Cross-cultural study on human-robot greeting interaction: acceptance and discomfort by Egyptians and Japanese

Gabriele Trovato[1], Massimiliano Zecca[2], *Member, IEEE*, Salvatore Sessa[3], *Member, IEEE*, Lorenzo Jamone[4], Jaap Ham[5], Kenji Hashimoto[6], *Member, IEEE*, and Atsuo Takanishi[7]*, *Member, IEEE*.

1   Graduate School of Science and Engineering, Waseda University, #41-304, 17 Kikui-cho, Shinjuku-ku, 162-0044 Tokyo, Japan

2   Faculty of Science and Engineering, Waseda University, and the Humanoid Robotics Institute, Waseda University

3   School of Innovative Design Engineering Mechatronics and Robotic Dept., Egypt-Japan University of Science and Technology, Borg El Arab, 21934 Alexandria, Egypt

4   Instituto de Sistemas e Robotica, Instituto Superior Tecnico, Av. Rovisco Pais 1, 1049-001 Lisbon, Portugal

5   Department of Innovation Sciences, Eindhoven University of Technology, P.O. Box 513 5600 MB, IPO 1.20, Eindhoven, the Netherlands

6   Faculty of Science and Engineering, Waseda University

7   Department of Modern Mechanical Engineering, Waseda University; and director of the Humanoid Robotics Institute (HRI), Waseda University

Abstract

As witnessed in several behavioural studies, a complex relationship exists between people's cultural background and their general acceptance towards robots. However, very few studies have investigated whether a robot's original language and gesture based on certain culture have an impact on the people of the different cultures. The purpose of this work is to provide experimental evidence which supports the idea that humans may accept more easily a robot that can adapt to their specific culture. Indeed, improving acceptance and reducing discomfort is fundamental for future deployment of robots as assistive, health-care or companion devices into a society. We conducted a Human-Robot Interaction experiment both in Egypt and in Japan. Human subjects were engaged in a simulated video conference with robots that were greeting and speaking either in Arabic or in Japanese. The subjects completed a questionnaire assessing their preferences and their emotional state, while their spontaneous reactions were recorded in different ways. The results suggest that Egyptians prefer the Arabic robot, while they feel a sense of discomfort when interacting with the Japanese robot; the opposite is also true for the Japanese. These findings confirm the importance of the localisation of a robot in order to improve human acceptance during social human-robot interaction.

1. Introduction

1.1. Cultural differences and robotics

In the near future humanoid robots are expected to play a major role in the society, the ability to interact and communicate with humans to help them in their work and daily life. Typical examples are serving as assistive robots for the elderly, or serving as companion robots. Assistive and personal robots are human-centric and their acceptance by their human users is the optimal priority for the robot designers to consider. The work in [1] provides an interesting review of studies about the acceptance towards assistive robot for the elderly. The work provides detailed information about 40 papers and underlining the importance of socio-demographic factors, including the cultural background of the human subjects.

Several studies have also shown that the cultural background affects the attribution of some form of personality to the robots [2], as well as the degree of anthropomorphism [3] and expectations and preferences about their role in the society and what they should look like [4, 5]. The idea that acceptance of robots depends on the culture is a very sensitive issue: Asimov was the first to introduce the Frankenstein com-

*E-mail: contact@takanishi.mech.waseda.ac.jp

plex [6], which describes the anxiety that people feel towards robots. The complex derives from the novel "Frankenstein; or, The Modern Prometheus" by Mary Shelley (1818) which at the beginning of the 19th Century expressed the fear that common people had for the technology, with technological creatures seen as a threat to humankind. According to the traditional view in literature, such anxiety is in part caused by popular fictional stories in which robots have negative connotations (e.g. Frankenstein, Terminator), at least in Western countries. This complex seems to be absent in Japan, where robots are viewed more like helpers or heroes. One possible explanation [7] of the latter fact lies in the Japanese animistic conception of religion, that ascribes souls to all living and non-living objects. While in Japanese mentality, living beings, objects, and gods are all parts of a whole picture, in the Western world, also because of Christianity, there is a strong distinction between the natural and the artificial [8]. As a matter of fact, differences between East and West in cognition, due to differing ecologies, social structures, philosophies, and educational systems, trace back to ancient Greece and China [9]. Drawing from these considerations, Kaplan suggested that "*...in the Western world machines are very important for understanding what we are. We think of ourselves by analogy with the way machines work. But at the same time, technological progress challenges our specificity. That is why we can at the same time be fascinated and afraid when confronted with new machines. In Japan, in contrast, machines do not seem to affect human specificity...*" [10].

However, stereotypes are not always true. For example, some of the oldest myths of artificial creation come from Greek culture, like for instance the myth of Pygmalion, who crafted a woman-shaped statue that eventually comes to life, after he falls in love with her. Most importantly, nothing in the myth condemns the creation of this creature [10]. Another milestone in the design and development of robots came with the discovery of Leonardo Da Vinci's journals, which contained plans for the construction of a humanoid robot [11]. Robotic heroes in science fiction are present in Western culture as well, like the "*cute, personable and highly marketable robots*" of Star Wars [12], and also some Japanese comics are in fact influenced by western science fiction [13].

Related studies support this more complex point of view. In contradiction to the popular belief that all Japanese are robot lovers, some results show that many of them are concerned about the emotional aspects of human-robot interaction [14]. Furthermore, differences in the anxiety towards robots can be found between people speaking different languages within the same country [15].

As for the Middle East, in order to improve acceptance of robots and their penetration into this culture, we should consider, especially in the case of humanoid robots, the implications of religious beliefs in those countries. Iconoclasm (the anti-iconic doctrine of prohibition of depiction of symbols and religion icons), found in many Middle East countries, has some reasons and implications. In fact, depiction of living beings, either animal or human, has been avoided, especially in sacred spaces, as depicting an image of a living being would be considered same as adopting the role of creator, which is reserved for only God [16]. Therefore, iconoclasm should be considered as a potential problem and definitely as an influencing factor on the attitude of people of Islamic countries towards humanoid robots.

However, there might be difficulties not related to iconoclasm. Technology acceptance, for instance, depends also on the country that is the producer, since culture of that country may bias some aspects of the product. As a consequence, localisation of products may be done. It is necessary to understand cultural norms of the country for ensuring technology acceptance [17, 18], and in the Middle East, where societal rules are often blended with religious beliefs, this is particularly important.

1.2. Greeting interaction and related works

As robots are expected to interact and communicate with humans of different cultural background in a natural way, without generating any sense of discomfort and ensuring acceptance, we believe that it is important to study greeting interaction between robots and humans. In fact, greetings play an important role in human-human communication, and are an aspect of human relations that varies between cultures. For example, the complexity of greetings in Japanese culture may cause possible communication problems with foreigners [19]. On the other hand, Middle Eastern countries, pervaded by Islamic culture, feature some distinctive traits. For this reason, customs and manners should be considered carefully when visiting those countries [20].

To the best of our knowledge, only a few greeting interaction experiments with robots have been conducted so far. Experiments done by Yamamoto et al. [21], who focused on timing, rather than on culture, and experiments featuring the social robot ApriPoco, in which Japanese, Chinese, and French greetings were compared [22, 23]. However, in experiments with ApriPoco, conclusions remain unclear due to the low number of subjects and the limited number of degrees of freedom of the robot, leading to difficulties in obtaining significant data from human biological signals. Compared to those experiments, our intention is to do a more extensive study with a greater number of subjects and a human sized humanoid robot. We chose Egypt as the location for the first session of our experiment: The Middle East and Islamic culture in general are a quite unexplored terrain in humanoid robotics. To the best of our knowledge, the only known studies of Human-Robot Interaction in the Middle East were performed by Makatchev et al. [24] in Doha, Qatar, focusing on ethnicity cues, and by Riek et al. [25], who found significant regional differences in overall attitudes towards Ibn Sina, an Arabian looking humanoid robot. That work, however, was only focused on the Middle East, without any comparison to subjects of other cultures or robots made for other cultures. Further insights were provided by Mavridis et al. [26], taking into account religion too.

1.3. Objectives of this paper

In this paper we present the results of two cross-cultural experiments in which the reactions of human subjects involved in a simulated video conference with a robot were observed. The subjects were either Japanese or Egyptian and the robot was greeting and speaking either like a Japanese or an Arab. We expected that Egyptians would have preferred the Arabic version of the robot, and that they might have felt symptoms of discomfort when interacting with the Japanese version. On the other hand, we expected Japanese subjects' perception to be the opposite, i.e. preference for the Japanese version of the robot and discomfort for the non-Japanese one.

We performed the first session of the experiment in Egypt, gathering Egyptian subjects as well as a few Japanese living there. Preliminary results have been published in [27]. We then performed a second session of experiments in Japan using the same experimental protocol. We can now have a look at the complete data (extracted from 61 subjects in total) and compare the cultural groups in this manuscript.

The rest of the paper is organized as follows: in section 2 we describe the hardware that we used and the protocol of the experiment; in section 3 we show the detailed results and we discuss them in section 4; in section 5 we conclude the paper and outline future works.

2. Experimental procedures

2.1. Hardware

For the experiment, we used the whole body emotion expression 48-DoFs humanoid robot KOBIAN [28] (Fig. 1). It is designed to provide support for the ADL (Activities of Daily Living) for elderly and disabled people, and to clarify the influence and effectiveness of physicality and expressivity during the interaction between human beings and robots. Humanoid robots are indeed possible candidates for being used as ADL-assistive devices, for example helping elderly people to perform activities of daily living. Besides emotion expression, KOBIAN is a robot capable of bipedal walking. These two abilities combined together make KOBIAN potentially able, in the future, to work as assistive robot in a human environment, such as a family or a public facility. Its newest version, KOBIAN-R [29], has been used to study culture differences in recognition of facial expressions [30].

In order to make an experiment with subjects in a place like Egypt, distant from the robot (which is in Waseda University, in Tokyo, Japan) a video conference system is needed. Despite there is only one KOBIAN, our purpose was to show two different robots (one Japanese-like, and one Middle Eastern-like) to the subjects; therefore, the video conference was simulated. We used the robot in two versions: KOBIAN, the original version, and AL-BIAN, which has different facial and body colours (see Fig. 2, a and b respectively). The colour differences between the two versions were chosen to be unrelated in any way to the specific culture, and they are not meant to make the robot more appealing for a specific group of subjects; their only purpose is to give to the subjects the impression that they are interacting with two different, although very similar, robots.

KOBIAN and AL-BIAN were used to realise the culture-specific greetings (motion of the arms and waist) and to simulate speech (motion of the lips and slight periodic oscillations of the head, that give a human-like appearance to the robot behaviour).

The robot body parts are controlled by both position-based and velocity-based controllers that have been implemented using YARP [31], a software framework for robot programming. The coordination of the different joints involved in the motion and the timing of the different movements were accurately designed to achieve a natural behaviour with smooth trajectories and mild transitions between the different motions.

2.2. Experimental protocol

The experimental protocol consists of the following 8 steps:

Step 1 Pre-questionnaire

Each subject is invited to sit at a desk, in front of a big screen, and to compile a preliminary questionnaire on likeability of humanoid robots in general and on their own perceived safety (details in section 2.4).

Step 2 Explanation

The subject (Fig. 3, a) is explained the purpose of the experiment and he/she is told there will be a call to a laboratory in Waseda University in Japan through the video conference system, for showing two different robots. Actually, a previously recorded video will be shown, as the TV is not connected to the device, but to a PC. No actual call is made, but the subject is tricked into believing that he/she is watching a live connection by adding the typical connection sounds and screenshots. This Wizard of OZ style experimental setup encourages natural behaviour of the participant.
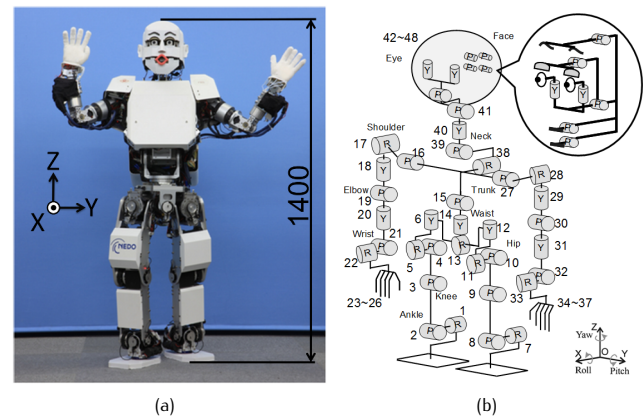

Figure 1. Emotion expressive humanoid robot KOBIAN: a) Overview (b) DoF configuration.

Step 3 Examiners preparation

One of the two examiners (Fig. 3, b) is in charge of measuring the response time of the subject's greeting (either spoken or a gesture) to the robot's greetings by using a stopwatch. The other examiner (Fig. 3, c), who controls the PC (Fig. 3, d) and the video conference system remote control, sits in front of the subject for examining any verbal or non-verbal cue expressed by the subject; he also takes notes using a checklist.

Step 4 First call

As one examiner pretends to start the call, video begins and connection is established with a Japanese student, who once more explains the purpose of the experiment; then the Japanese student switches the camera to KOBIAN, who greets, does a self-introduction and says goodbye (more detail in section 2.3).

Step 5 First questionnaire

After closing the connection, the subject compiles a questionnaire about KOBIAN, including all the questions shown in section 2.4.

Step 6 Second call

A new call is made, this time to an Arabic speaking student who greets and tells the subject to wait, then switches the camera to AL-BIAN, who greets, does a self-introduction and says goodbye.

Step 7 Second questionnaire

As the video conference ends, the subject is invited to compile a questionnaire about AL-BIAN, including all the questions shown in section 2.4, and to express a preference between the two robots.

Step 8 Closing explanations

At the end, the subject is informed that the video conference was not real, and of the motivation of the use of this trick. If he/she knew beforehand that was watching a video, there would be no reactions, and
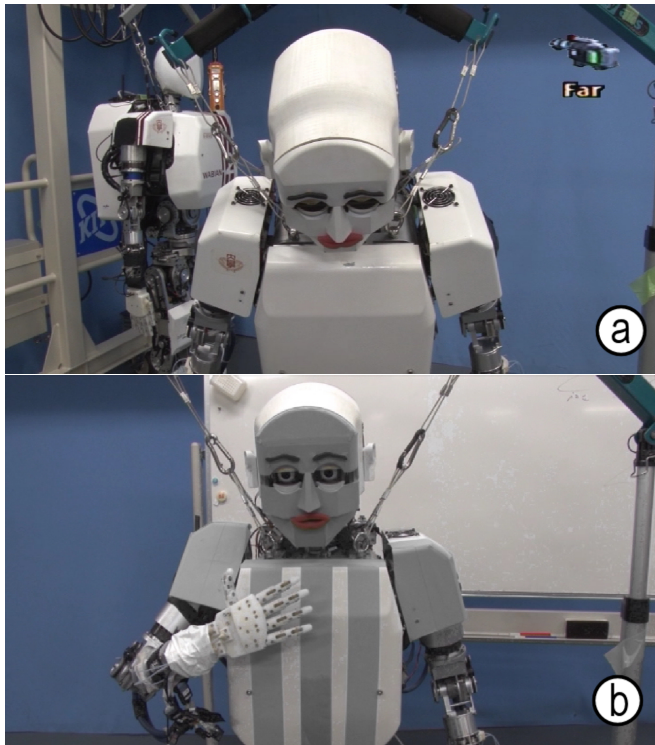
Figure 2. Two screenshots of the video shown to the participants. (a): the robot KOBIAN performing a bow. (b): the ficticial robot AL-BIAN performing a salaam greeting. They are in fact the same robot.

Figure 3. Experimental setup, with the subject (a) watching the screen, and the two examiners (b and c) focusing on the subject and controlling a computer (d).

no interaction. Through this trick, we could collect meaningful data from their spontaneous reactions (in fact, as we later verified, nobody noticed the trick).

Note: for all subjects the order of the robots was randomly chosen (steps 4-7). This means that for around one half of the subjects, the order of the robot was (AL-BIAN, KOBIAN) instead of (KOBIAN, AL-BIAN).

2.3. Videos

Several videos were recorded beforehand and assembled together into a single video file. Interface screens and sounds were added for simulating a real call through a video conference system. The video was composed by the following parts:

- Japanese person greeting in Japanese, introducing in English the next robot;

- KOBIAN performing a bow – with Konnichi wa (which means Hello or Good day) speech added – as initial greeting;

- KOBIAN introducing himself in English with Japanese accent;

- KOBIAN performing a bow – with Otsukaresama desu (which is a standard idiomatic phrase that fellow workers use at the end of a working day) speech added – as final greeting;

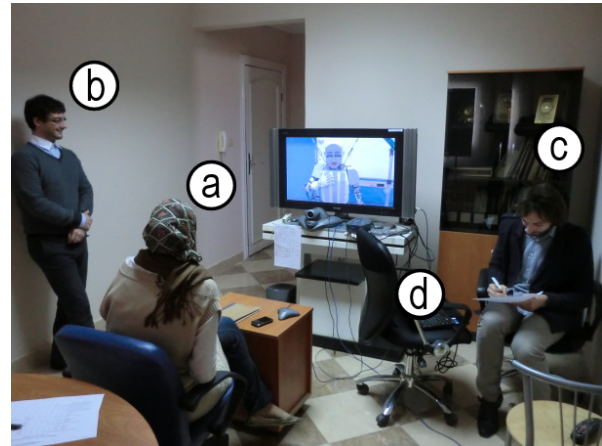- Middle Eastern person greeting in Arabic, and introducing in English the next robot;

- AL-BIAN raising hand – with Alsalamo alikum (which means Hello or Good day) speech added – as initial greeting;

- AL-BIAN introducing himself in English with Arabic accent;

- AL-BIAN moving its hand on the heart and nodding (a shortened version of the Mouth-and-forehead salaam greeting described in [32]) – with Alsalamo alikum speech added – as final greeting.

2.4. Assessment

A combination of physiological responses and written questionnaires were considered for the assessment of the interaction, since in this way it is possible to catch both explicit opinions and psychological reactions. For assessing the degree of discomfort of subjects, a good method is to observe eyebrows frowning, through measurement of movement of the corrugator supercilii muscle [33, 34]. In fact, frowning is known to be a symptom of either incomprehension or anger [35]. However, in our pilot study, facial Electromyography did not provide reliable data; furthermore, electrodes placed on subjects' face caused discomfort to them. Therefore it was decided to use an examiner who would observe facial expressions, non-verbal cues (not limited to frowning) and behaviour of the subjects, and compile a checklist with all these relevant information.

Assessment in human-robot interaction through survey is preferably done using standardised measurements. Bartneck [36] devised reliable 5-point semantic differential scales called Godspeed for measuring anthropomorphism, animacy, likeability, perceived intelligence, and perceived safety for robots. We decided to use likeability and perceived safety; moreover, we added a new set of scales for measuring cultural closeness. The three resulting groups of scales (first and third from [36]) were presented as follows:

Additional questions included some demographic information like age and gender, and some more explicit questions regarding what the subject liked about the two robots. Moreover, some specific questions were made about the gesture and the words the robot used, and the way it spoke English. In section 3 all the significant answers collected from these questions are shown. Questionnaires were written in two languages (English and Arabic or English and Japanese).

```
LIKEABILITY
Dislike           1 2 3 4 5  Like
Unfriendly        1 2 3 4 5  Friendly
Unkind            1 2 3 4 5  Kind
Unpleasant        1 2 3 4 5  Pleasant
Awful             1 2 3 4 5  Nice

CULTURAL CLOSENESS
Impolite          1 2 3 4 5  Polite
Mysterious        1 2 3 4 5  Familiar
Incomprehensible  1 2 3 4 5  Comprehensible
Foreign           1 2 3 4 5  Native

PERCEIVED SAFETY
Anxious           1 2 3 4 5  Relaxed
Agitated          1 2 3 4 5  Calm
Quiescent         1 2 3 4 5  Surprised
```

3. Analysis of results

3.1. Participants

The whole experiment was done in two sessions. The first one was done in Egypt, inviting 36 subjects; the second session was done in Japan, with 25 subjects. The experimental setup was the same in both locations. In total, we could gather the data of 61 participants (male: 37; female: 24; average age: 30.33; standard deviation: 10.29). We gathered a heterogeneous group of participants consisting of people with different age and education level, rather than just students.

The unbalance between male and female happened because it's not easy to find female subjects in Egypt available to do an experiment, compared to men. As a consequence of this unbalance, an analysis on differences between genders might produce misleading results and therefore it was not carried out. The total of the subjects were instead divided in four groups:

· Group J: Japanese people with no previous experience with Middle Eastern culture (18 subjects);

· Group JE: Japanese people living in Egypt (5 subjects) or with some degree of interest in Arabic language or Middle Eastern culture (7 subjects). (Total: 12 subjects);

· Group EJ: Egyptian people who can speak Japanese, or have been in Japan or have interest in Japanese culture (13 subjects);

· Group E: Egyptian people who have no previous experience with Japanese culture (18 subjects).

As mentioned in section 2.2, the order of the two robots ((KOBIAN, AL-BIAN) or (AL-BIAN, KOBIAN)) was randomly chosen for each subject in every group. This manipulation, while useful for avoiding a bias, did not produce any significant effect on the results, therefore it is excluded from further analysis.

The duration of the experiment described in section 2.2 was approximately 20 minutes.

3.2. Data analysis

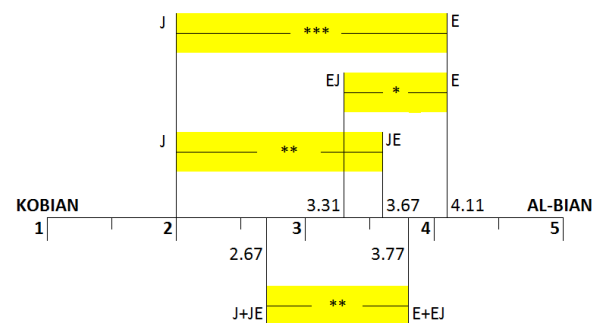Gathered data were analysed using the Kruskal-Wallis test [37] and subsequently the Mann-Whitney U-test [38]. In all the cases in which the U-test was performed, it means that the Kruskal-Wallis test already gave a low p value as output. The classical Student's t-test and ANOVA could not be applied, because the shape of the distribution graph resulting from the semantic differential scales data was not a normal distribution. In all the following graphs, one asterisk (*) means $p < .05$; two asterisks (**) mean $p < .01$; three asterisks mean $p < .001$.

3.2.1. Subjects' preference

At the very end of the experiment, the subjects were asked to express their preference between the two robots. Result of this explicit question shown that while Japanese subject of group J have a strong preference for KOBIAN (Fig. 4, on the left), Egyptian subjects prefer AL-BIAN (Fig. 4, on the right), and the other groups stand in the middle. In Fig. 4 average values are highlighted when the U-test produced significant results ($p<.05$).

Subjects were also asked to justify their choice adding a free comment. We have collected all the comments and divided into the following categories, shown in Fig. 5:

Figure 4. Significant difference in preference, on a scale from 1 to 5, between KOBIAN and AL-BIAN among the different groups J, E, EJ and JE (described in section 3.1), and between the total of the Japanese (J+JE) against the total of the Egyptians (E+EJ). In yellow, statistically significant differences (one asterisk (*) means p <.05; two asterisks (**) mean p <.01; three asterisks mean p <.001).
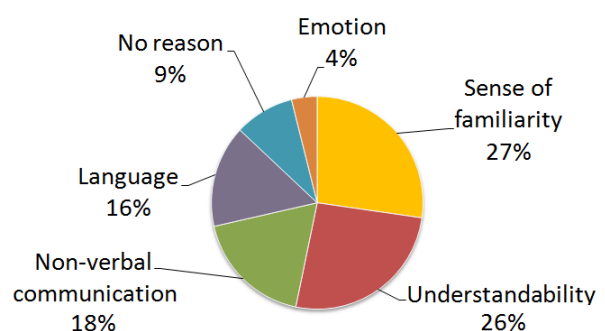

Figure 5. This graph reports the reasons why subjects expressed a preference for one robot.

· Non-verbal communication: gesture more natural / uses hands / moves hands like humans / better body language / better movement / more realistic;

· Sense of familiarity: it is more comfortable / more familiar / more friendly;

· Language: speaks my language / greeting is in Arabic;

· Understandability: more understandable / clear language / clear spelling / voice is more clear / speaks more fluently / better English;

· Emotion: emotion more clear / shows emotions better;

· No reason: I don't know / just my feeling.

We included any comment related to the appearance to the "No reason" category. This is because physical appearance of the two robots was essentially the same, and claiming that one of the two is better looking may be caused by personal feelings.

Additional negative comments were made about the quality of the voice, but as these comments were made on both robots, we believe that this is not an important factor for our evaluation and therefore did not include it in the diagram.

The most important categories were the sense of familiarity, understandability, and non-verbal communication.

As integration to the explicit preference, we asked one additional question to the subjects: "Would you like to meet this robot again?", using again a 5-point semantic differential scale. Results are coherent with the ones seen so far: subjects of group J would prefer to meet KOBIAN (+0.39 compared to AL-BIAN); Japanese of group JE do not have a strong preference (+0.08 for AL-BIAN). Egyptians would like to meet AL-BIAN (+0.23 for group EJ, +0.44 for group E compared to KOBIAN).

3.2.2. Cultural closeness

For measuring cultural closeness, we introduced a new set of scales, described in section 2.4 and presented to subjects in steps 5 and 7 of section 2.2. These scales can be considered reliable, as their Cronbach's alpha, a coefficient of internal consistency used to estimate the reliability of a psychometric test, is greater than 0.7 [39]. Subtracting the average score (from 1 to 5) obtained by AL-BIAN and KOBIAN, we can measure perceived cultural distance of the two robots for each group. Results in Table 1 show that this difference is significant for the groups E, who feel AL-BIAN closer, and J, who feel KOBIAN closer (cells highlighted in yellow). In addition, differences among groups (highlighted in yellow, on the right) are also present. Group JE shows on average almost no preference between the two robots, and is significantly different from Group J (p <.05). A much stronger difference (p <.001) can be found between groups J and E and between the total of Japanese subjects (J + JE) and the total of Egyptian subjects (E + EJ)

3.2.3. Likeability and perceived safety

Both likeability and perceived safety were measured three times, namely at steps 1, 5 and 7 of the protocol described in section 2.2. We consider the measurement of step 1 a preliminary assessment (Pre in Fig. 6) of the subject's attitude towards humanoid robots in general (not on the two specific robots) and it is useful to give a hint of the acceptance of the robots in absolute terms.

Significant data for likeability are as follows: 3 groups out of 4 (E, EJ, JE) showed a significant preference for AL-BIAN, whereas the score for group J was relatively low. On the other hand, before drawing conclusions on perceived safety, one of the scales (Surprised/Quiescent) has to be dropped, because it does not seem to be consistent with the other scales, leading to a low Cronbach's alpha (<0.7). As a result, average is calculated on the two variables Anxious/Relaxed and

Agitated/Calm. Probably because of this inconvenience, no significant shift of perceived safety before/after meeting the robots is detected. Kruskal-Wallis test also confirms this assumption (p = 0.23). Nevertheless a trend can be noticed in Table 2: meeting AL-BIAN seems to have a slightly better effect for all groups except group J. In the table, negative values are marked in yellow: the subject feels more anxious afterwards, while positive values (the subject feels safer) are marked in green, and lime means no difference.

Table 1. Difference in cultural closeness of the two robots for each group and significant differences between two groups.

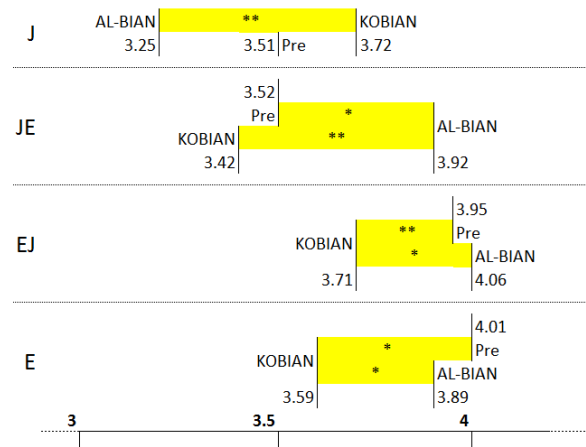|	AL-BIAN – KOBIAN	
J	–0.61 (**)	*
JE	–0.04	
EJ	0.25	***
E	0.514 (*)	

Figure 6. Zoom in variations of Likeability on 1 to 5 scale. In yellow, statistically significant differences: one asterisk (*) means p <.05; two asterisks (**) mean p <.01; three asterisks mean p <.001. J, E, EJ and JE indicate the groups described in section 3.1. "Pre" indicates the preliminary assessment on Humanoid robots done before doing the experiment.

3.2.4. Reaction to greeting types

We recorded detailed information about each subject's reaction to the greetings of both human operators (we call here human operators the two students who introduced the robots during the video conferences: see section 2.2, steps 4 and 6) and robots. Particular emphasis was placed on measuring response time of the subject after human/robot greeting speech, since a delay could be a hint of hesitation and feeling of bewilderment. From Table 3, comparing all matches, it can be seen that subjects experienced hesitation mainly with robots rather than with humans. For Egyptians, the highest scores (considering long reaction

Table 2. Differences in Perceived Safety between the preliminary assessment on humanoid robots ("Pre") and after interacting with the two robots.

	KOBIAN – Pre	AL-BIAN – Pre	Difference
J	0.14	–0.25	KOBIAN: +0.39
JE	–0.21	0	AL-BIAN: +0.21
EJ	0.23	0.42	AL-BIAN: +0.19
E	–0.19	0.14	AL-BIAN: +0.33

Table 3. Percentage of cases of greeting interaction and of long reaction time in the answer.

		Human (Japanese)	KOBIAN	Human (Arabic)	AL-BIAN
J	Answer	75%	20.8%	18.1%	4.2%
	Slow response	0%	14.6%	0%	0%
JE	Answer	62.5%	18.8%	27.1%	0%
	Slow response	0%	0%	0%	0%
EJ	Answer	61.54%	26.92%	50%	7.69%
	Slow response	0%	29.17%	5%	0%
E	Answer	38.9%	12.5%	61.1%	26.3%
	Slow response	0%	17.5%	4.51%	9.38%

time as >1 second) were hit when facing KOBIAN, while it is not possible to judge Japanese subjects, as the interaction with AL-BIAN was too poor. In general, it is clear that the amount of interaction with the two robots is still low compared to humans (rows labelled Answer in Table 3, where the answer can be either spoken or by gesture).

3.2.5. Relative weight of speech and gestures

In order to understand which factors, among gestures and voice, had a stronger impact on subjects' preferences, the questionnaire featured the following questions (to be answered with the 5-points semantic differential scale):

· Do you like the gesture the robot used to greet you?

· Do you like the words the robot used to greet you?

· Do you like the way the robot speaks English?

As a result, we got the data displayed in Table 4. It appears that both channels of communication contribute to the preference.

The same investigation was extended to compare robots' greetings with the human operators' greetings. In fact, the two operators performed exactly the same greetings, in terms of speech ("Konnichi wa" and "Alsalamo alikum") and gestures, of the two robots; thus they can be compared.

Given some comments made by the participants in this experiment, we hypothesised that the ones who belong to a certain culture are stricter when evaluating an imitation of their own way of greeting. For example, a Japanese is more likely to notice any incorrectness in the angle of the bow. We expected this kind of bias to be stronger in groups J and E. However, this hypothesis could not be verified through the questionnaire results and no significant conclusion can be drawn. For the sake of completeness, we report here these results in Table 5. Row data contain no significant high or lows (average is 3.82; standard deviation is 0.31). Some small differences can still be noticed. For example group J prefers the robot in case of Japanese greetings, but the human's in case of Arabic.

3.2.6. Non-verbal communication

One additional proof of subjects' feeling can be obtained by analysing non-verbal cues. Positive ones include smiling, laughing, and nodding. Negative ones include eyebrow frowning, eyelids tightening, head shake, and similar neck movements. In Table 6, where higher values are highlighted in different colours, it is possible to see how negative cues are concentrated in the interaction between KOBIAN and Egyptians of group E, and between AL-BIAN and Japanese of group J, proving the discomfort experienced by subjects, and some particular examples are shown in Fig. 7 and 8.

Table 4. Differences in preference of greeting due to verbal and non-verbal channels.

	Gesture	Greeting words	English speech
J	KOBIAN +0.56	KOBIAN +0.72	KOBIAN +0.11
JE	AL-BIAN +0.25	AL-BIAN +0.17	AL-BIAN +0.42
EJ	AL-BIAN +0.22	AL-BIAN +0.08	AL-BIAN +0.77
E	AL-BIAN +0.17	AL-BIAN +0.56	AL-BIAN +1.39

Figure 7. Example of some positive non-verbal cues (a) and of some negative ones (b) for Egyptian subjects.

Table 5. Differences in preference of greeting compared to human operators.

		Human (Japanese)	KOBIAN	Human (Arabic)	AL-BIAN
J	Negative	0.06	0.33	0.11	0.78
	Neutral	0.00	0.11	0.39	0.56
	Positive	0.17	0.72	0.39	0.33
JE	Negative	0.00	0.17	0.08	0.08
	Neutral	0.08	0.00	0.08	0.08
	Positive	0.00	0.50	0.25	0.58
EJ	Negative	0.00	0.31	0.00	0.00
	Neutral	0.00	0.08	0.00	0.08
	Positive	0.15	0.62	0.38	0.54
E	Negative	0.11	0.83	0.06	0.06
	Neutral	0.00	0.17	0.06	0.06
	Positive	0.28	0.50	0.39	0.56

Figure 8. Example of neutral (a) and negative (b) non-verbal cues for a Japanese subject. We consider astonishment (a) as neither positive nor negative.

Table 6. Average number of occurrences of non-verbal cues per subject.

		Human (Japanese)	KOBIAN	Human (Arabic)	AL-BIAN
J	Negative	0.06	0.33	0.11	0.78
	Neutral	0.00	0.11	0.39	0.56
	Positive	0.17	0.72	0.39	0.33
JE	Negative	0.00	0.17	0.08	0.08
	Neutral	0.08	0.00	0.08	0.08
	Positive	0.00	0.50	0.25	0.58
EJ	Negative	0.00	0.31	0.00	0.00
	Neutral	0.00	0.08	0.00	0.08
	Positive	0.15	0.62	0.38	0.54
E	Negative	0.11	0.83	0.06	0.06
	Neutral	0.00	0.17	0.06	0.06
	Positive	0.28	0.50	0.39	0.56

4. Discussion

In section 3 we presented the results of the experiments. Our goal was to investigate the different attitudes of Egyptian and Japanese people towards two different versions of the same robot, programmed to greet and speak with Egyptian-like and Japanese-like manners. We

expected the reactions of the subjects, both explicit and implicit, to be different according to their culture.

Data were collected in different modalities: using questionnaires for investigating both explicit comments and implicit effects on subjects' emotional state, measuring response of interaction, and keeping track of all verbal and non-verbal cues.

Results indicated that our hypothesis was expected that Japanese subjects and Egyptian subjects perceive the two humanoid robots differently. Japanese seem to prefer KOBIAN, whereas Egyptians seem to prefer AL-BIAN. This can be seen in section 3.2.2 and 3.2.3 in terms of attitude towards the robots, and in section 3.2.4 and 3.2.6, in terms of interaction. Some interesting points can be deducted by combining all the data:

· Egyptians feel in some cases discomfort when interacting with KOBIAN (section 3.2.4 and 3.2.6), and even end up in a more anxious state compared to before the experiment (section 3.2.3). AL-BIAN, who (citing a subject's comment) "Moves hands like humans" does not seem to cause such anxiety. On the other hand, a few comments we gathered from Japanese subjects explain their point of view on AL-BIAN: "Ayashii" (suspicious), "Iwakan" (discomfort), "Tsumetai" (cold), "Kowai" (scary). Such words were not used when commenting KOBIAN, and it is odd, because the appearance of the two robots is almost the same.

· Subjects familiar with the other culture tend to like both robots and react in the same way. The tendency of groups EJ and JE to stand in the middle of the other two groups in terms of results is common to most of the gathered data, including subjects' preference and cultural closeness (section 3.2.1 and 3.2.2). Among these groups, the presence of subjects not only familiar, but also enthusiastic about (in case of Egyptians) Japan or (in case of Japanese) Middle East, might explain the cases in which attitude of Egyptians towards KOBIAN is even more positive that AL-BIAN (see Table 3) and in which Japanese prefer AL-BIAN (see Table 2 and Fig. 4 and 6).

· It is possible to notice from the data many hints that Egyptians not familiar with Japanese culture have a strong preference for

AL-BIAN and that Japanese not familiar with Middle East have a strong preference for KOBIAN. The analysis of the reasons of this preference reveals that causal relationship among the different categories of reasons (shown in Fig. 5) might exist. In particular, it is possible that gesture and words play a role in making the robot more familiar. In this regard, interaction mechanisms described in The Media Equation [40] should be considered, as similarity to a computer agent [41] and politeness [42] are proved to play a role in human perception of a machine.

· Another point of discussion is whether roboticists should really need to take care about even small cultural differences. We believe that in the future, when robot might enter the mass market, these small details can make a difference between a product that gets sold and another that does not get sold. Designers might be interested in knowing what to think about when designing for a robot in terms of appearance as well as behaviour. In our experiment, we made AL-BIAN look very similar to KOBIAN; however, the use for instance of clothes (in a similar way to Ibn Sina [25]) might make significant differences between groups bigger.

· As seen in Table 3, amount of interaction with the two robots is still low compared to humans (see Fig. 9 as one case of successful interaction with a robot). For this reasons, we further investigated and asked to the subjects the reason why they did not reply to the robot but they did to the human operators (who were recorded as well). The most common answers were:

  – "I didn't think the robot would listen to me"
  – "I thought it wouldn't answer"
  – "It made me agitated"
  – "I was too shy to answer the robot"
  – "I don't think I will be considered impolite if I don't answer to the robot"
  – "Not feeling its presence"
  – "Not enough eye contact"

We believe that the comment about politeness is particularly interesting, because in order to make humans and robots, in the future, develop a more natural interaction, culture and politeness have to be considered. In fact, as hypothesised in a formula made by Brown and Levinson [43], politeness is dependent on culture.
Taking a further look at Table 3, it is possible to notice that the interaction gap reduces when robot's greeting matches language and gesture of subject's background culture. This fact suggests that interaction can be encouraged by a robot that looks more familiar and it supports the need of developing culture-specific customisation of robots.
Differences in national culture, history, and religion are known to have an impact on the design of products [44]. Even in software, when people from different cultures look at an object in an interface, they may have a different understanding of what it represents [45]. As robots need to interface with humans, we believe that the concept of localisation of products needs to be extended to robots too, and the results reported in this paper seem to support this hypothesis.

· Is it just a matter of language? Indeed, it could be argued that the results we obtained in this experiment are somehow obvious because of language barrier. However, a closer look to the numbers supports our belief that this is not the case. For example, we can cite the evidence of a Japanese subject, completely unfamiliar with robots and not very interested in the experiment. This subject's answers were '3' for all the questions in the 5-point semantic differential scales, for both robots. In spite of this pronounced non-preference, she chose KOBIAN in the last question, with no special reason. This fact suggests that there are some subtle factors which influence people's judgement other than language. In fact, in Fig. 4 the categories Understandability and Language, put together, correspond to 42% of the reasons of preference. The rest is due to other reasons. In order to shed more light on this matter, there is the need of a further experiment in which the two robots will both speak a language that is not the subjects' mother tongue, whereas the non-verbal part will be, for each robot, respectively belonging to a culture that is considered close to the subjects' one, and to a culture that is considered distant.

Figure 9. Successful moment of greeting interaction. Even for Japanese subjects, this happened seldom.

5. Conclusions and future work

In the present manuscript, two experiments of Human-Robot Interaction, performed in Egypt and Japan, are described. Subjects of the two nationalities participated to a simulated video conference with two robots which performed greetings and a self introduction, respectively using Arabic and Japanese gestures and way of speaking. The purpose of this work was to prove that a robot that can adapt to the verbal and non-verbal communication styles of a specific culture may make a better impression and reduce discomfort of human subjects. Results suggested the existence of difference in perception between Egyptians and Japanese, as the former prefer the Arabic version of the robot and experience several symptoms of discomfort when interacting with the Japanese version. The same things happen the other way round. This fact supports our hypothesis; therefore, design of a robot which moves and speaks in a way that is linked to a certain cultural background should be carefully considered when thinking about integration of assistive robots into society. Future works include the repetition of the same experiment in a third Western country. In particular, it would be interesting to measure the effects of cultural closeness, between subjects of

two countries of the same area, which share similar culture but differ by language. Results of the present study highlight the need of diversification of robots and justify the realisation of a system for greeting mode selection for humanoid robots. Through the development of a model of greetings and using multimodal input and output, robots would be able in the future to switch between different modes depending on the cultural background of the human partner.

Acknowledgements

References

[1] P. Flandorfer, Population Ageing and Socially Assistive Robots for Elderly Persons: The Importance of Sociodemographic Factors for User Acceptance, *International Journal of Population Research*, 2012 (2012), Article ID 829835, 13 pages,. DOI:10.1155/2012/829835

[2] A. Weiss, V. Evers, Exploring cultural factors in human-robot interaction: A matter of personality?, International Workshop on Comparative Informatics (IWCI-2011), Copenhagen, Denmark, 2011

[3] F. Eyssel and D. Kuchenbrandt, Social categorization of social robots: Anthropomorphism as a function of robot group membership, *British Journal of Social Psychology*, 51 (4) (2012), 724–731

[4] T. Nomura, T. Suzuki, T. Kanda, J. Han, N. Shin, J. Burke, K. Kato, What people assume about humanoid and animal-type robots: cross-cultural analysis between Japan, Korean, and the United States, *International Journal of Humanoid Robotics*, 05(1) (2008), 25-46

[5] H. R. Lee, J. Sung, S. abanovic, J. Han, Cultural Design of Domestic Robots: A Study of User Expectations in Korea and the United States, The 21st IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN), Paris, France, 2012

[6] I. Asimov, The Machine and the Robot. Science Fiction: Contemporary Mythology, P.S. Warrick, M. H. Greenberg, J. D. Olander (Ed.), Harper and Row, 1978

[7] F. L. Schodt, Inside the Robot Kingdom – Japan, Mechatronics, and Coming Robotopia, Kodansha, Tokyo, New York, 1988

[8] B. Latour, Nous n'avons jamais été modernes (La découverte). English translation revised and augmented: We Have Never Been Modern, Simon and Schuster, 31 England and Harvard University Press, 1991

[9] R. Nisbett, The Geography of Thought: How Asians and Westerners Think Differently...and Why, Free press, New York, 2004

[10] F. Kaplan, Who is afraid of the humanoid? Investigating cultural differences in the acceptance of robots, *International Journal of Humanoid Robotics*, 1 (3) (2004), 465-480

[11] M. E. Rosheim, Leonardo's Lost Robots, Springer, 2006

[12] J. P. Telotte, Replications: A Robotic History of the Science Fiction Film, University of Illinois Press, 1995

[13] L.Graillat, America vs. Japan: the Influence of American Comics on Manga, *Refractory: A Journal of Entertainment Media*, 10, 2006

[14] C. Bartneck, T. Suzuki, T. Kanda, T. Nomura, The influence of people's culture and prior experiences with Aibo on their attitude towards robots, *AI & Soc.*, 21 (2007), 217-230

[15] K. O. Arras, Do we want to share our lives and bodies with robots? A 2000-people survey, Autonomous Systems Lab, EPFL, Technical Report Nr. 0605-001, 2005. Available: http://publications.asl.ethz.ch/files/arras05want.pdf

[16] M. Saif, The evolution of persian thought regarding art and figural representation in secular and religious life after the coming of Islam. *Macalester Islam Journal*, 1(2) (2006), 53-95

[17] R. M. Thomas, Computer technology: an example of decision-making in technology transfer. Educational technology – its' creation, development and cross-cultural transfer. In: R.M. Thomas, V. N. Kobayashi (Ed.), Pergamon Press, Oxford, 1987, 25-34

[18] E. M. Rogers EM, Diffusion of innovations, 4 ed., The Free Press, New York, 1995

[19] S. K. Fan, Japanese communication beyond language: from the viewpoint of Hong Kong Chinese (in Japanese), Kanda University of International Studies, 2002, 21-35

[20] Y. H. Zoubir, Doing business in Egypt, *Thunderbird International Business Review*, 42 (3) (2001), 329-347

[21] M. Yamamoto, T. Watanabe, Time Delay Effects of Utterance to Communicative Actions on Greeting Interaction by Using a Voice-Driven Embodied Interaction System, Proceedings of International Symposium on Computational Intelligence in Robotics and Automation, 2003, 217-222

[22] S. Suzuki, Y. Fujimoto, T. Yamaguchi, Can differences of nationalities be induced and measured by robot gesture communication?, 4th International Conference on Human System Interactions (HSI), 2011, 357-362

[23] H. Aoki, Y. Fujimoto, S. Suzuki, E. Sato-Shimokawara, T. Yamaguchi, Interaction robot considered difference of culture and physiological responses on greeting with the robot, SICE Annual Conference 2011, 2510-2513

[24] M. Makatche, R. Simmons, M. Sakr, M. Ziadee, Expressing Ethnicity through Behaviors of a Robot Character, Proceedings of the 8th ACM/IEEE international conference on Human-robot interaction (HRI), Tokyo, Japan, 2013, 357-364, arXiv:1303.3592

[25] L. D. Riek, N. Mavridis, S. Antali, N. Darmaki, Z. Ahmed, M. Al-Neyadi, A. Alketheri, Ibn Sina Steps Out: Exploring Arabic Attitudes Toward Humanoid Robots, in Proceedings of Second International Symposium on New Frontiers in Human-Robot Interaction, Leicester, UK, 2010

[26] N. Mavridis, M.S. Katsaiti, S. Naef, A. Falasi, A. Nuaimi, H. Araifi, A. Kitbi, Opinions and attitudes towards humanoid robots in the Middle East, *Springer Journal of AI and Society*, 27(4) (2012), 517-534, DOI: 10.1007/s00146-011-0370-2

[27] G. Trovato, M. Zecca, S. Sessa, L. Jamone, J. Ham, K. Hashimoto, A. Takanishi, Towards culture-specific robot customisation: a study on greeting interaction with Egyptians, The 22nd International Symposium on Robot and Human Interactive Communication (RO-MAN), Gyeongju, South Korea, 2013

[28] N. Endo, A. Takanishi, Development of Whole-body Emotional Expression Humanoid Robot for ADL-assistive RT services, *Journal of Robotics and Mechatronics* 23(6) (2011), 969-977

[29] T. Kishi, T. Otani, N. Endo, P. Kryczka, K. Hashimoto, K. Nakata, A.

Takanishi, Development of Expressive Robotic Head for Bipedal Humanoid Robot, Proceedings of the IEEE/RSJ International Conference on Intelligent Robots and Systems, Vila Moura, Portugal, 2012, 4584-4589

[30] G. Trovato, T. Kishi, N. Endo, K. Hashimoto, A. Takanishi, A Cross-Cultural Study on Generation of Culture Dependent Facial Expressions of Humanoid Social Robot, *International Conference of Social Robotics*, Chengdu, China, 2012, 35–44

[31] G. Metta, P. Fitzpatrick, L. Natale, Yarp: yet another robot platform, *International Journal on Advanced Robotics Systems*, special Issue on Software Development and Integration in Robotics, 3(1), (2006) 43-48

[32] D. Morris, Bodytalk: a world guide to gestures, Ed. Jonathan Cape, University of Michigan, 1994

[33] T. D. Blumenthal, B. N. Cuthbert, D. L. Filion, S. Hackley, O. V. Lipp, A. van Boxtel, Committee report: guidelines for human startle eyeblink electromyographic studies, *Psychophysiology* 42, 2005, 1-15

[34] P. Cipresso, S. Serino, D. Villani, C. Repetto, L. Sellitti, G. Albani, A. Mauro, A. Gaggioli, G. Riva, Is your phone so smart to affect your state? An exploratory study based on psychophysiological measures, *Neurocomputing* 84, 2012, 23–30

[35] S. Kaiser, T. Wehrle, Facial Expressions as Indicators of Appraisal Processes. In K. R. Scherer, A. Schorr, & T. Johnstone, Appraisal processes in emotions: Theory, methods, research, Oxford University Press, New York, 2001, 285-300

[36] C. Bartneck, E. Croft, D. Kulic, Measuring the anthropomorphism, animacy, likeability, perceived intelligence and perceived safety of robots, Proceedings of the Metrics for Human-Robot Interaction Workshop in affiliation with the 3rd ACM/IEEE International Conference on Human-Robot Interaction, Technical Report 471, Amsterdam, 2008, 37-44

[37] W.H. Kruskal, W.A. Wallis, Use of ranks in one-criterion variance analysis, *Journal of the American Statistical Association* 47 (260), 1952, 583–621

[38] H. B. Mann, R. Whitney, Donald R, On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other, *Annals of Mathematical Statistics* 18 (1) (1947), 50–60

[39] D. George, P. Mallery, SPSS for Windows step by step: A simple guide and reference, 11.0 update (4th ed.), Allyn & Bacon, Boston, 2003

[40] B. Reeves, C. Nass, The Media Equation: How People Treat Computers, Television and New Media Like Real People and Places, University Press, Cambridge, 1996

[41] C. Nass, K. M. Lee, Does computer-synthesized speech manifest personality? Experimental tests of recognition, similarity-attraction, and consistency-attraction., *Journal of Experimental Psychology: Applied* 7(3) (2001) 171-181.

[42] C. Nass, Y. Moon, et al., Are people polite to computers? Responses to computerbased interviewing systems, *Journal of Applied Social Psychology* 29(5) (1999), 1093-1110

[43] P. Brown, Politeness: Some Universals in Language Usage, Cambridge University Press, 1987.

[44] C. H. Lovelock, L. Wright, Principles of service marketing and management, Prentice Hall, 2002.

[45] V. Evers, Cross-cultural Differences in Understanding Human-Computer Interfaces, in Adjunct Proceedings of the 13th British Computer Society Annual Conference on Human Computer Interaction (1998, Sheffield, UK), Sheffield, UK, 1998, 88-89