

EVALUATION OF AN ANTHROPOMORPHIC USER INTERFACE IN A TELEPHONE BIDDING CONTEXT AND AFFORDANCES

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Keywords: Anthropomorphism, User Interface Feedback, Evaluation, Affordances.

Abstract: Various researchers around the world have been investigating the use of anthropomorphism in some form at the user interface. Some key issues involve determining whether such a medium is effective and liked by users. Discovering conclusive evidence in relation to this medium would help user interface designers produce better user interfaces. Currently conclusive evidence is lacking. However the authors of this paper have been investigating these issues for some time and this paper presents the results of an experiment which tested anthropomorphic voices against neutral voices. This was in the context of telephone bidding. The results indicated the impersonal human voice condition to foster higher bids, while the user satisfaction was inconclusive across all four conditions tested. The results have also been examined in terms of the Theory of Affordances with the aim of finding an explanation for the observed results. The results indicate that issues of affordances played a part in the results observed.

1 INTRODUCTION

The idea of using anthropomorphic feedback at the user interface has been around for some time and has attracted attention from researchers around the world. One of the concerns of such types of user interfaces or feedback that is anthropomorphic is whether it is effective and liked by users. While an answer to this issue may appear to be intuitive, the evidence so far in the research community is that it is still an open issue requiring to be solved. Solving such as issue would help to increase the usability of user interfaces and the applications behind them. Products can fail if their usability is not at its best. Despite efforts over the years at resolving these usability issues, results from various studies indicate a lack of a clear pattern of results leading to appropriate conclusions.

Therefore the authors of this paper are investigating the effectiveness and user satisfaction of anthropomorphic type user interfaces and

feedback in various contexts. To achieve this, the authors are using rigorous experimental techniques to gather data which is then statistically analysed. Appropriate links are also being made with existing theories, such as the theory of Affordances.

Anthropomorphism at the user interface usually involves some part of the user interface, taking on some human quality (De Angeli, Johnson, and Coventry, 2001). Some examples include a synthetic character acting as an assistant or a video clip of a human (Bengtsson, Burgoon, Cederberg, Bonito and Lundeborg, 1999).

In a study by Hongpaisanwiwat and Lewis (2003), in the context of teaching computer graphics, the effects of using an animated character were investigated. They designed a three condition experiment, consisting of an animated character, a 'pointing finger' and no character. Synthetic or human voices were used in all three conditions. Their aims were to measure understanding and concentration in the learning of the participants whilst using a set of learning materials about

computer graphics. The overall results showed no significant difference in understanding with respect to the participants using the animated character. There was an interaction effect showing the animated character with synthetic voice to be better for remembering aspects of learning materials, compared to the character with human voice condition. Further, interaction effects were observed showing that the amount of emphasised items remembered by participants using the 'pointing finger' and no character conditions with a human voice was greater than participants using the synthetic voice. Also, participants remembered more in the animated character with synthetic voice condition compared with the animated character with human voice condition. There were no significant differences concerning participants' subjective opinions of the learning materials. Overall this experiment did not provide any conclusive evidence favouring the use of anthropomorphism.

The general results found by these authors does not match with certain other research, e.g. Moreno, Mayer and Lester (2000) in the context of tutoring about plant design tended to find evidence that anthropomorphic information was better when one had to use learned knowledge to solve new similar problems. Participants were also more positive towards the anthropomorphic type information.

Further, in a study by David et al (2007), the authors conducted a three condition experiment in the context of a quiz about ancient history. They were investigating different anthropomorphic cues in terms of character gender and attitude and user perceptions about the character in relation to quiz success (or not). The overall results of their experiment suggested that anthropomorphic cues led to users believing the character to be less friendly, intelligent and fair. This finding was linked with the male character and not with the female character.

Lastly, in a study by Prendinger et al (2007) which involved an investigation into using eye tracking for data collection, the authors specifically tested an animated character with gestures and voice, voice only and text. The context they used involved showing users around an apartment on a computer monitor. Their main findings were that the character condition seemed to be better for directing 'attentional focus' to various objects on the screen. However the voice only condition fostered more attention on the part of the users towards 'reference objects' on the screen. They also observed that the text only condition induced participants to look at the text more than the character, in terms of gaze points. Finally, subjective aspects were inconclusive.

Despite this study having some experimental flaws, such as having very small sample sizes, it does indicate that using an anthropomorphic entity is not necessarily better than other modes.

In the authors' own work (Murano et al, 2009), an experiment in the context of downloading and installing an email client, an anthropomorphic character condition was tested against a non-anthropomorphic textual condition. The conditions were designed to assist novice users in the act of downloading and installing an email client. The main results indicated the anthropomorphic condition to be more effective (based on various errors and user behaviour) and preferred by participants.

However, we have also seen that this pattern of results does not hold for all our work. In another study by Murano et al (2008) in the context of PC building instructions, an anthropomorphic character condition was tested against a non-anthropomorphic text condition. For this experiment the main results for effectiveness (based on errors) were inconclusive. However the results for subjective satisfaction were slightly more tending towards a preference for the anthropomorphic condition. (The reader is also referred to further work carried out by the principal author of this paper indicating a lack of an overall pattern in results for effectiveness and user satisfaction (Murano and Holt, 2009, Murano et al, 2007 and Murano, 2005).

A brief review of some key work in this area confirms that overall results regarding effectiveness and user satisfaction are currently inconclusive. There could be various reasons for these results. Some reasons could concern specific context or aspects of experimental design. However another explanation could concern aspects of certain key affordances either being violated or properly facilitated.

The original Theory of Affordances (Gibson, 1979) has been extended by Hartson (2003) to cover user interface aspects. Hartson identifies cognitive, physical, functional and sensory affordances. He argues that when a user is doing some computer related task, they are using cognitive, physical and sensory actions. Cognitive affordances involve 'a design feature that helps, supports, facilitates, or enables thinking and/or knowing about something' (Hartson, 2003). One example of this aspect concerns giving feedback to a user that is clear and precise. If one labels a button, the label should convey to the user what will happen if the button is clicked. Physical affordances are 'a design feature that helps, aids, supports, facilitates, or enables

physically doing something' (Hartson, 2003). According to Hartson a button that can be clicked by a user is a physical object acted on by a human and its size should be large enough to elicit easy clicking. This would therefore be a physical affordance characteristic. Functional affordances concern having some purpose in relation to a physical affordance. One example is that clicking on a button should have some purpose with a goal in mind. The converse is that indiscriminately clicking somewhere on the screen is not purposeful and has no goal in mind. Lastly, sensory affordances concern 'a design feature that helps, aids, supports, facilitates or enables the user in sensing (e.g. seeing, feeling, hearing) something' (Hartson, 2003). Sensory affordances are linked to the earlier cognitive and physical affordances as they complement one another. This means that the users need to be able to 'sense' the cognitive and physical affordances so that these affordances can help the user.

Therefore, in section 2 the experiment and results are discussed. In section 3 the results of the experiment are discussed in light of the Theory of Affordances as identified by Hartson (2003). Then in section 4 some overall conclusions and proposals for ways forward for the research are presented.

2 VOICES AND BIDDING EXPERIMENT

2.1 Aims

This particular experiment aimed to specifically investigate personal voices (e.g. a personal voice could say: 'I am your helper') and neutral voices (e.g. a voice could say: 'This is your help') and human and text-to-speech (TTS) voices. This was in the context of trying to determine which voice type may have been more effective and preferred by users. Nass and Brave (2005) have also used voices in some of their experiments where their overall aims were to discover how users react in a social manner towards a computer. They specifically were not investigating anthropomorphism.

2.2 Users

- 32 participants were recruited for this experiment.
- Although gender was not the main issue of this research, the participants were students of computer science. There were 25 male partici-

participants and seven female participants.

- Participants were in the 18-35 age range.
- All participants had experience with online bidding.

The participants were all recruited through the principal author's own classes at the university. Specific details about the participants were then elicited by means of a pre-experiment questionnaire which principally asked specific questions about bidding experience, e.g.

Have you ever used online auctions? *Yes/No*

(If your answer is NO, please go to Q. 7, otherwise please answer parts (i) to (iii) before going to Q. 7)

(i) State the name of the online auction you used. _____

(ii) Did you purchase an item? *Yes/No*

(iii) Did you enjoy using the online auction?

Yes/No

2.3 Experimental Design

A between users design was used for this experiment. This design method is good for controlling issues of practice and order effects. Participants were randomly assigned to one of four conditions. Randomness was achieved by alternately assigning a participant to a condition until all participants had been assigned to one of the four conditions. The four conditions were impersonal human voice, personal human voice, impersonal Text-to-Speech (TTS) and personal TTS. The only difference between the personal and impersonal aspects, were that the personal utterances used human-like language, e.g. 'I...' etc. and the impersonal voices used neutral language. The human voice was a clear English accented male voice of a colleague. The TTS voice was a generic electronic voice.

2.4 Variables

The independent variables were (1) the types of feedback, (Voice Type, consisting of TTS personal voice, TTS impersonal voice, Personal human voice and Impersonal human voice) and (2) Type of Task (Bidding on five different household items). This is a 2x2 Factorial Design, where the values from the bids made were averaged and included in the analyses (i.e. not the tasks themselves).

The dependent variables were the participants' performance in carrying out the tasks and their subjective opinions.

The dependent measures were that the perfor-

mance was measured by examining the average bid amount. From an auction point of view, the higher the bid made, the better the business outcome. From a user's/buyer's perspective the lowest amount is the best outcome. The average bid was recorded by means of an observation protocol. This was a small grid which allowed the author to write down the bid for each item bid. The average was then calculated when the participant had left the experiment location. The subjective opinions were measured by means of a post-experiment questionnaire. The post-experiment questionnaire had six main sections. These were sections covering the usefulness of the system, the trustworthiness of the system, the formality of the system, the likeness to a person, the participants' feelings during the interaction and the enjoyment of the system.

2.5 Apparatus and Materials

- A laptop running Windows XP with 256 Mb RAM.
- The laptop's own TFT display was used – 14”.
- A headphone set with inbuilt microphone.
- CSLU Toolkit (2009).

2.6 Procedure and Tasks

The recruitment questionnaire was handed out and the completed forms were scrutinised for suitability. The main aspect that was required for this experiment was to have participants with an awareness of online auctions. Also it was required by implication to have participants with computing knowledge so that the results would not be biased with issues concerning lack of knowledge in using computer systems, which could indirectly affect bidding behaviour. This was assumed though as all the participants were computer science students.

The suitable participants were then contacted by email, where an appointment during the day was arranged.

Upon arrival the participants were welcomed and comfortably seated at the computer. They were initially briefed with the following points:

- All the data would be kept confidential, they could leave at any time they wanted and should they not want their data to be used after the experiment had taken place, this was their prerogative.
- A scenario informing them that they had graduated and were about to leave university and

had decided to obtain some household items by means of a telephone auction.

- Some general information was given regarding how to use the microphone attached to the computer.

Then the participants were asked to read the content of a one page web site, which contained more detailed information than the initial briefing points.

When the reading was completed, the actual auction was started. A virtual telephone keypad appeared on the screen and the participants pressed the speed dial button. An audible ring tone could be heard and after a short while, the telephone was answered by one of the voice conditions being tested. The 'voice' gave an initial introduction detailing that there were five items for sale. Then the participant was informed that they would hear a description for each item and that they would need to bid at the end of each item's description.

The next stage involved the 'voice' giving some details of the item. The description gave a guide price and a brief physical description of the item. When the description was completed, a short beep was heard which was the cue for the participant to make their single bid via the microphone (the participant had been initially briefed about this). The amount bid was then discreetly written down by the experimenter. When the single bid was made, the system automatically proceeded to issue the description for the second item in a similar manner. This was done for five items in total. The actual items were a futon, refrigerator, microwave oven, television and a telephone answering machine.

When the five bids had been placed, the participants were asked to complete a post-experiment questionnaire regarding their subjective opinions and feelings about their interaction experience. When this was completed, they were thanked for their time, asked to not tell anyone what they had done and reminded that they were now entered in a prize draw for their participation. This procedure was followed in the same manner for all the participants.

2.7 Results

The data were analysed using a multifactorial analysis of variance and when significance was found, the particular issues were then subjected to post-hoc testing using in all cases either t-tests or Tukey HSD tests (NB: DF = Degrees of Freedom, SS = Sum of Squares, MSq = Mean Square). Firstly

the means and standard deviations are presented for the results in Tables 1 to 3 below:

Table 1: Means and SD, Average Bid.

Mean	115
Std Dev	32.74
Std Err Mean	5.79
upper 95% Mean	126.80
lower 95% Mean	103.20
N	32

Table 2: Means and SD, Fair.

Mean	6.41
Std Dev	1.78
Std Err Mean	0.31
upper 95% Mean	7.05
lower 95% Mean	5.77
N	32

Table 3: Means and SD, Likeness to Person.

Mean	5.69
Std Dev	2.58
Std Err Mean	0.46
upper 95% Mean	6.62
lower 95% Mean	4.76
N	32

For the variables 'average bid' and 'condition' there is a significant ($p < 0.05$) difference. The participants in the impersonal voice condition significantly placed higher average bids than the participants in the personal voice conditions. Also participants in the personal TTS condition placed significantly higher average bids than the personal voice condition. The F-ratio is 4.21*. This is shown in Table 4 below:

Table 4: MANOVA, Average Bid/Condition.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	13866.75	4622.25	4.21
Error	28	30730.75	1097.53	Prob > F
C. Total	31	44597.50		0.01

For the variables 'likeness to person' and 'condition' there is a significant ($p < 0.05$) difference. The personal human voice was perceived as significantly more like a person than the voices in the other conditions. The F-ratio is 3.43*. This is shown in Table 5 below:

Table 5: MANOVA, Likeness to Person/Condition.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	55.63	18.54	3.43
Error	28	151.25	5.40	Prob > F
C. Total	31	206.88		0.03

For the variables 'fair' and 'condition' there is a significant ($p < 0.05$) difference. The impersonal TTS voice was significantly perceived as being more fair (or unbiased) than the other voice types. The F-ratio is 3.77*. This is shown in Table 6 below:

Table 6: MANOVA, Fair/Condition.

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	3	28.09	9.36	3.77
Error	28	69.63	2.49	Prob > F
C. Total	31	97.72		0.02

Lastly the data collected concerning subjective opinions did not show any significant effects.

2.8 Discussion of Results

Participants perceived the personal human voice condition to be more like a person than the other conditions. This result had been expected as it was one of the manipulations of the experiment.

Also, the results indicate with significance that the highest bids were placed by participants in the impersonal voice condition and participants in the personal TTS condition placed significantly higher average bids than the personal voice condition. The reason for this result is unclear. However while the recruitment procedure aimed to ascertain awareness of bidding on the part of the participants, the procedure did not ascertain perceptions of household items and prior learned bidding strategies. These two aspects could have biased the results if a number of participants in the impersonal voice condition happened to have certain perceptions about bidding and household items. This could have more easily happened given the fact that the sample size was smaller than desired. This aspect is worthy of further study in conjunction with a larger sample size.

Lastly there was a significant result for the fairness issue, where the impersonal TTS voice condition was perceived as being fairer than the other voice types. However this voice type incurred the second lowest average bids. One reason for this outcome could be that the impersonal voice was perceived as being more neutral and perhaps more fair, however this aspect is also worthy of further study.

3 THE EXPERIMENT AND AFFORDANCES

The experiment tested four different voice types with an identical user interface. The results for user satisfaction were inconclusive. However, as stated above, the impersonal voice condition incurred significantly higher bids than the other conditions. This can be viewed as a form of effectiveness from the perspective of an auction owner who may be interested in achieving overall higher bids.

Due to the nature of the conditions involved and the fact that the user interface was identical under each of the four conditions, the authors conclude that the affordances should have been the same irrespective of the four different conditions. The cognitive affordances would have involved the virtual telephone keypad on the screen and the voices issuing the items' descriptions. These would have facilitated the simulation of an on-screen or online telephone call and the receiving of descriptions enabling a bid to be placed.

The sensory affordances would have particularly aided the feature of listening or hearing items' descriptions. As stated these were so similar to one another that these affordances should not have been affected differently depending on the condition tested.

Regarding the physical affordances, the on-screen telephone keypad would have facilitated the action of making a call. This was a large and clear enough keypad to allow easy clicking. Even if this was not the main aspect of the interaction, it would have contributed to a positive effect on the participants.

Lastly the functional affordances would also have been equivalent, as the on-screen keypad was the same for all participants and worked in the same manner. Further the participants placed their bid via the head mounted microphone, which also worked in the same manner for all participants under all the conditions being examined.

To that end the authors conclude that for this experiment the four types of affordance would have been equivalent under the four different conditions. The only unclear aspect is that it is unknown why one condition significantly incurred higher bids than the other conditions. However the authors suggest that if thought about, the action of deciding how much to bid is not an issue to do with affordances. Looking at the experimental tasks, there were essentially four stages. Stage one involved using the virtual keypad. It is suggested above that this would have involved some affordances issues, but should

have been equivalent under each condition. Stage two involved listening to a series of descriptions and would have involved some affordances issues, but should have been equivalent under each condition as all that varied was the voice type and not the content or ordering of the content of the descriptions. Stage three involved the 'mental' or 'internal' process of deciding how much to bid. This had nothing to do with affordances as making the 'internal' decision would probably be more affected by past experiences and perceptions of the items (despite trying to obtain balanced users). Finally stage four involved uttering the bid into the microphone. As discussed above the affordances for this stage should have been identical under each condition as well.

Therefore the authors are suggesting that the user interface aspects (i.e. virtual keypad, descriptions and microphone) involving some manipulation on the part of the user were equivalent to one another and therefore so were the affordances. However the actual 'internal' human process of making a decision regarding how much to bid could have varied, despite best efforts at obtaining balanced participants. On the other hand the balance was achieved in terms of awareness of bidding, but no attempt was made to obtain perceptions about household items or perceptions about attitudes to bidding, e.g. 'always bid as low as possible' or 'always bid what you think the item is worth' etc. Such attitudes could affect overall average bids.

4 CONCLUSIONS AND FURTHER WORK

It is clear that there is still more work to be done in relation to discovering if anthropomorphic user interfaces are really usable and liked by users. We are suggesting that effectiveness and user satisfaction of anthropomorphic interfaces is linked to whether the various strands of affordances are being positively observed or ignored in interface design. However the issue of the affordances requires further study and experimentation. One approach to further study could be to design and develop prototypes in some domain and context. This could be done by trying to develop one prototype that specifically violates the four strands of affordances and compare this with an equivalent prototype that facilitates the four strands of affordances. These could make use of anthropomorphic feedback to maintain the theme of the research. Furthermore, based on the experiences

of this research, the work would ideally require several slightly different experiments investigating the facilitation of affordances. The reason for this is that conducting only one experiment and obtaining only one set of results could give an incorrect overall picture of the matter.

Future work should also address the main shortcoming of this experiment. The sample size used was rather small in nature and future experiments should ideally have more participants. Also future work should continue to ensure realistic scenarios, such as the one adopted in this experiment. Realistic scenarios would help the research to be more applicable in the real world and more readily accepted by actual user interface designers.

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