perform certain tasks. The central hypothesis of this investigation is that, the trigger and interaction differences, may have effects in the quality of work or in the time of completion of the task. The employed robot was basically an art box positioned relatively far from user, containing materials such as crayons, brushes, watercolors, etc. The box was automated by installing a hidden remote controlled system with four wheels to apply Wizard of Oz technique and to allow the robot to move.

Surprise effect is used to capture the immediate reactions of the person, and the mode of interaction of the robot for the subsequent reactions. The modes were divided according to its nature. Proactive mode robot is insistent, and comes to the user even if it is not needed, and this fact may produce a hurry sensation in the subject. Reactive one takes into account the information that it can collect, recognizing what the user is doing and triggering when it is needed even before the user realizes that he needs it, so it does not pressure or gets closer in an unnecessary way. Manual mode is designed to trigger when the subject calls the robot, analyze gestures and movements of him and gets closer when it determines that it is being called; at the beginning of the experiment this happens when the user stretches or stands up to reach the art box.

The study involved participants from a wide range of ages, isolated in a supervised room configured as a Gesell dome, who were asked to complete a series of instructions presented to them by slides on a computer screen. Instructions were the same for the whole sample of subjects, who prior to the experiment had no knowledge about the robot's existence. The objective was to observe initial reactions when they realized that the art box could move by itself, and analyze time of completion of the tasks and quality of work.

Methodology

The idea of this study is based on the experiments realized by Wendy Ju and another researchers with the purpose of observing human-technology interaction [2] [3] [4] [5]. In our case, the subjects had interaction with an art box, which was mounted on a remote controlled car disguised in a way the users couldn't perceive it. Our experiment, just as Wendy Ju's, had

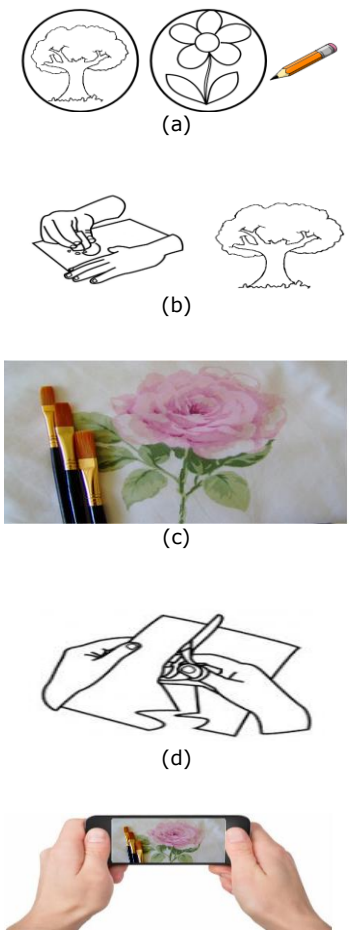

Figure 2: The users were asked to perform six different tasks.

the purpose of observing the reactions from people and how their behavior changed.

Our experiment differs from others since we asked the users to perform tasks and forced them to interact with the robot. The tasks that the subjects had to complete were: drawing a flower and a tree (Figure 1a), erasing the tree (Figure 1b), coloring the flower (Figure 1c), cutting out the flower (Figure 1d) and taking a picture of the flower (Figure 1e). The experiment was done in a more controlled scenario, which allows a study with a different approach. We were interested in other factors besides human reactions, like time to perform a task and quality of the work after users noticed the existence of the robot. This allowed the experiment to be based on quantitative and qualitative variables. The results from this experiment are completely based on the time and observations recorded in the video of the subjects interacting with the robot.

Participants

During the study, 36 participants were randomly chosen. The majority of the subjects were students from Francisco Marroquín University, a few were workers from the campus, and 2 kids. From the 36 participants, 3 were excluded from the results because of technical difficulties which compromised the results.

Study Overview

The experiment was designed to last from five to ten minutes per subject, range that endured with certain exceptions. We took random subjects, alternating the robot's mode with each participant using between subjects configuration. The subjects were divided into three groups.

Mode	Proactive	Reactive	Manual
Participants	11	11	11

Table 1: Indicates the details in which groups of subjects were divided.

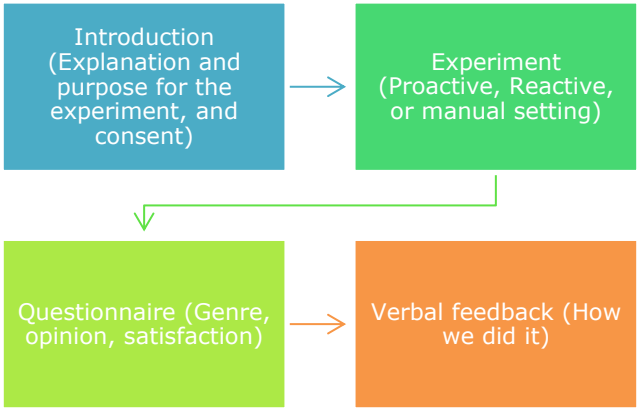

Figure 3: Shows the executed procedure with each one of the subjects during the experiment.

Data

Each subject was video recorded using two different cameras [6]. One of the camera was focused on the subject's reactions and the other was focused on the work area. The videos were used to take time and quality of the work done by the participants. Subjects were asked to fill a questionnaire at the end of the session, which was used to classify the subjects into age groups, to record their thoughts during the experiment, and to know their acceptance towards these kinds of assistance.

Figure 4: Some flowers that the subjects made during the experiment.

Results

The data gathered from the experiment was analyzed using the Pearson's coefficient, ANOVA, and CHI squared test.

Figure 5: Positive correlation between quality and time for task completion, r=0.5806, n=33, p<.05, calculated with online calculator [7].

Pearson's coefficient allowed to correlate the data of the quality of work based on our criteria, with the time it took the subjects to complete the task for each modality of the robot and for all the results. This returned a correlation of 0.5484 on the proactive modality, 0.638 on the reactive modality, 0.5367 on the manual modality, and 0.5806 on the three of the modalities. This indicates that the correlation is positive, variances in the value of the quality or time are reflected in some other variable and these are not strongly related, but there exists a relation between these variables which indicates that the more time the subjects dedicated to the experiment they obtained a better quality of work.

During the experiment, we realized the manual modality didn't work as expected due to the fact that the subjects didn't use the button that was inside the testing area, which they had to identify, to call the robot and ended up doing signs or gestures to request the robot's help. To know if the "Wizard of Oz" technique produced variances on the results with each robot's modality, the ANOVA analysis was used.

When applying the "Wizard of Oz" technique, the result was to reject the null hypothesis with the three modalities, indicating that the "Wizard of Oz" technique produced different results. The same test was applied when comparing the manual and the reactive mode,

Condition	N	Mean	Variance
Manual	11	4.98	5.19
Proactive	11	4.16	2.57
Reactive	11	6.33	3.55

	Sum of Squares	df	Mean Square	F
Between	26.48	2	13.24	3.513
Within	113.06	30	3.77	
Total	139.54	32		

Table 2: Input data (left) and ANOVA results (right) obtained with an online calculator [8]. There was a significant effect of the mode (manual, proactive or reactive) in the time to complete the tasks at the p<.05 level for the three conditions [$F(2,30) = 3.513$, $p < 0.05$.] In addition ANOVA was used to compare Proactive and Reactive modes, those groups also differ significantly, [$F(1,20) = 8.486$, $p < 0.05$.]

Condition	High Quality	Normal	Low Quality	High Use	Normal	Low Use
Manual	6 [0.02]	2 [0.76]	3 [1.07]	9 [0.57]	1 [1.04]	1 [0.08]
Proactive	4 [0.49]	5 [0.48]	2 [0.07]	3 [2.29]	6 [4.17]	2 [0.33]
Reactive	7 [0.31]	4 [0.03]	0 [1.67]	9 [0.57]	1 [1.04]	1 [0.08]
Totals	17	11	5	21	8	4

Table 3: Contingency tables for quality of work (center) and intensity of use of the art box (right) obtained with an online calculator [9]. Each cell contains the observed values and the corresponding chi-square statistic enclosed in brackets. For the quality of work the chi-square statistic is 4.8963. The p-value is .298109. The result is not significant at $p < .05$. This may indicate that the modality does not affect the quality of work. For the intensity of use the chi-square statistic is 10.1786. The p-value is .037525. The result is significant at $p < .05$, indicating that that variable is affected by the robot mode.

which failed to reject the null hypothesis, indicating there is no significant difference between the data from the two modes. It was later applied to manual and proactive modes, failing to reject the null hypothesis again. At last, the proactive and reactive modalities were analyzed, indicating the rejection of the null hypothesis, since the data of these modalities differ significantly.

To check these results, the percentage of usage of the robot in each modality was calculated (number of times the robot approached to the subject and was used divided by the total number of times it approached to the subject) and grouped them in three categories: Heavy use (above 80%), Normal, light use (below 50%). The CHI squared test was used with the incidences of the modalities on each category and the result was that the incidences differ significantly, meaning that each mode was associated with a distribution of incidences of different use. This result is important because it shows that the "Wizard of Oz" technique worked as expected and the modalities were substantially different, especially between proactive and reactive modalities.

The CHI squared test allowed to determine if the quality variable is related with the modality of the robot or not. For that, the score for the drawings was used (a scale from 0 to 5 was used, depending on the quality of the drawing based on our criteria). The results were divided in three categories: high quality, normal, and bad quality. The incidences of the modalities on each category was calculated. It was determined that the incidences on each category were not significantly different, it is not certain to say that a modality induced a better quality of drawing than another. It can be confirmed that the improvement on performance of the subjects when using the proactive mode does not affect the quality of work. The performance does improve on this modality, since the subjects on this group of modality have a lower average time to complete the experiment.

Conclusion and future research

In this study, a set of artistic tools were presented, mounted on an interactive system that provides assistance to the users, analyzing three modalities: proactive, reactive, and manual. The objective was to measure the performance of each one when realizing the assigned tasks.

The recorded data indicates the impact each modality has on the performance of the subjects to perform the task. The data was analyzed with statistic techniques to verify its validity. It could be stated that the results obtained were significant, concluding a satisfactory research, being the proactive mode the one with which the users performed the task in a more efficient way, without compromising quality of work. This result is important, since it gives the opportunity to design and create assistance robots that could have a meaningful impact on performance for certain tasks.

For future research, the experiences obtained in this study could be used and applied to different kinds of assistance in different fields. It´s important to rethink the role of the button in the reactive modality and, either make improvements to it or eliminate it. As well, the different reactions of the users for each modality could be analyzed, which can be obtained from our video recordings of each subject. Finally, an important variable between subjects is age, therefore it could be relevant taking it into account in further investigations.

References

1. I. Scott MacKenzie. 2013. *Human-Computer Interaction: An Empirical Research Perspective* (1st ed.). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.
2. Yang, S., Mok, B., Sirkin, D., Ive, H., Maheshwari, R., Fischer, K., Ju, W. *Experiences Developing Socially Acceptable Interactions for a Robotic Trash Barrel*. In Proceedings of Robot and Human Interactive Communication (RO-MAN 2015). August 31-September 3, 2015. Kobe, Japan.
3. Fischer, K., Yang, S., Mok, B., Maheshwari, R., Sirkin, D. & Ju, W. *Initiating Interactions and Negotiating Approach: A Robotic Trash Can in the Field.* In AAAI Spring Symposium on Turn-taking and Coordination in Human Machine Interaction. Palo Alto, CA. 23-25 March 2015.
4. Martelaro, N., Nneji, V., Ju, W., Hinds, P. *Tell Me More: Designing HRI to encourage more trust, disclosure and companionship*. Human Robot Interaction (HRI 2016). March 7-10, 2016. Christchurch, New Zealand.
5. Neidlinger, K., & Ju, W., Sound Bending:Talking Bodies Quantum Sound Suits. In Design, User Experience, and Usability. User Experience Design for Diverse Interaction Platforms and Environments, Lecture Notes in CS Vol 8518, 2014 (pp. 598-605). Springer International Publishing.
6. Morales, C. *HCI LCSv Robot Experiment*. 2017. [online] Available at: https://youtu.be/RbRRItEfsro.
7. Statisticslectures.com. (2017). *Free Pearson's r Hypothesis Test Calculator*. [online] Available at: http://www.statisticslectures.com/calculators/pearsonrhypothesis/[Accessed 8 Dec. 2016].
8. Statisticslectures.com. (2017). *Free Between-Subjects ANOVA Calculator*. [online] Available at: http://www.statisticslectures.com/calculators/anovabetween/[Accessed 8 Dec. 2016].
9. Socscistatistics.com. (2017). *Chi-Square Test Calculator - Up To 5 x 5 Contingency Table*. [online] Available at: http://www.socscistatistics.com/tests/chisquare2/Default2.aspx [Accessed 9 Dec. 2016].