Development and Perception Evaluation of Culture-specific Gaze Behaviors of Virtual Agents

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Abstract. Adequate gaze control of a virtual agent is also essential for successful and believable human-agent interaction. Researchers in IVA have developed gaze control models by taking account of gaze duration, frequency and timing of gaze aversion. However, none of them have considered cultural differences in gaze behaviors. We aim to investigate cultural differences in gaze behaviors and their perception, by developing virtual agents with Japanese gaze behaviors, American gaze behaviors, their hybrid gaze behaviors, and full gaze behaviors, and compare their effects on the impressions of the agents and interactions. We will demonstrate the four gaze behaviors.

Keywords: gaze, shyness, intelligent virtual agents, non-verbal behavior, cross-culture, perception, evaluation

1 Introduction

Gaze plays an important role in our social interactions such as controlling the flow of a conversation, indicating interest and intentions, and improving listener's attention and comprehension [1, 2]. As in humans, virtual agent's gaze behavior is also important to provide natural interaction. Previous research on modelling gaze behavior of virtual agents were conducted to make appropriate turn management [3], to figure out where to look at [4], to make idle gaze movements [5], to express social dominance by gaze [6], and what the adequate amount of gaze is to facilitate interaction [7, 8], all of which report modelling realistic human gaze behavior to an agent resulted in more natural and smooth interaction.

None of the above IVA research has addressed and implemented cultural difference in gaze behaviors, while researchers in psychology report cultural difference in gaze behaviors and their perception. We believe there is a strong need to develop enculturated agents by making them exhibit culture-specific non-verbal behaviors such as gaze.

In terms of culture-specific gaze behaviors, there are findings from observation and video analysis of human-human and human-agent interactions that show cultural differences. Elzinga reported that Japanese had "more frequent and shorter lasting other directed gazes" than Australian participants [9]. Argyle found that Swedes gaze at their

conversation partner more than English [1]. In terms of perception of gaze behaviors, there are studies that indicates cultural preferences of gaze amount that one receives.

If there are cultural differences in performing gaze behaviors, there should be cultural differences in perceiving gaze behaviors of other cultures. We aim to investigate cultural differences in gaze behaviors and their perception by developing virtual agents with Japanese gaze behaviors, American gaze behaviors, their hybrid gaze behaviors, and full gaze behaviors, and compare their effects on the impressions of the agents and interactions. Furthermore, we consider shyness level of participants in perceiving gaze from the agent based on the results of our previous work [10]. We formed the following two hypotheses: H1) Shy people form lower impression on the agent whose gaze model is not originated from the same culture. H2) Not-shy people are more tolerant to other cultures' gaze model.

2 Gaze Models

We implemented "American gaze behaviors (AG hereafter)", "Japanese gaze behaviors (JG hereafter)", "hybrid gaze behaviors (HG hereafter)", and "full gaze behaviors (FG hereafter)" to our virtual agent in order to compare the impression of different cultural gaze behaviors.

AG is implemented in accordance with the gaze model proposed by Cassell et al. [11]. Their model shows American's gaze patterns by analyzing video recordings of human dyad conversations. The model shows probability of "looking away" at the beginning (44%) and the end (84%) of an utterance. Fig. 1a shows the state transition diagram of AG at the beginning of an utterance, and Fig. 1b shows the AG at the end of an utterance. The agent keeps its gaze toward the user during the utterance and while listening. The "looks away" timing at the end of the utterance is calculated by estimating the duration of the synthesized speech. JG is implanted in accordance with the gaze model proposed by Ishii et al. [7, 8]. Their model shows Japanese gaze patterns by analyzing video recordings of human conversations. The agent follows the gaze transitions during its utterance and while it is listening (shown in Fig. 2a). HG is implemented by combining JG and AG (shown in Fig. 2b) as a culture-independent model, neither American nor Japanese. The agent follows the transition of AG at the beginning of an utterance, then follows JG during the utterance. The agent follows the state transition diagram of AG while listening. In addition to AG, JG, and HG, we implemented FG, a full gaze model to the agent as a control gaze condition.

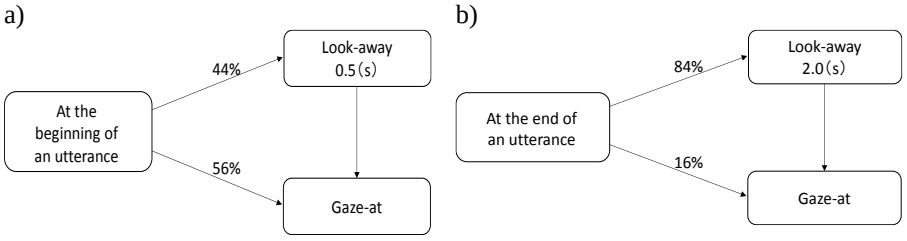

Fig. 1. a) State Transition Diagram of American Gaze Behavior at the Beginning of an Utterance, b) at the End of an Utterance

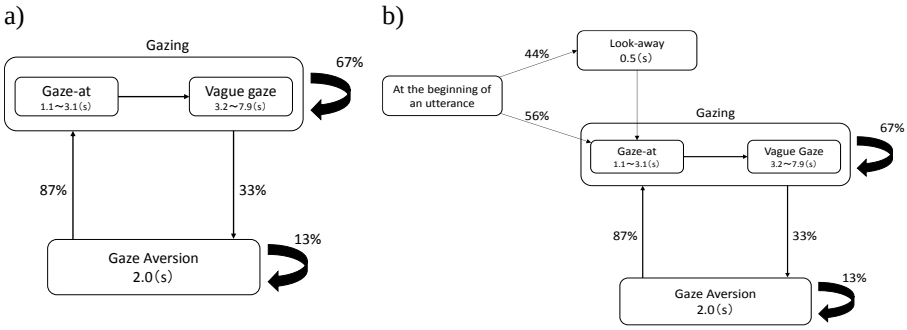

Fig. 2. a) State Transition Diagram of Japanese Gaze Behavior, b) Hybrid Gaze Model

3 Virtual Agent and Gaze Animations

The agent's appearance and gaze animations are developed by Unity 5.2.1fl. The agent's voice was synthesized with AITalk (http://www.ai-j.jp/english/). The gaze behaviors implemented to the agent are the four types described in section 2.

"Gaze-at" is a state where the agent keeps gazing at a user (shown in Fig. 3a: top). "Vague gaze" is described in [7, 8] "in order to express less-face-threatening eye-gaze in virtual space avatars", which is implemented as the agent looks at five degrees lower than the user's eye position (shown in Fig. 3a: bottom). "Look-away" is implemented as an animation that the agent discontinues its gaze for 0.5 seconds and looks up. The agent looks up (in "look-away" state for 0.5 second) before an utterance (shown in Fig. 3b). "Gaze aversion" is implemented in two directions, to the right and the left, and each aversion lasts for 2 seconds as described in [8] (shown in Fig. 3c). Validation check for each gaze animation were conducted by 8 university students. The agent performs blinks, head rotation, lip sync in addition to gaze patterns. The gaze behaviors are fully automated according to a dialogue the agent speaks. The amount of gaze of each condition is not fixed since it is affected by the duration of utterance from the agent and a participant, randomized transition processes of each model. However, we can estimate that the amount of gaze become bigger from HG, JG, AG, and FG.

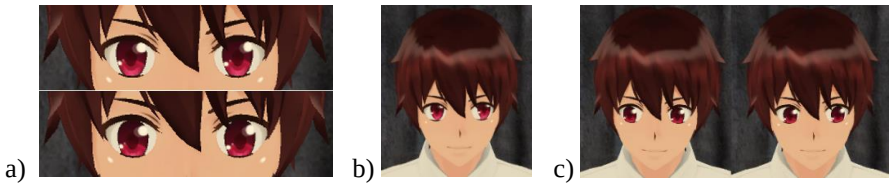

Fig. 3. Agent's Gaze-at State (a: top) and Vague Gaze State (a: bottom), b) Agent's Look-away state, c) Agent's Gaze Aversion States (to left and right, in either direction)

4 Experiment

The experiment is conducted as a Wizard of Oz experiment. Participants are asked to have four formal conversational sessions with a conversational virtual agent to assess its functions. The true purpose of the experiment is not explained to the participants during the experiment. The agent's gaze models and conversational topics are randomly assigned in each of the four conversation session in order to minimize the effect of conversational content. The participants are asked to answer a questionnaire after each session, i.e., the agent's perceived shyness, perceived friendliness, their friendly feeling toward the agent, and comfortableness and naturalness of the conversation.

We gathered 18 Japanese university students (15 males and 3 females, age range from 19 to 23 years old). Their shyness level was measured by Shyness Scale questionnaire [12] beforehand. Our experimental results with Japanese participants suggested that impression of the agent is affected by participants' shyness level and familiarity of the gaze patterns performed by the agent. The results and discussion of the experiment is described in detail in our oral presentation paper presented at IVA 2017.

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