Affective Interfaces of Embodied Conversational Agents  
– A Study of Character Interfaces –  

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Abstract: The visual representations of intelligent agents draw increasing attention recently. Additionally, the first impression of humans toward agents is the visual representations. How these man-made creatures’ looks determine users’ will to interact with. This research focuses on the appearances of embodied agents to investigate the affective interactions between users and agents. This study conducted one experiment to study the affective influences of embodied conversational agents (ECAs) on users in the learning tasks. A one-factor-at-three-levels counterbalanced by within-subjects design is employed in this study. This study asks whether there are significant experiential differences between ECAs when they are represented by different character classifications, such as character preference, user engagement and user-agent relationships. The main contributions of this study are summarised as follows: (1) character classifications can be related to human affective factors; and (2) there may be significant relations among character preference, engagement and user-agent relationships.  

Keywords: Human-Computer Interactions, Embodied Conversational Agents, Affective interfaces

1. BACKGROUND AND INTRODUCTION

This research concerns human feelings when they interact with computational agents, and these are regarded as affective factors. Computational agents that interact with humans through natural language with embodied characters are referred to as ECAs. This research tackles alterations of human affective states when users interact with different ECA interfaces. As a consequence, humans interact with computational devices that are represented by ECAs by means of a natural and intuitive manner, and this enables easy communication via natural language and gestures. With developments in computer technology and advancements in computer graphics, ECAs are expected to be increasingly employed in human-computer interactions (HCIs), in which affective interfaces of ECAs play a critical role.

In this study, ECAs act as learning companion agents (named CompanionBots in this research) in different classifications of characters, the human affective factors involved in a learning task were explored at length.

1.1 Affective Factors

Affective factors typically address how humans feel and their underlying emotions. According to Russell [1], affect as classified by psychologists generally covers feelings and emotions. In addition, Corsini [2] has described affective interaction as an “interpersonal relationship carried out on an emotionally-charged level”. As a result, it is patently clear that affect is intimately involved with human emotions. Moreover, Forgas [3] has stated that affect plays a strategic role in the thought processes and actions of humans in social situations. In truth, humans are not entirely rational or logical beings, given that feelings, moods, emotions, and other types of affective factors have a significant influence on people’s thoughts and behaviours.

Affective factors are also affected by external objects, events and other individuals. Norman [4] suggested that “pleasing things work better”, given users are attracted by beautiful products and express greater willingness to use those products. In fact, even a single external objective event can clearly alter humans’ affective states [1]. These represent some of the reasons why Zhang and Li [5] pointed out that utility and accessibility were not the only factors that Information Technology designers should pay attention to, as affective factors should be given due consideration.

1.2 Agent Interfaces

In order to improve HCI performance towards human-human interactions, computers are required to possess more human-like capabilities [6]. For example, computers are represented by visual characters as well as being designed with emotional facial expressions in order to
express thoughts and communicate with humans naturally.

Maes [7] posits that building a successful embodied agent is likely to help users to understand the capacities, limitations, and operations of agents. In a similar vein, Koda and Maes [8] claim that agents with faces and facial expressions were normally regarded as more likeable and attractive. In fact, adding a graphical character to an agent for expressing emotions makes users feel that they are interacting with an independent social actor [9]. Additionally, when computers are displayed in the form of social cues, users unconsciously apply social rules to the interactions with these agents [10].

ECAs are intelligent agents equipped with conversational abilities to communicate with users via natural language and normally represented by anthropomorphic interfaces [11]. ECAs are the fine media for users to control agents. Additionally, Nass et al. [10] state that humans willingly treat computers as other social actors. Moreover, ECAs have the potential to improve HCIs towards human-human interactions, and as a result this study deploys ECAs as the tool to investigate agent interfaces during HCIs.

In addition to developing functional and various ECA applications, researchers have determined that ECAs have a positive effect on HCIs. In this field, a study applied ECAs to a memory performance task and proved that ECAs have a positive effect on retainable human memory [12]. In the same way, ECAs have a positive impact on humans’ impression of these representations because ECAs are equipped with the persona effect [13]. Moreover, anthropomorphic interfaces on ECAs enable HCIs to perform as humans in face-to-face conversations.

According to this research, it is evident that agents with visible appearances have affective effects on humans. In this research, the visual forms of agents deserve particular exploration. However, there remain limited studies conducted on interfaces with embodied agents compared to the amount of studies on other aspects of interface design, such as in websites, games, portable device applications and computer software. That said, the appearance of embodied agents continues to have a significant role in human affective factors. As a consequence, designers and researchers should give additional attention to better design of interfaces with embodied agents. This also highlights the need for this research to focus on the interface design of ECAs, and develop better interfaces, which could improve HCIs.

### 2. FOCUS OF THIS STUDY

Several studies (already mentioned in the previous sections) have found that users have different levels of affective responses towards different interfaces of ECAs. However, few studies have addressed the classifications of characters, particularly in the performing in learning tasks. When beginner English learners undertake a language practice task, do they have different affective responses (such as character preference, user engagement and user-agent relationships) towards distinct character classifications of ECAs (humans, animals and creative creatures)? Additionally, what is the relationship, if any, among different affective factors during HCIs, such as character preferences, user engagement and user-agent relationships?

### 3. EXPERIMENT

In this case, the independent variable is the character classification, and its attributions are human, animal and creative creature. This survey intends to compare the affective influences between different ECA character classifications. In order to achieve this object, subjects were asked to interact with different character classifications of CompanionBots and compare them. A one-factor-at-three-levels (a human form – an animal form – a creative creature form) counterbalanced by within-subjects design is employed in this study. In reality, the dependent variables encompassed the degree of user engagement, user-agent relationships, character preference, learning attitudes and empathy, given that human affective factors are the variables this survey attempts to study. In this survey, the main purpose is to ascertain the different influences among various character classifications of ECAs on users. Language practice is a domain designed as the conversational content to attract subjects to have conversations with the CompanionBots. Subsequently, subjects were asked to type conversations in order to practice English with three learning companion agents in Table 1.

The three CompanionBot are as follows, one agent named Andrew was designed with a human form, another named Ben with an animal form, and Chris with a creative creature form.

<table>
<thead>
<tr>
<th>Name</th>
<th>Andrew</th>
<th>Ben</th>
<th>Chris</th>
</tr>
</thead>
<tbody>
<tr>
<td>Character</td>
<td><img src="human.png" alt="Andrew" /></td>
<td><img src="animal.png" alt="Ben" /></td>
<td><img src="creative.png" alt="Chris" /></td>
</tr>
<tr>
<td>Classification</td>
<td>Human</td>
<td>Animal</td>
<td>Creative Creature</td>
</tr>
</tbody>
</table>

### Table 1: ECAs as CompanionBots
Ben was conceived with an animal form, and the other known as Chris was devised with a creative creature form. In the course of the research, each CompanionBot accompanied subjects through online English conversations for at least five days during the experiment.

18 characters were grouped into three categories, with each category containing six characters were designed for this experiment. The chat flow of CompanionBots is depicted in Figure 1. There are two phases in the chat flow, whereby in the textual response phase subjects input sentences in the conversational user interface. In fact, the IELTS-Bot will generate a response according to the sentence that subjects input if the sentence is related to the knowledge of IELTS speaking test. Alternatively, PI-Bot will answer the question if the sentence concerns personal information about the CompanionBots. In all other circumstances, the AAA-Bots will answer other general questions or generate a random response. In truth, the PI-Bot administers all personal information about ECAs, and IELTS-Bot are responsible for the specific domain knowledge. Subsequent to generating a textual response, the ‘Emotional Keyword Filter’ selects one facial expression according to the textual response. Finally, both the textual response and facial expression are displayed in the conversational user interface in order to elicit further responses from users.

Six basic emotional expressions (happiness, anger, surprise, disgust, sadness and fear) as well as one neutral facial expression were designed for the CompanionBots to depict their emotions during the conversations.

3.1 Measurements

A questionnaire is deployed to quantify character preference, user engagement, user-agent relationships, learning attitude and empathy for characters. In reality, user engagement measurements from the I-PEFiC framework, adjusted by van Vugt and his colleagues [14,15] from the PEFiC framework [16], have been implemented in this research. Additionally, user engagement is an index composed of seven items that were grouped into two tendencies, namely involvement and distance.

In terms of character preference, two types of character preferences were measured, one prior to subjects interacting with agents and the other after subjects had chatted with the agents for at least five days. In the course of this experiment, subjects were asked to choose five characters from 18 characters and rank them in order of preference prior to subject interaction with the CompanionBots. In this way, the character preferences of each character classification and CompanionBot were measured by the total score amount. However, the character preference material obtained after interaction was measured by an index composed of two items on the five-point Likert scales.

This study has adopted the relationship assessment scale (RAS) of Hendrick [17] to measure the relationships between agents and users. The items on the RAS encompass several relationship dimensions, such as love, problems and expectations. In this experiment, the RAS has been adopted with minimal changes in order to measure the generic relationships between users and agents.

This experiment is primarily a language-learning task. Although language learning is only a cause to attract users to interact with agents, the learning attitudes of users are also measured during this experiment. In fact, learning attitudes of users may provide evidence to explain the influences of agents on users. Moreover, the evaluations of learning attitudes – including positively and negatively worded items, integrative and instrumental orientation and English anxiety – have been adopted partly from ‘The Attitude/Motivation Test Battery Manual (AMTB)’ [18] and measured by single items on five-point Likert scales.

Empathy is an index, which is composed of two items, namely sorrow and anger on the part of the agent. In this domain, Hall et al. [19] used sorrow and anger expressions to measure the empathic responses of users to characters.

Additionally, a semi-structured interview approach is employed to investigate user feelings toward their preferred agent characters and user expectations concerning their ideal learning companion agents by means of pertinent questions. Furthermore, data gleaned from auto-recorded keyboard conversations between subjects was used to observe the interactions between users and agents. These two types of qualitative data were used to ascertain clear the insights into the results.
3.2 Procedure

For this study, subjects were randomly recruited from an International English Language Testing System (IELTS) training school.

The experiment was likely to continue for at least three weeks to be entirely completed. Prior to the commencement of the actual experiment, subjects were clearly introduced to the experiment process and content.

In addition, subjects were also introduced to the concept of ECAs. Learning companion agents (called CompanionBots in this study) are one form of ECAs and were designed for users in order to assist English learning. Furthermore, subjects have the ability to chat with CompanionBots anytime and anywhere online. The study obliged subjects to chat with three CompanionBots with whom they had the opportunity to practice English conversations. Subjects had to communicate with each CompanionBot textually online for at least five days. Finally, after subjects had become accustomed to the workings of this experiment, they were asked to sign the consent forms and the actual experiment began.

Subjects were informed that each CompanionBot possessed some emotional facial expressions that reacted to the subject’s input, and they had the possibility to attempt to observe how many facial expressions they could make them display. Moreover, CompanionBots were designed with an IELTS speaking database included and subjects had the ability to practice the speaking component of the IELTS exam with the CompanionBots. Additionally, the keyboard conversations between subjects and the three CompanionBots were recorded automatically for analytical examination. After completing the keyboard conversations with the three CompanionBots, subjects were asked to partake in a face-to-face interview.

3.3 Subjects

42 subjects partook in the actual experiment, of which 11 subjects failed to complete the experiment procedure (seven did not finish the keyboard conversations with three CompanionBots and four did not attend the interview), and their responses were discarded from the analysis, which was performed on the remaining 31 cases. All subjects were learning English as a second language and were recruited on the basis of this to partake in the experiment.

Other personal information gathered in the first part of the questionnaire is as follows: 11 of the 31 subjects were male, and 20 were female. 14 subjects were aged from 15 to 25 years and the other 17 were aged between 26 and 35. Overall, the entire subject group seemed to have relatively developed usage experience of computers, thereby meaning that it should not be a problem to have keyboard conversations with CompanionBots via computers. In terms of factors of learning English as second language, 67.7% of subjects possessed more than six years of English learning experience, though it seemed that those subjects had spent some time learning English. On the other hand, 45.2% of subjects chatted with others for more than two hours per day, however, only 21.4% of them chatted with others in English for in excess of two hours daily. In summary, the entire subject group were learning English as a second language when they partook in this experiment. This experiment provided them with the opportunity to practice English conversations online. As a result, these factors might influence subject’s willingness to undertake keyboard conversations with CompanionBots online.

4. RESULTS

Subjects completed the questionnaires when they had finished the keyboard conversation component of the experiment with each individual CompanionBot. This data was collected from the questionnaire and was utilised to provide meaningful qualitative results in this experiment. Other data was obtained from the keyboard conversations between the subjects and the CompanionBots, and this information has been recorded and stored as text files. These files were employed to determine the validity of the data based on the level of activeness of the conversations. The third type of data was garnered from the audio recordings of the in-person interviews. This form of data was the qualitative component of the experimental results, and was analysed to identify interactions between subjects and the three classifications of CompanionBots.

4.1 Quantitative Results

The questionnaire entailed four parts. The first one was concerned with the personal information of the subjects. There were also questions surrounding the subjects’ selection of their five favourite CompanionBots selected from the list of 18. The second, third and fourth parts were questions in relation to the interactions between subjects and the three respective CompanionBots. Each part contained 27 questions surrounding aspects, including their character preference, user engagement, user-character relationships and empathy formation.

The first part of the questionnaire intends to investigate the character preference of users towards CompanionBots
prior to any interactions with particular CompanionBots. This part intends to ascertain which type of character is popular as language companion agents before having interactions with users. Among the top five characters, two derive from the human classification, two belong to the animal classification, and one from the creative creature classification. On the other hand, the least favoured category also entailed two preferences arising from the human classification, two from the animal classification, and one from the creative creature classification. In fact, the most and least popular character both belonged to the animal classification, namely the monkey and the turtle. As a result, it is problematic to determine the character preferences of users prior to interactions. Additionally, the total scores of the three classifications were ranked from highest to lowest as animal, human and creative creature respectively.

In the following parts of the questionnaire, seven categories of user affective responses were measured in total. Those affective responses of users were analysed by means of a one-way ANOVA test. Significant differences were found in ‘Engagement (F=11.210, p<.05)’ and its two factors, ‘Involvement (F=7.901, p<.05)’ and ‘Distance (F=11.610, p<.05)’, among the three CompanionBots. Among the three classifications that exhibited significant differences, they all indicated that Chris>Ben>Andrew. This demonstrates that subjects experienced a stronger engagement in the interactions with Chris (creative creature), followed by Ben (animal), and weakest with Andrew (human). In fact, no significant differences were determined between ‘Preference’, ‘Empathy’, ‘Enjoyable’, ‘Anxious’, ‘Learning Attitude’, ‘Relationship’ and ‘Engagement’. This indicates that the subjects experienced a similar level of these affective responses towards the three CompanionBots.

The relationship between character preference, user-agent relationships and user engagement were analysed using the Pearson’s product-moment correlation coefficient.

There are significant correlations exist between preference, relationship and engagement, thereby indicating the close connections that pertain between them. The strongest correlation determined was between preference and relationship (r=0.800, p<.01), and the second being between preference and engagement (r=0.540, p<.01), although a weaker correlation was established between relationship and engagement (r=0.486, p<.01). The entire range of relationships between the three affective responses achieved statistically significant correlations. The level of user preference for an agent character directly impacts the degree of user engagement in interactions with the agent character, and the degree of user engagement further influences the development of relationships between the user and the agent character.

The collected data from the questionnaires was also employed to compare the various affective responses between gender and age. These various affective responses between males and female were analysed utilising the T-test. In reality, no significant differences (p>.05) existed between males and females as well as among the four particular age groups in terms of ‘Preference’, ‘Empathy’, ‘Enjoyable’, ‘Anxious’, ‘Learning Attitude’, ‘Relationship’ and ‘Engagement’. As a result, this indicates that males and females as well as different aged subjects have a similar level of affective responses towards the CompanionBots.

4.2 Qualitative Results

The interview process involved six structured questions and some open-ended questions that considered the subjects’ answers to the previous six questions.

The first question concerned the English learning assistance offered by the CompanionBots. Subjects involved in chatting with the CompanionBots sensed that the experience aided them to think in an ‘English’ way, and increased the prospect of employing formal or academic style English. This result indicates that the CompanionBots in this experiment did adequately perform their function with their utilities to assist subjects with their English learning.

This section was followed by three questions, which invited the subjects to select which of the three CompanionBots they most liked to chat with, which one helped them to learn the most, and which one they would want to spend more time with. Firstly, according to 15 subjects, most of them felt that Chris was lovelier than Andrew and Ben, and they felt more comfortable when they chatted with Chris. Secondly, there were 13 subjects judged that Chris was the most accommodating of the CompanionBots, as they sensed a stronger connection towards Chris, and therefore spent more time conversing with this particular CompanionBot. Thirdly, 15 subjects believed that Chris was preferable to the others, as it he had some funny expressions, and as a result they wanted to spend more time with Chris. Overall, more subjects intended to spend more time with Chris, followed by Ben, and finally Andrew, as well as subjects seemed more engaged with Chris than either Ben or Andrew. Moreover, 14 of the 31 subjects chose the same CompanionBot for each of these three
questions. In reality, subjects declared that the more they liked the CompanionBot, the more time they wanted to spend time with it in order to facilitate the CompanionBot to assist them with their English learning.

The fifth question invited subjects to estimate which scenario is likely to make them feel most relaxed during English learning activities in terms of interacting with a CompanionBot, with an English native speaker or with a classmate who was learning English as a second language. Firstly, eight of the 31 subjects selected English native speakers, mostly based on the reason that speaking with native speakers would improve their oral English communication by the greatest amount or it may imbue subjects with additional fluency and correct English. Secondly, 11 subjects selected classmates as their preferred means to develop their English skills. Subjects who suggested classmates made them feel the most relaxed to practice English with, stated that classmates had a similar level of English ability, and thus only had the ability to extend them to a limited degree. Finally, the other 12 subjects chose CompanionBots as their preferred and most relaxed mode of English conversation. In truth, some subjects experienced stress when conversing with native English speakers and were afraid to learn incorrect English from their classmates. Conversely, subjects felt more relaxed while chatting with CompanionBots. Firstly, they judged that CompanionBots used correct English even when they gave incorrect answers. Secondly, CompanionBots were constantly available. Thirdly, subjects were not afraid to hurt CompanionBots feelings. Fourthly, CompanionBots were unlikely to display impatience or negative emotions towards the subjects personally. Finally, subjects typically were not afraid of making mistakes when they chatted with the CompanionBots.

The final structured question of the interview process asked subjects concerning the appearance and functions of their ideal CompanionBot. 26 subjects depicted the appearances of their perfect CompanionBots with the majority stating that their ideal CompanionBot is likely to be lovely, cartoon-like and good-looking characters, such as babies, handsome gentlemen or beautiful ladies. In terms of the functions of CompanionBots, the majority of subjects suggested that CompanionBots should possess more intelligence, as existing CompanionBots often offered incorrect answers. Heylen, van Es, Nijholt and Dijk [20] also proved that a cartoon-like character with human-like gaze is rated as having more usability, satisfaction, involvement and naturalness. Another function mentioned during these interviews was the ability of CompanionBots to correct their mistakes, whether in grammar, spelling or pronunciation. Other functions, such as telling joke and weather forecasting were mentioned while several subjects indicated that more expressions might improve the interactions between users and CompanionBots.

After the six structured questions, subjects were asked about their interactions with the CompanionBots and their opinions in relation to them. In fact, variables of character classifications, backgrounds, gestures and expressions were discussed in terms of visual interface. Subjects believed that assorted characters and backgrounds may generate varied conversational topics as well as suggesting that additional gestures and expressions may create more vivid CompanionBots. Subjects suggested that a significant difference existed between chatting with a human-like character rather than with an animal or creative creature. As a consequence, users hinted that they might feel more relaxed when chatting with an animal-like or a creative creature character.

Several subjects referred to the personalities of CompanionBots, and they suggested that different personalities of the CompanionBots were likely to elicit fresh feelings and new conversation topics. According to the study of Chen, Naveed and Porzel [21] that the personalities of agents do influence user preference and behaviour, and users typically prefer extroverted agents to introverted ones. In addition, the visual appearance of the CompanionBots often affected how the user views the CompanionBots’ personalities. Furthermore, subjects also raised the intelligence level of CompanionBots as a major topic of concern, as the existing CompanionBots often offered incorrect answers. Accordingly, subjects suggested that a more intelligent CompanionBot may be more helpful to assist language learning.

5. CONCLUSIONS

This experiment has been conducted to determine the answers to the questions concerning whether learners have different affective responses towards distinct character classifications of ECAs. Moreover, it aims to define the precise nature of relationship, if any, amongst character preference, user engagement and user-agent relationships. The result has been determined that distinct character classifications of ECAs influence human affective factors differently, and significant correlations exist among character preference, user engagement and user-agent relationships during HCIs.

According to the analysed quantitative results, subjects were more engaged in interactions with Chris (the
creative creature), followed by Ben (the animal) and least with Andrew (the human). While no significant difference was discovered between ‘Preference’, ‘Empathy’, ‘Enjoyable’, ‘Anxious’, ‘Learning attitude’ and ‘Relationship’, subjects had a similar level of affective responses towards the three CompanionBots. However, there remains some minor differences of the quantities of means, which indicated that the creative creature, Chris, as the agent interface that had more affective influences on users on average. Moreover, subjects sensed greater empathy towards Andrew, the human-like character, followed by Ben, the animal-like character, and Chris, the creative creature. In fact, Chris did offer more affective influences on users according to the analysis of qualitative data, including preference, utility and engagement, with Ben offering less and Andrew the least.

All relationships among the three affective responses, namely character preference, user engagement and user-agent relationships, achieved statistically significant correlations. The qualitative data also proved that various agent interfaces have assorted levels of impact on affective factors, and connections existed among affective factors during HCIs, such as preference, utility and engagement.

In terms of the future development of CompanionBots, subjects answered that chatting with the CompanionBots during the experimental period did assist them to think in an ‘English’ way, and increased the opportunities to use formal and academic style English. Moreover, more subjects agreed that the CompanionBots are the ideal language practice companions as opposed to classmates and native speakers, and the majority of subjects reported that the CompanionBots did improve their English in the domain of vocabulary and grammar. In addition to the affective factors explored in this survey, the ECAs have also been discovered to be suitable to be developed as language practice companions.

ACKNOWLEDGEMENTS
This study was assisted by IASL, Institute of Information Science, Academia Sinica.

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