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Multimodal Corpus Analysis as a Method for Ensuring Cultural Usability of Embodied Conversational Agents

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Abstract. In this paper we propose the method of multimodal corpus analysis to collect enough empirical data for modeling the behavior of embodied conversational agents. This is a prerequisite to ensure the usability of such complex interactive systems. So far, the development of embodied agents suffers from a lack of explicit usability methods. In most cases, the consideration of usability aspects is constrained to preliminary user tests at the end of the development process.

Keywords: Multimodal Corpora, Embodied Conversational Agents, Cultural Usability.

1 Introduction

In this paper we are dealing with interactive systems that come in the form of virtual characters, which use verbal as well as nonverbal input and output channels, relieving the user from the burden to learn specialized control sequences and instead allowing for interacting with a complex system based on natural communicative habits. Such characters are often called Embodied Conversational Agents [3] emphasizing the available nonverbal communication channels as well as the fact that the interaction with such characters is realized as a communication between the agent and the user. At this point the question of cultural usability of such ECA systems comes into play. If people behave according to heuristics provided by their cultural groups [7], then simulating verbal and nonverbal behavior in ECAs has to adhere to such implicit cultural norms to prevent the agents from being perceived as behaving funny, weird, unnatural, annoying or even insulting.

Let's consider an example. You are staying at a hotel and discover that the WLAN is not working in your room. You go to the reception to complain about this fact and the clerk at the front desk listens carefully to you and then leans over touches your arm and assures you that he will do his utmost to fix this problem. Depending on your cultural background this might be an unwanted and unacceptable invasion of your personal space or it might just be a sign of empathy and care towards you. Such differences in spatial behavior and especially in the interpretation of spatial behavior by others have been described in [6]. The example illustrates the severe problems that can arise when quite different heuristics of how to behave "naturally" collide. Often such differences in perceiving and interpreting behavior have negative implications

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leading to irritations, attribution of negative personality traits or unwanted insults. One reason might be that nonverbal behavior transports relevant non-symbolic information like feedback signals or emotions [18].

To prevent our ECA systems from failing, two challenges need to be tackled: i.) describing culturally determined differences in a principled way, and ii.) basing the design of ECA systems on reliable empirical data from different cultures. To tackle the first challenge we need a theory of culture that allows for explaining the differences that can be observed. There is one theoretical school that offers some promising ideas and defines culture as sets of norms and values which the members of a given culture have internalized (e.g. [6], [24]). Our work is based on the broadly applied dimensional model of Hofstede [7]. For the second challenge we suggest using multimodal corpus analysis (MCA) to prepare a solid empirical basis for modeling the behavior of an ECA system that adapts to the cultural background of the user.

In the remainder of this paper we describe how MCA can be employed to unravel cultural differences in behavior of two cultures that are positioned on different locations on Hofstede's dimensions (Germany and Japan) and how this information is then used to set up a model that predicts these behavior differences based on the empirical data and the dimensional theory of culture.

2 Related Work

Multimodal Corpus Analysis has been used increasingly over the last decade to decipher the specifics of nonverbal behavior in order to extract parameters for controlling the animation of virtual characters (see [19] for an overview). The general idea is to keep the intuition of the researcher at bay and at the same time to gain insights into the specifics of synchronizing different modalities like speech and gestures. Additionally, the data gathered during a corpus analysis can serve as a baseline against which the interactions between human user and embodied agent can be evaluated. [2] give an account on how the data from such a corpus can be used to directly mirror the behavior of a human speaker with an agent. This approach goes under the name of copy synthesis and is limited insofar as the agent can only directly reproduce aspects of the corpus data. A similar approach is described by [12]. Whereas [2] aim at real-time mirroring of human behavior, [12] try to extract specific behavioral data from the corpora that describe the "style" of the human speaker, which is then mimicked by the agent. A different type of approach tries to extract general behavioral information in the form of statistical data or behavioral rules that can then be employed to control an agent's behavior. [13] extract statistical rules from a corpus of natural dialogues that allow them to generate appropriate head and hand gestures for their agent that accompany the agent's utterances. An example rule would be something like "if the utterance contains a negation, shake the head". Thus, their approach exploits the relation between words and gestures. [16] concentrate on grounding phenomena in interactions with virtual characters and also extract rule-like regularities for gaze behavior from a corpus of human interactions. The same corpus is later used to judge the results of the human-agent dialogues. Instead of rules, [20] have shown how statistical information can be extracted from a multimodal corpus and used as control parameters for a virtual character. To this end they analyzed what kind of relation exists between certain types of gestures and verbal strategies of politeness.

All of the above work focuses on multimodal aspects of interaction and does not regard culture as a crucial parameter. The need to do so has been acknowledged [17] but there are few systems that actually try to tackle this challenge in a principled manner. This might easily be due to the multifaceted influences of culture that have to be regarded on different levels during the development process. Concerning the agent itself we can distinguish between cultural aspects of the agent's appearance (black, white, with French beret or an English bowler hat, etc.), cultural aspects of its verbal behavior (language, formal vs. informal, slang, etc.) as well as cultural aspects of its nonverbal behavior (use of gestures, proxemics, volume of speech, etc.), and cultural aspects of its cognitive processes (relevant features for persuasion, reaction to high status individual, etc.). Additionally, [23] gives an account on the difficulty of designing culturally adequate systems due to the fact that the designer's culture always interferes in the process by providing him with implicit assumptions about many design choices that have to be challenged actively. [9] focus on verbal and nonverbal behavior to manifest the cultural background of an agent, others try to simulate culture-specific behavior in order to train intercultural communication. Currently, this seems to be the main application area. [11] describe a language tutoring system that also takes cultural differences in gesture usage into account. [25] as well as [22] aim at cross-cultural training scenarios and describe ideas on how these can be realized with virtual characters. [10] present an approach to modify the behavior of characters by cultural variables relying on Hofstede's dimensions. The variables are set manually in their system to simulate the behavior of a group of characters. Most of this work is based on general claims from the literature, which brings the danger of realizing only stereotypic and cliché-like behavior in the agents. To base such systems on reliable empirical data we suggest the method of multimodal corpus analysis and in the remainder of this paper are going to exemplify this method for realizing culturally adequate behavior for German and Japanese agents.

3 Multimodal Corpus Analysis for German and Japanese Interactions

A corpus is a collection of (video) recordings of human interactive behavior that is annotated or coded with different types of information. A multimodal corpus analyses more than one modality in a single annotation, e.g. speech and gesture in order to explicate the links and cross modal relations between the different modalities. Which kind of information is coded in a given corpus is defined in an annotation scheme that specifies the coding attributes and values, for instance coding the type of a gesture along McNeill's taxonomy [15].

This short introduction already introduces a number of challenges that have to be faced if this method should be employed in a multicultural setting. A standardization of most steps in the process of recording and analyzing the data is necessary including a standardized design for the recording session, a standardized annotation scheme, and a standardized analysis of regularities in the data.

3.1 Standardized Design of Corpus Study

To ensure the replication of conditions in all cultures participating in the study, a common protocol had to be established on how to conduct the study with detailed instructions to be followed at every step. These instructions had to cover recruiting of subjects and actors, the timeline of each recording as well as "scripts" for the people conducting the experiment as well as detailed information about the necessary materials and the setup of the equipment. To produce comparable data sets it was indispensable to define technical requirements for the video recording sessions. This included the specifications for the recording equipment as well as the layout of the recording area to be able to reproduce the recording conditions.

In our study of German and Japanese behavior, dyadic interactions between human subjects were recorded in three scenarios: (i) first meeting, (ii) negotiation, (iii) interaction with status difference. One of the interaction partners in each scenario was an actor following a script for the specific situation. The rationale for using actors as interaction partners was that we would be able to elicit sufficient interactions from the subjects and to control the conditions for each participant more tightly. To control for gender effects, a male and a female actor were employed in each scenario interacting with the same number of male and female subjects. The actual number of participants differed between Germany and Japan. 21 subjects (11 male, 10 female) participated in the German data collection, 26 subjects (13 male, 13 female) in the Japanese collection. For each subject, around 25 minutes of video material was collected, 5 minutes for the first meeting, 10-15 minutes for the negotiation, and 5 minutes for the status difference. Participants were told that they take part in a study by a well-known consulting company for the automobile industry, which would take place at the same time in different countries. To attract their interest in the study, a monetary reward was granted depending on the outcome of the negotiation task. To be able to control for effects of personality on the behavior under examination, participants had to fill out a NEO-FFI personality questionnaire [12].

3.2 Standardized Annotation Schemes

The corpus study focused on nonverbal behaviors taking spatial behavior (proxemics), volume of speech, gestural expressivity, and posture into account. Initially, the analysis concentrated on expressivity and posture. Posture was annotated following the coding scheme outlined in [1], which describes posture in terms of relative positions of body parts and thus restricts interpretations to a minimum. To give an example, consider one-handed postures that require touching the other arm. These are coded in the following way: PHSr (put hand to shoulder), PHUAm (put hand to upper arm), PHEw (put hand to elbow), PHLAm (put hand to lower arm), PHWr (put hand to wrist). These hand positions are unambiguous; either the subject is touching the elbow or not, thus keeping culture-specific interpretations at a minimum. Similar codes are used for all hand, head and leg postures.

Gestural expressivity is a little more challenging. Apart from coding the type of a gesture for instance following the coding scheme described in [15], gestures provide information on a non-symbolic level by the way how they are performed. [4] has shown in a large-scale study of US-immigrants that culturally determined preferences exist on this level of granularity. To capture these differences he described the following levels of gestural activity: (i) spatio-temporal, (ii) interlocutional, and (iii) co-verbal. Co-verbal coincides with McNeill's [15] definition of co-verbal gesture usage. The interlocutional level is concerned with aspects of proxemics for instance body contact while gesturing and interacting (remember the example from the beginning). The spatio-temporal level at last describes how a gesture is performed, which we call expressivity following ideas of [5], who showed a relation between such parameters and personal style of a speaker. In [18], more details can be found on the similarities and differences of these taxonomies in describing non-symbolic gesture usage.

Gestural expressivity is analyzed with the following parameters, where each parameter was coded using a seven-point scale. On this scale, 1 denotes small values and 7 large values for the parameter: activation (number of gestures per dialog), spatial extent (space occupied for realizing the gesture), speed, power, fluidity (smooth vs. jerky). According to [4], different cultures exhibit different values of these parameters. Thus, following [7], in a culture that generally uses high spatial extent, this is also perceived as the "normal" way of doing gestures. Thus, we can expect that the baseline for attributing high or low spatial extent to a given example of gestural expressivity might depend on the coder's own culture. To prevent our coders from relying solely on their intuition in ascribing values to the expressivity parameters, a coding manual was created (accompanied by example videos) that defines high and low values based on objective criteria. The spatial extent of a gesture for instance is described by the angle between upper and lower arm.

3.3 Preliminary Analysis of Nonverbal Behavior

The results presented in this section are based on the analysis of 8 German and 8 Japanese samples to exemplify how the analysis can be done. Comprehensive results will be available soon.[1]

3.3.1 Posture Analysis

Results. The average number of head posture shifts in the German samples was 22 and in the Japanese samples it was 15.6. The average duration of each posture (how long the subjects were keeping the same posture) differed between 2.57 (German) and 2.54 (Japanese). Both differences are not statistically significant in a t-test. However, the distribution of the categories was different between the two cultures. Japanese participants generally did less head posture shifts than Germans, except for THdAP (turn head away from person). This difference was statistically significant: $\chi^2(5)=20.308$, $p<0.05$. The average number of leg posture shifts in the German samples was 9.5 and in the Japanese 16.56. A t-test revealed this to be a weak trend: $t(15)=1.764$, $p<0.1$. The average duration of each posture was 19.93 (German) vs. 24.64 (Japanese), but the difference was not statistically significant. Similar to head postures, we found that the difference in category distribution was statistically significant: $\chi^2(3)=9.205$, $p<0.05$. While LSF (lean sideways on foot) were the most frequent in both samples, Japanese people also frequently did MLP (move leg to person). The

[1] Please visit http://mm-werkstatt.informatik.uni-augsburg.de/projects/cube-g/ for up-to-date information.

average number of arm posture shifts in the German data was 40.38 and in the Japanese 22.8. The average duration of each posture was 7.79 (German) vs. 14.08 (Japanese). For both differences, a t-test revealed a weak trend: $t(16)=1.931$, $p<0.1$, and $t(16)=2.061$, $p<0.1$, respectively. The differences in category distributions were statistically significant in hand-to-arm (one-handed), hand-to-arm (two-handed), hand-to-head, and hand-to-cloth postures: $\chi^2(4)=70.482$, $p<0.01$; Fisher's Exact Test $p<0.01$; $\chi^2(2)=7.208$, $p<0.01$; $\chi^2(2)=91.447$, $p<0.01$, respectively. Also, a trend was found in hand-to-trunk postures: $\chi^2(2)=5.708$, $p<0.1$. Hand-to-head postures more frequently occurred in the Japanese data; especially PHFe (put hand to face) was the most frequent. Hand-to-arm (one-handed) postures were different depending on the culture. The most frequent category in the German samples was PHEw (put hand to elbow), and in the Japanese samples PHWr (put hand to wrist). Vice versa, German participants rarely did PHWr, and Japanese rarely did PHEw. As for hand-to-arm (two-handed) postures, the most frequent category in German data was FAs (fold arms) and that in Japanese data was JHs (join hands). Hand-to-cloth postures were rarely observed in Japanese data, but they were very frequent in German data (especially PHIPt (put hand into pocket)).

Discussion. Generally, head postures did not differ between cultures but Japanese more frequently looked away from the partner than Germans. Significant differences were found regarding arm postures. Germans more frequently changed arm postures than Japanese, and Japanese kept the same posture longer than Germans. Posture shapes also differed. Germans mainly used their arms, such as folding their arms (FAs) and putting their hands on the elbows (PHEw). In contrast to this behavior, Japanese mainly used their hands, such as joining the hands (JHs), or putting their hands on the wrists (PHWr). Moreover, Japanese frequently touched their heads, and Germans put their hands in the pockets. Although Japanese did not move their upper bodies as frequently as Germans, they used more leg postures. Additionally, the total number of posture shifts per conversation is not depending on culture. To sum up, these results suggest that the frequency of posture shifts is not different depending on culture, but the types of frequently used postures differ. Thus, the employed body parts as well as the shapes of the postures express the characteristics of each culture.

Table 1. Results of expressivity analysis

	G	JP	F
Activation	22.12	6.62	4.177^{*}
Power	3.21	3.39	0.736
Speed	3.81	3.39	2.929^{+}
Fluidity	4.40	2.87	68.591^{**}
Repetition	1.38	2.70	50.247^{**}
Spatial Extent	3.01	4.02	18.703^{**}
Duration	2.39	5.13	15.461^{**}

3.3.2 Expressivity Analysis

Results. In order to gain insights in the supposed differences in the use of gestures, we compared expressivity parameters of the German and the Japanese samples. Table 1 lists the results of the analysis. First of all, it has to be said that there is a significant difference in the number of gestures that were used in the German and the Japanese samples, i.e in the overall activation. On average, German participants used three times more gestures than Japanese participants (22.12 vs. 6.62), which is shown to be statistically significant (ANOVA): $F=4.177$, $p<0.05$. For the overall comparison between the German and the Japanese sample, no significant difference can be seen for the parameter power and only a weak trend for speed ($F=2.929$, $p<0.1$). For the other parameters (fluidity, repetition, spatial extent, and duration) the difference is highly significant: $F=68.591$, $p<0.01$; $F=50.247$, $p<0.01$, $F=18.703$, $p<0.01$; $F=15.461$, $p<0.01$, respectively.

Discussion. These preliminary results show a tendency concerning the differences in how gestures are expressed in the two cultures. Germans use significantly more gestures than Japanese. On the other hand, if Japanese participants do a gesture, this takes on average twice as long compared to a German participant. But the gesture is less fluently performed that is with more interruptions. Moreover, spatial extent for the gestures is higher than in the German samples.

4 Employing the Results for Designing Enculturated Agents

In Section 2, we presented how the information derived from a MCA can be utilized to control the interactive behavior of embodied conversational agents. Here, we present a slightly different approach. Having extracted the statistical information as reported in the previous section, this is correlated with Hofstede's ideas of cultural dimensions. By setting up a Bayesian network, it becomes feasible to model the causal relations between a culture's location on Hofstede's dimensions and the observed nonverbal phenomena. Figure 1 depicts a version of such a network. The middle layer defines Hofstede's [7] five dimensions: hierarchy, identity, gender, uncertainty, and orientation. We will not go into detail here but give an example on possible correlations between dimension and behavioral heuristics. According to [8], the location on the identity dimension (individualism vs. collectivism) is for instance related to proxemics behavior. Interlocutors from individualistic cultures tend to stand further apart in face-to-face encounters than interlocutors from collectivistic cultures.

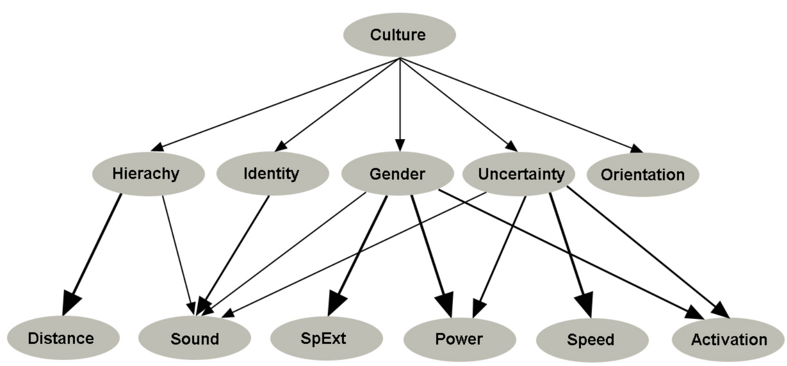

Fig. 1. Network model of causal relations between cultural dimensions and nonverbal behavior

The bottom layer consists of nodes for nonverbal behavior that can be set for a given agent. The top node which is labeled "Culture" is just for demonstration and interpretative purposes. It mainly translates the results from the dimensional representation of cultures into a probability distribution for some example cultures. The Bayesian network only presents one building block for integrating culture as a computational parameter in an agent system. Cultural influences manifest themselves on different levels of behavior generation and interpretation and thus penetrate many processing modules in a system that takes these influences into account. In [21], details of the complete system architecture are given.

5 Conclusion

In this paper, we have argued that multimodal corpus analysis can serve as a valuable method of ensuring cultural usability in systems that make use of embodied interface agents. To exemplify this method, we gave details of a study looking into culture specific nonverbal behavior in face-to-face interactions. This study was done in Germany and Japan and allows extracting statistical information about behavior routines in three prototypical scenarios. This information was then utilized to set up a Bayesian network in order to model the causal relation between a culture's position on Hofstede's dimensions and correlating nonverbal behavior.

It remains to be shown, how users from different cultures perceive the agents' behavior that is based on this network model. A first user study in Germany was very promising [21] in this respect. But research in cultural aspects of interactions with embodied agents has just recently come to the focus of attention, and thus there exist more questions than answers concerning the cultural usability of such systems. For instance, neither the importance of an agent's appearance nor of its behavior has been investigated in principle so far. There are a number of agent systems that make use of non-human characters that nevertheless exhibit human-like behavior (e.g. [16]). Others have investigated the consequences of a mismatch between the appearance of a character and its verbal and nonverbal behavior [9]. With the system described in this paper we could easily realize an agent that exhibits a severe mismatch in nonverbal behavior traits like German spatial extent, Japanese speed, and Italian proxemics. It is unclear if this would be perceived as really odd, or as the agent's individual culture, or just as a badly designed animation.

With the advent of massive 3D multiuser environments like Second Life or World of Warcraft, this question becomes relevant beyond the area of embodied interfaces. In such environments, users interact in the form of avatars, 3D virtual agents that are tightly controlled by the user. Users can create their own animations, which must not adhere to any cultural heuristics. Thus, the question arises if culture does not matter in such an environment or how culture manifests itself. An answer to this question might also shed some light on how to ensure cultural usability for embodied agents.

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