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The Impact of Avatar Blushing on the Duration of Interaction between a Real and Virtual Person

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Abstract

This paper describes an experimental study on human participants' reactions towards a blushing avatar. As one of the "most human of all expressions", blushing serves an important role in interpersonal communication. In this paper we describe an experiment in which there is an interaction between a person and an avatar who "blushes" in an embarrassing situation. Our major question of interest was whether participants would be influenced by the blushing, and whether they would tolerate the avatar longer than in the situation where there was no blushing. Moreover, two different type of blushing were considered: whole-face blushing and cheek blushing. This work uses behavioural and questionnaire responses. The results show first, participants tended to withdraw early when the avatar was blushing only on the cheek; second, the whole-face blushing improved participants' degree of "co-presence".

1. Introduction

As one of the "most peculiar and the most human of all expressions" [9], blushing is a popular topic in psychological research, which has been proved to be a significant facial cue which serves important functions in interpersonal communication [13]. The reason why people blush is still an arguable issue among psychologists. Most people consider blushing in public as an undesirable response and some people even feel embarrassed when they blush in public. Moreover, profound blushing is one of the symptoms that exacerbates anxiety amongst people who suffer from social phobia [20].

In spite of its importance little work on blushing has been done in character animation. Moreover, research on how human participants react towards a blushing virtual character (avatar) has not been reported to date. This neglected area of research is nevertheless extremely important because applications in computer character animation, ranging from industrial training to entertainment and psychotherapy, are eventually to be experienced and evaluated by human participants. In this paper we describe an experiment in which there is an interaction between a person and an avatar, the goal of which is to assess the role of blushing on the person's responses. We view this as a very first experiment in this domain, which maps out a field of inquiry for methods to improve the quality of interaction between people and virtual characters.

This work is part of an on-going research project on social phobia and shyness related behaviours. Social phobia involves a strong fear of one or more social performance situations. People with this condition fear that they will act in a way that is humiliating or embarrassing and that others will judge them negatively. In previous research we have studied male human participants' reaction towards a forward female avatar [17]. In the work presented here we evaluate the empathic interaction between male human participants and a "shy" virtual woman.

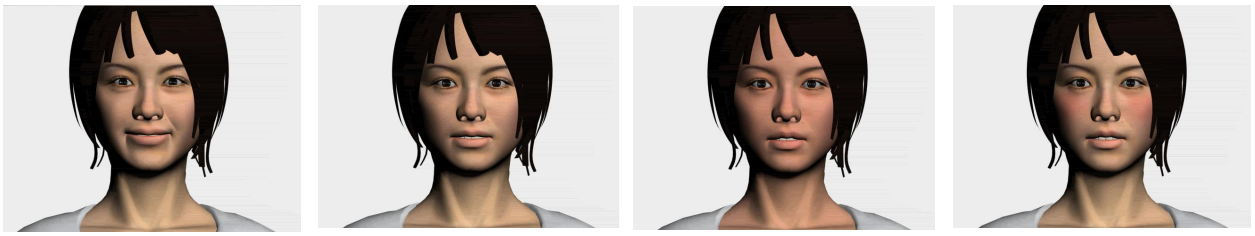
In the experiment participants were told that some information would be presented to them about the 2008 Olympic Games, by an avatar who would present a video. However, repeatedly, this video failed to load, the avatar apologised, and the interaction started over again. There were three conditions in a between-groups experiment, with 11 people per group. In one condition the avatar never blushed, and in the two other conditions either whole face or partial face blushing was increasingly apparent on the avatar's face as the program seemingly failed to load. After each failure the participant could either end the interaction or try again. Our major question of interest was whether participants would be influenced by the blushing, and whether they tolerate a greater number of trials than in the situation where there was no blushing.

In Section 2 we present some background work on blushing in both facial animation and psychology studies, in Section 3 we describe the experiment in detail, and the procedures in Section 4. Results are given in Section 5 followed by conclusions in Section 6.

2. Background

2.1. Related work in facial animation

As the most closely observed area during an interaction [2], the face is capable of producing about twenty thousand



(a) (b) (c) (d)

Figure 1 Before the "incident" happens, the virtual woman looks cheerful (a). After the incident happens, she apologises to the participants, and looks slightly embarrassed, without blushing (b), with whole-face blushing (c), or with cheek blushing (d)

different expressions and therefore is one of the most expressive areas of the body [4]. Facial expressions are readily recognizable by others even in a synthetic static sketch format. Many facial animation systems have been implemented, either to express human emotion [1, 5] or to serve communicative functions in interpersonal interaction [3, 19].

Among existing facial animation systems, few have included facial colouring (face turning pale or red, rosy cheeks, etc.) [14, 18]. In Patel's work on digital cosmetic [18], blushing was implemented as to express the emotion "embarrassment", where the avatar's whole face turns red with an emphasized rosy cheek. In Jung and Knöpfle's work [14] the avatar would express shame and embarrassment with blushing which covers cheeks, ears, nose, and forehead. In both works, however, no evaluation with human participants was carried out. In our work we have used a simple approach to the animation of blushing by blending two facial texture maps over time rather than an attempt at full photo-realistic rendering of blushing.

2.2. Psychological studies on blushing

2.2.1. The visual effect of blushing Before implementing blushing, the first problems we need to understand are the visual effects of blushing. In a review paper on social blushing, Leary, Britt, Cutlip, and Templeton defined blushing as "a spontaneous reddening or darkening of the face, ears, neck and upper chest that occurs in response of perceived social scrutiny or evaluation" [15]. In an interview conducted by Shields, Mallory, and Simon, when asked about the blushing area, 68% of the participants described that blushing occurs primarily on the cheeks and 26% said it occurs over the whole face [21].

2.2.2. When does blushing occur? In order to design the scenario of blushing experiment, we also need to understand when people blush, although the reason why people blush is still a controversial issue amongst psychologists. In the review paper on social blushing, the elicitors of blushing were summarized into four categories: threats to public identity, praise and positive attention, scrutiny, and accusations of blushing [15]. Castelferanchi and Poggi's paper suggested blushing as the expression of shame in front of others [6].

2.2.3. How is blushing perceived: With the purpose of understanding how human participants respond towards a blushing avatar, it is necessary to understand how they respond towards blushing in real life. Because of its saliency (colour and localization), blushing is an obvious candidate for being ashamed and embarrassed and *de facto* might appease the observer [6,8], and thus may attenuate the offender's negative social impression and diffuse interpersonal threats [12]. De Jong's work [10,11] suggested that blushing serves a remedial function, such as attenuating the negative impression and favourably influencing the attributed seriousness of the incident. His experimental studies provided evidence that indicates that negative evaluation of actors who violate a social rule is attenuated by the blush response. However, in de Jong's experiment only paper-based scripts were used where an embarrassing situation and the actor's reaction to it were described. As a visual cue, blushing has not been tested visually with humans. One of the reasons is that it is almost impossible to "represent" blushing because it is not a facial feature that can be intentionally generated by people. However, now with character animation, blushing can be generated on avatars, and enables the possibility of testing how participants react towards it.

3. Experimental design

Compared to inducing blushing in an experimentally controlled way on real people, rendering the appearance blushing on avatars with current computer animation technology is not difficult, especially if there is not the attempt at photo-realism, but rather to give the *impression* of blushing. However with the intention to provoke and evaluate people natural responses towards blushing, the experimental design is critical. In this section we first define our research questions, followed by a description of the factorial experimental design, and finally we present the design of the scenario.

3.1. Research questions

Our research questions are:

- Will participants notice blushing on an avatar?
- Psychological studies have shown that blushing has a remedial effect, with paper-based scripts. However, will avatar blushing have a similar remedial effect, and provoke higher degree of sympathy in the participants?
- Will blushing increase/decrease the degree of co-presence between the avatar and the participant?

3.2. Factorial design

In this work we are interested in how people respond towards a blushing avatar compared to responses towards a non-blushing avatar. Two main different types of blushing for rendering were considered: "rosy cheek" and whole-face blushing [18]. Related psychological literature also discusses both blushing effects [21]. In our work, both blushing effects were implemented. As shown in Fig. 1, three factors are included regarding blushing: non-blushing (see Figure 1b), whole-face blushing (Figure 1c), and rosy-cheek blushing (Figure 1d). In all conditions the same female avatar was used and we invited only male participants for our study. This is because, as mentioned in the introduction, in our research we are interested in empathic interaction between male human participants and a "shy" virtual woman.

3.3. Scenario

In this work we intended to induce participant's natural responses towards a blushing/non-blushing avatar, without revealing our purpose during the experiment. Therefore, we have designed a cheerful avatar (see Fig. 1a) who gives presentation on a chosen topic to the participants. During the presentation, an "incident" (database loading problem) happens. The avatar then apologises to the participant asking him to wait. When doing so, the avatar looks slightly embarrassed, with or without blushing (Fig. 1b, c, and d). The participant then has to choose either to stop the experiment or to continue. This procedure repeats several times, until the participant chooses to stop, or the experimental trial is terminated after 10 repetitions.

3.4. Measurements

Our premise was that if the avatar blushes, the participant would wait longer before terminating the experiment due to sympathy evoked by the blushing. Therefore our primary behavioural response variable is the number of times each participant chooses to continue, and in particular whether they continue with all 10 trials. (Of course they did not know in advance how many trials there would be).

Other measurements are based on data collected with questionnaires. This included:

First, a pre-questionnaire was used to record basic information of the participant such as age, gender, status, and prior experience of virtual reality and computer games.

To investigate the relationship between the participant and the avatar, a standard POMS (profile of mood states) questionnaire was used twice to assess their change of mood states, both before the experiment and after the experiment [16].

Moreover, as primary measurement, we evaluate participants' behaviour, which may also be influenced by their personality. Therefore we have also used the NEO big five factors questionnaire in order to include their personality as an additional factor in our analysis [7].

Finally, a post questionnaire was used to assess their experience towards the virtual agent and the presentation, including: co-presence, personal trait, and blushing related questions, described as follows:

(1) There are 3 co-presence questions asking the extent to which participants find themselves responding to the avatar as if she were a real person, concerning their *thoughts*, *feelings and emotions*, and *physical responses* (1: not at all; 7: very much).

(2) Personal trait questions ask how the participants think about the avatar, considering her *reliability*, *honesty*, *sociability*, *friendliness*, and if she is *sympathetic* and *likable* (for example, 1: unlikable, 7: likable). These questions are taken from de Jong's experiment on blushing [10,11].

(3) Blushing related questions ask the extent to which the participant (a) *thinks that the avatar has blushed* (1: not at all; 7: very much), (b) *generally notices other people blush* (1: not at all; 7: always), (c) *usually blushes* (1: not at all; 7: very much), and (d) *has blushed during the experiment* (1: not at all; 7: very much). These blushing related questions were asked on a separated sheet which the participants were to answer in the end after the whole experiment. There was no other mention of blushing during the whole experiment, and they only see these blushing related questions at the very end of the experiment.

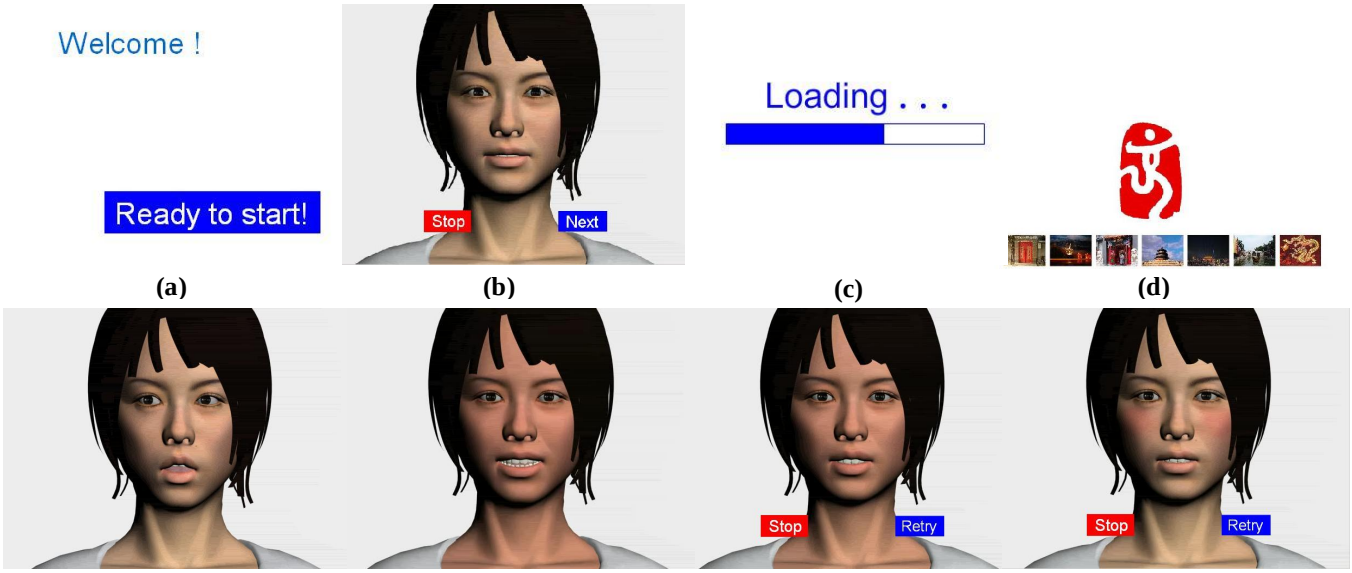


Figure 2 The procedure of the experiment. The participants had to click to start (a), and choose to continue or stop by clicking "stop" or "next" (b). After showing a loading bar (c), the virtual agent introduced the emblems and the mascot of the 2008 Olympic Games with animated graphics (d). After that, there appeared to be a failure in the computer program to load the next sequence, by showing the animated loading bar twice (c). The virtual agent then appeared to be surprised (e), and feel sorry with a blush on her face (f). The participant had to choose either to "retry" or to "stop" (g), (h)

4. Materials

The animation of the avatar was developed with 3DsMax[4]. Her facial expression was implemented to be either cheerful (see Fig. 1(a)) or slightly embarrassed (Fig. 2(f)), with blinking and head movements. Both blushing effects were rendered by blending two facial texture maps over time (3 seconds, 30 frames per second) in 3DsMax. The avatar's lip movements were synchronized to the audio with Voice-O-Matic[5]. The user-interface and other animations were developed with Adobe Flash[6], where the participants could use the mouse button to start (Fig. 2(a)), and choose to continue or to stop (Fig. 2(b)) the experiment.

The experiment was conducted on a desktop machine running Windows XP. The participants were seated about half a meter away from the 17" computer display. They were given a set of headphones to listen to the experiment and the mouse to interact with the user-interface.

5. Procedures

The experiment was approved by the UCL Research Ethics Committee. Participants were recruited by email on the campus at UCL to all levels of staff and students, with finally 33 male participants (11 for each condition). The mean age was 20 (ranging between 18 and 28) years with no significant difference in age within the 3 conditions. Among the 33 participants, 29 were undergraduates and 4 were master students. They were all native English speakers.

The experiments were carried out in January and February, 2008. Participants attended the experiment at pre-arranged times. After arriving, the participants were given an information sheet, a consent form, and the pre-questionnaires. After that they were introduced to the lab and seated in front of the computer. They then were told that they would watch a presentation about the 2008 Olympic Games and to follow the instructions provided by the virtual agent in the presentation, which would last about 5 minutes. They were also informed that their reaction to the quality of the interface would be studied. The experimenter then left the participant alone in the room.

The presentation started with a virtual agent representing a Chinese woman introducing information about the 2008 Olympic Games to the participant (See Fig. 2 (a), (b)). After introducing the emblems and the mascot of the 2008 Olympic Games (Fig. 2(d)), there appeared to be a failure of the computer program to load the next sequence properly (Fig. 2(d)). The virtual agent then appeared to feel sorry, with slightly embarrassed facial expressions, and apologised to the participant for the inconvenience (Fig. 2 (e), (f)). She suggested that the participant wait a bit longer but also mentioned that they could give up and leave anytime they wished. Then the

[4] http://www.autodesk.co.uk/
[5] http://www.di-o-matic.com/
[6] http://www.adobe.com/

participant had to choose either to "retry" or to "stop" the presentation (Fig. 2 (g), (h)). A similar "error message" would occur 10 times, with the virtual agent saying different apologetic sentences each time.

The whole scenario lasted between 3 and 8 minutes, depending on when the participant chose to stop. The number of times participants chose to "retry" when the "incident" happened was recorded. After completion the participants then were given the post-questionnaires.

6. Results

6.1. Did the participant notice the blushing?

Our first concern is the extent to which the participants noticed that the avatar had blushed. Table 1 shows the mean value of the extent to which they have noticed the avatar was blushing. The results suggest that cheek blushing was more noticeable than the other two, but in fact the only significant difference was between cheek blushing and no blushing.

Condition		Mean	Standard Deviation
1	Non-blushing	2.0	1.09
2	Whole-face blushing	2.7	1.62
3	Cheek blushing	3.7	1.95

Table 1 Mean value of the extent to which they have noticed the avatar was blushing. (1: not at all; 7: very much). A one way analysis of variance on the null hypothesis that the means of all three groups are equal has significance level P = 0.053. A multiple comparisons tests at the 5% level on the differences between the means reveals that the mean for condition 3 is significantly greater than the mean of condition 1 (no other comparisons are significant). The Jarque-Bera test does not reject the hypothesis that the residual errors of the model follow a normal distribution

6.2. Behavioural measurement: stopping time

We have recorded the times that each participant pressed "continue" before choosing to stop. Among the 33 participants, 18 of them pressed the "stop" button before termination of the experiment. The remaining 15 participants have carried out the experiment until finally the program terminated after 10 trials.

Table 2 shows the proportions of people who continued to the end under each of the three conditions and it is clear that less people continued to the end under the cheek-blushing condition.

Condition		Proportion	Standard Deviation
1	Non-blushing	0.55	0.52
2	Whole-face blushing	0.63	0.50
3	Cheek blushing	0.18	0.40

Table 2 Proportion of participants who continued to the end for each condition. n = 11 for each condition

In order to test the significance of this, and also to relate it to other variables we constructed a binary variable (*continued*), which indicates whether they did stop voluntarily (0) or carried on throughout the whole experiment but were forced to stop after the 10th trial (1).

We carried out a binomial logistic regression with *continued* as the dependent variable, and condition as the independent variable. In this case condition 3 has a lower proportion than condition 1 and 2 with significance level $P < 0.09$. When we included the NEO questionnaire it was found that "Agreeableness" was significantly and positively associated with *continued* – in other words a positive association between the degree of "Agreeableness" and continuing with the trials until stopped by the program. Therefore we included "Agreeableness" in the binary regression as shown in Table 3. The results suggest that participants were more likely to stop in Condition 3 compared to 1 or 2, and that there was no difference between condition 1 and 2. Moreover, they were more likely to continue, the higher their score on Agreeableness.

Term	Coefficient	P
Constant	-4.1	
Condition 2 (whole-face blushing)	0.52	0.59
Condition 3 (cheek blushing)	-1.97	0.07
Agreeableness	0.14	0.05

Table 3 Binomial Logistic Regression of Continue (1 if the participant continued to the end and 0 otherwise) on Condition (type of blushing) and the Agreeableness (NEO questionnaire). Deviance = 35.12, ∂.f. = 29. Condition 1 is subsumed under the constant term, and the coefficients for Conditions 2 and 3 are differences from Condition 1

6.3. Other questionnaire results

No statistically significant differences were found in relation to the POMS and the personal trait questionnaire. However, there was a difference between condition 2 and condition 1 and 3 with regard to our "co-presence" questions. Table 4 shows the regression analysis of "co-presence" on condition, the NEO questionnaire, and the blushing condition. The results indicated that there is no association between "co-presence" and Conditions 1 or 3, but that it is positively associated with Condition 2. However, it is negatively associated with Openness. It is positively associated with the

extent to which the participants report that they generally notice others blush.

Term	Coefficient	P
Constant	4.29	
Condition 2 (whole-face blushing)	1.52	0.004
Condition 3 (cheek blushing)	0.44	0.371
Openness	-0.11	0.008
Others blush	0.33	0.017

Table 4 – Regression analysis of "Co-presence" (the mean of the three co-presence questions) on condition, and "Openness" (NEO questionnaire), and "other blush" (the extent to which the participants report that they generally notice others blush, from the blushing questionnaire). R^2 = 0.50, ∂.f. = 28. A test of the residuals of the model does not reject the hypothesis of normality (P = 0.46 on a Jarque-Bera test for normality)

Conclusion and future work

First, one of the interesting findings is that participants noticed the avatar's cheek blushing more than the whole-face blushing.

Second, results of the behavioural responses suggest that the participant tended to withdraw earlier, and were therefore less tolerant if the avatar was cheek blushing. However, there was no difference between non-blushing and the whole-face blushing regarding participants' behavioural responses. This suggests that 'cheek blushing' was not convincing as a blushing response, at least it did not evoke sympathy responses, and that this type of blushing was worse than having no blushing at all.

Finally, the co-presence questionnaire indicates a strong correlation between whole-face blushing and "co-presence". However, as mentioned above, the evidence suggests that the participants were less prone to notice the whole-face blushing. This implies that the participants felt increased co-presence with a whole-face blushing avatar even though they may not have been consciously aware of the blushing.

As a very first experiment in this domain, this study maps out a field of inquiry for methods to improve the quality of interaction between people and virtual characters. Our fundamental measure was a behavioural one – whether or not people stopped before the end of the experiment, and this showed that cheek blushing was not as convincing as either whole-face or no blushing. (In portrayal of virtual characters, it is likely to be the case that doing something wrongly is worse than not doing it at all). Connected with this was the fact that whole face blushing resulted in higher reported co-presence. This points the way for our future work to put more resources into adequate representation of whole-face blushing.

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