Effects of facial color and expression of the interviewer avatar on user's tension and anxiety in VR interview training

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Abstract

In recent years, with the outbreak of Covid-19, there has been an increasing opportunity to move communication with others to online venues. In addition, job interviews, which are important for many students with regard to communication, have been moved online. In order to avoid tension and anxiety during the interviews, it is important to train using the VR interview simulator. However, the effects of the interviewer's facial color and expression on the interviewee's sense of tension and anxiety have not been clarified. With regard to facial color and expression, it has been found that a red face enhances the perception of anger. In this study, we conducted tense VR interview training focusing on the relationship between red face and anger facial expression perception. Then, we investigated the effects of the interviewee's perception of interviewer's anger by the interviewer's red face and angry expression on the interviewee's tension and anxiety. We then developed a more effective interview simulator. In the experiment, the interviewer avatar's complexion was made to turn red or change to an angry expression in response to what the subject said during the interview training. The subjects' tension and anxiety changes before and after the interview were then surveyed using a questionnaire. The results showed that in the VR interview training, there is a synergistic effect of the interviewer avatar's facial color and expression that significantly affects the interviewee's tension and anxiety due to the interviewee's perception of interviewer's anger, which may be an important factor in developing effective, tension-filled interview training.

Keywords

Virtual reality, Avatar, Communication, Interview training

1. Introduction

In recent years, with the global outbreak of Covid-19 and the rapid development of virtual reality (VR) technology, there have been increasing opportunities to move communication with others, such as meetings and interviews, which used to be conducted face-to-face, to online venues such as telework and video conferencing. Furthermore, social VR contents represented by VRChat [1] are currently attracting attention and are one of the useful tools for communicating with others remotely. There have been many studies on avatar-mediated communication using VR here, and in a study [2] that compared multi-person interaction in the video conference and avatar-mediated communication in a VR space using intellectual, subjective judgment, and negotiation tasks between subjects, it was found that suggests that VR can be used to achieve communication similar to face-to-face communication. Furthermore, a number of studies have shown that communication in a virtual space using VR can also affect individual personality traits. A previous study [3] investigated the impact of virtual space experiences on individual communication compared to face-to-face communication. In addition, the impact of personal personality traits such as shyness on the communication experience was also investigated, and it was found that shy participants were less anxious when communicating online in virtual space than they were when communicating in person.

Furthermore, many studies have been conducted on the effects of visual characteristics such as the appearance and facial expressions of the partner avatar on subject's impressions of the partner avatar. In a previous study [4] that investigated the involvement of nonverbal visual features in impressions given by manipulating the size of the avatar's pupils, blink frequency, and viewing angle, the avatar with larger pupils and less frequent blinking, as well as the avatar viewed from below, were rated as the most sociable, confident, and attractive. In addition, a previous study [5] that investigated the effects of the facial expressions

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of the partner avatar on subjects in communication using a trust game in a VR space suggested that the facial expressions of the partner avatar, regardless of whether they were positive or negative, influenced subject's trust and decision-making behavior.

In addition, in terms of communication with others, interviews in job hunting and examinations are important for many students. With the recent outbreak of Covid-19, the global economic situation has worsened, and problems such as the employment crisis and unemployment have made many job-seeking university students anxious [6]. Therefore, interview training is considered to be effective in order to avoid being driven by tension and anxiety in the interview situation. An interview simulator using VR is an effective and efficient tool for improving the interviewee's skills, providing the interviewee with an opportunity to practice in a virtual space and feedback from a virtual interviewer to relieve tension and reduce interview anxiety. In a previous study [7], a virtual mock job interview simulation was developed as a career support for college students preparing for job hunting, and VR exposure therapy was used to reduce anxiety about job interviews. They then investigated the impact of the level of reality of the virtual interviewer's graphics during the process. The results suggested that the higher the level of graphics, the greater the sense of presence, but did not have the significant effect on the sense of anxiety. In a previous study [8], it focused on job interviews, which cause anxiety in people of all occupations, and investigated what level of reality is necessary for subjects to cope with their anxiety by conducting interviews with virtual avatars of various levels of reality, such as realistic, cartoonish, and actual photographs. As a result, subjects showed more anxiety depending on the avatar's attitude than on the avatar's reality. In a previous study [9], factors that potentially influence interviewee behavior in VR interview training were examined separately. Then, a virtual reality job interview simulator was developed to investigate what factors influence interviewee's anxiety. The results showed that the type of interview questions had the most significant effect on anxiety. Questions related to the interviewee's college expertise, such as computers, algorithms, and programming, may have caused a cognitive load on the interviewees, leading to increased anxiety and decreased communication skills in their interview performance. The Trier Social Stress Test (TSST), which measures subject's acute stress response, has also been VR-ized, suggesting that the VR-TSST is effective in inducing psychosocial stress, although the effect is smaller than the traditional TSST [10].

Many studies have investigated the factors that influence interviewee`s anxiety in VR interview simulators. However, the relationship between the facial color of the virtual interviewer and expression has not been clarified in terms of its effect on interviewee`s anxiety. Several studies have been conducted on the recognition of facial color and facial expression. In a previous study [11], changes in blood pressure, heart rate, and blood flow in the face and fingers were investigated in Chinese and Caucasian males during the reading of anger-provoking events. Results showed that facial blood flow increased when anger was expressed, and the face turned red with anger. In a previous study [12], to investigate whether the recognition of facial expressions is affected by facial color or vice versa, we varied the color of the fear-rage and sadness-happiness expression morph continuum created from facial images obtained from a database and asked subjects to identify these expressions. The results showed that reddish faces enhanced the perception of anger and bluish faces enhanced the perception of sadness from Experiment 1, and that the boundary of facial color was significantly shifted only for sad facial expressions from Experiment 2, with sad faces appearing pale (bluish). These results demonstrate that facial color affects the perception of facial expressions. In addition, a previous study [13] examined changes in facial color based on cardiovascular and hemodynamic changes when subjects were shown anger- or fear-inducing movies. Results suggested that fear, or mixed emotions of fear and anger, can cause a pallor in facial color.

The relationship between communication with avatars using VR and facial color has also been studied; a previous study [14] investigated the interaction between people and avatars who blush in embarrassing situations, and whether subjects were affected by the blushing of the partner avatar, and for longer than in situations without blushing the experiment was analyzed to see if the subjects would tolerate it towards the avatar or not. Results suggested that when the avatar blushed only on the cheeks, participants tolerated it less, and when the avatar blushed the entire face, participants were more likely to feel a sense of co-presence with the avatar.

In this study, we focused on the relationship between anger perception by facial color and expression revealed in previous studies, and clarified the effects on tension and anxiety when subjects were made to strongly perceive the interviewer avatar's angry emotion. Then, we intentionally conducted virtual interview training with a sense of tension to verify what effect it has on subjects' interview performance and developed an effective VR interview simulator. To this end, we created a VR interview simulator that changes the facial color and expression of the negative interviewer avatar, which affected subjects' anxiety in previous studies, to blush or angry expression depending on subjects' answers.

2. Experiment

2.1. Environment

The experimental program used in this study was created using Unity (2019.4.12f1). Two PCs were used in this experiment: one for the subject and one for the experimental assistant who played the interviewer avatar. The subject's PC was equipped with Windows 10 OS, Intel® Core™ i7-11700KF 3.60GHz CPU, NVIDIA GeForce RTX 3060 Ti GPU, and 32GB memory. The PC for the experimental assistant was equipped with Windows 10 OS, Intel® Core™ i7-4790F 4.00GHz CPU, NVIDIA GeForce GTX 2070 GPU, and 16GB memory. The subjects wore a head-mounted display (HMD: VIVE Pro, HTC, resolution 2880*1600, refresh rate 90 Hz, viewing angle 110°) on their heads and trackers (VIVE Tracker 3.0, HTC) on their right and left wrists, and the position and rotation information of the subject's head and wrists were obtained from the base station (SteamVR Base Station 2.0, HTC), which is an infrared sensor. The movements of the avatar were synchronized with those of the user by tracking the movements using Final IK, a Unity asset. In this experiment, the subject and the avatar played by the assistant communicated in the same virtual space, so it was necessary to synchronize the movements of the subject's avatar from the perspective of the interviewer avatar. To this end, we created a communication environment in Unity and imported PUN2 (Photon Unity Networking 2), an asset that enables multiplayer play, to construct an experimental system in which the subject and the other party can each assume the role of an avatar and face each other and communicate. Figure 1 shows a subject participating in the experiment, and Figure 2 shows each avatar facing each other in the created virtual space.

2.2. Avatars

MakeHuman (The MakeHuman team.), an open-source 3D character creation software, was used to create the avatars used in this experiment. This software allows the user to adjust the height, gender, age, skin color, and skin aging of the avatar by setting parameters. Using this system, we created an avatar that looks like a Japanese male, based on a questionnaire.

Figure 1: A subject participating in the experiment

Figure 2: Avatars facing each other in the created virtual space

In this study, we also examined the possibility of using face tracking to express the interviewer avatar's angry facial expression. However, we found that face-tracking could not express the anger that was conveyed to the subject, and that the assistant who played the role of the interviewer avatar required considerable training to perform the expression of anger. Therefore, animated facial expression changes were substituted. The created avatars were imported into Blender (Blender Foundation), and animations were created for mouth movements, blinking, and transitions to angry expressions. Figure 3 shows the interviewer avatar with normal and angry faces. We considered having the experimenter's assistant actually speak the voice and dialogue of the interviewer's avatar. However, the assistant's voice as it was would have revealed the identity of the assistant to the subject, so it was necessary to use a voice changer. However, the voice changer was not compatible with an angry speech style, which could make subjects feel uncomfortable, so we used Japanese text-to-speech software. In this study, we referred to previous studies [8, 9] and carefully selected somewhat harsh phrases such as "Why can't you answer?" and "Shouldn't be that hard a question, right?" to create an interviewer with a negative attitude that influenced the subjects' anxiety. The lines of the interviewer avatar were played along with corresponding animations when the experimenter hit a key on the keyboard.

Figure 3: The interviewer avatar with normal and angry faces

2.3. Avatar skin color

In this experiment, it was necessary for the interviewer avatar to blush and show angry expressions in response to the subject's statements during the interview training with the interviewer avatar. For this reason, the skin color of the avatar created by MakeHuman was dyed red using Adobe Photoshop 2022 (Adobe Systems Inc.). It was necessary to investigate what level of skin redness was appropriate to express anger in a more realistic manner. To this end, we manipulated the CIE Lab a* (red-green) values of MakeHuman's skin images using Adobe Photoshop 2022, and presented avatars with skin of different redness for a questionnaire-based survey. The CIELAB color space is modeled after the human visual system and is designed to be perceptually uniform. As a result of the survey, an avatar with skin set to 0 points for a* input and 15 points for output in the CIELAB color space of Adobe Photoshop 2022 was judged to have an appropriate skin tone for an angry expression. Regarding the animation of the interviewer avatar blushing, a questionnaire was used to create one that more realistically conveyed the change in skin tone. Figure 4 shows the interviewer avatar blushing with normal and angry faces.

2.4. Task

In this experiment, the speech task was performed in which subjects answered questions from an interviewer avatar. The subject's viewpoint during

Figure 4: The interviewer avatar blushing with normal and angry faces

the speech task is shown in Figure 5. After confirming the operation of the HMD and tracker, the subject followed the instructions of the experimenter and faced the interviewer avatar, which was played by an assistant. After the interviewer avatar said, "Please introduce yourself," the subject introduced his or her name and affiliation, and then answered the questions posed by the interviewer avatar. The subject was instructed to look at the interviewer avatar's face at all times while answering. The time for answering the questions was two minutes, which was not told to the subjects during the experiment. The questions were randomly selected from the following four types of questions: "What are your strengths?" "What are your weaknesses?" "Please tell me about your dream," and "What kind of person are you said you are?" The interviewer avatar was randomly selected from the following conditions: "Normal face - normal skin," "Normal face - red skin," "Angry face - normal skin," and "Angry face - red skin. The interviewer avatar said "Why can't you answer?" when the subject could not speak for 5 to 10 seconds after being asked a question, and if there was extra time to answer, he said "Is that all you have to say? Talk more!" After that, the interviewer avatar shifted into an angry mode.

Figure 5: The subject's viewpoint during the speech task

In the angry mode, the interviewer avatar in the angry face condition frowned and the interviewer avatar in the red skin condition blushed. The interviewer avatar continued to make intimidating comments in response to the subject's answers, such as "Please be more specific," and "Not yet? Answer quickly!" After two minutes had elapsed, the interviewer avatar said, "Unfortunately, time is running out," and terminated the speech task. Table 1 shows the correspondence table between the inputted keys and the interviewer avatar's lines.

2.5. Procedure

The procedure of this experiment is described next. First, informed consent was obtained from the subjects, and an overview of this experiment and its procedures was provided. Next, a preliminary questionnaire was administered. The pre-questionnaire asked about the subject's name, age, VR experience, and job interview experience, and then asked for answers about the subject's pre-experiment state anxiety and mood state.

Next, the flow of the speech task was explained so that after meeting the interviewer avatar, the subject would introduce himself/herself and then answer questions posed by the interviewer avatar. The subject

was then asked to put on the HMD and tracker, and after immersing himself/herself in the virtual space, he moved his own avatar to check the arm movements. After that, the interviewer avatar, played by an assistant, entered the virtual space and faced the subject's avatar. In this trial, we did not conduct a practice run because we thought that if we conducted a practice run, subjects would become accustomed to the task and this would affect the results. In this trial, subjects faced one of four types of avatars, introduced themselves, and answered questions from the avatars. To take into account the effect of habituation, the avatars and questions were presented randomly, and the same avatars and questions were never presented.

Subjects answered the in-experiment questionnaire after the interview with the interviewer avatar was over. The questionnaire asked for the subject's name, age, impressions of the appearance of the interviewer avatars, impressions of the interaction itself, state anxiety after the interview with the interviewer avatars, and mood state. This trial was conducted four times, one interview question per interviewer avatar. There was a break of at least 2 hours between each trial, and subjects had interview with all interviewer avatars over the course of two days. At the end of the experiment, subjects were asked in a post-test questionnaire to freely express their opinions and impressions about whether facial color or facial expression was more important in expressing the interviewer avatar's anger, based on this experiment.

Table 1
The correspondence table between enter keys and the interviewer avatar's lines

Enter Key	What the interviewer avatar said
↑	Please introduce yourself
↓	Thank you
Key Pad 0	What are your strengths?
Key pad 1	What are your weaknesses?
Key pad 2	Please tell me about your dream.
Key pad 3	What kind of person are you said you are?
Key pad 4	Please speak more clearly.
Key pad 5	Shouldn't be that hard a question, right?
Key pad 6	Is that all? Tell me more.
Key pad 7	Not yet? Answer quickly!
Key pad 8	Please be more specific
Key pad 9	Unfortunately, time is running out.
Space	Why can't you answer?
Tab	Is that all you have to say? Talk more!
Back Space	I'm not sure, please be specific.
Delete	Please speak a little more clearly

2.6. Evaluation methods

In this experiment, the State-Trait Anxiety Inventory (STAI) [15] developed by Spielberger et al. was used to assess state anxiety before and after the interview with each avatar. The STAI consists of 20 items for each of the state anxiety scale and the trait anxiety scale, and subjects were asked to choose one item from a 4-point scale ranging from 1 (not at all applicable) to 4 (very applicable) that represented their feelings of anxiety. Subjects were instructed not to think too much when answering the questions. The minimum score for each scale was 20 points and the maximum was 80 points. In addition, the Temporary Mood Scale (TMS) [16] developed by K. Tokuda. was used to evaluate the mood state before and after the interview with each avatar. This scale was developed based on the Profile of Mood States (POMS) [17] developed by McNair et al. and, like the POMS, consists of six sub-scales of "Tension," "Depression," "Fatigue," "Vigor," "Anger," and "Confusion," each with three items. The TMS were administered to subjects on a 5-point scale from 1 (not at all applicable) to 5 (very applicable), and the total score for each subscale was calculated. In the TMS, Q1-Q3 correspond to the "Tension," Q4-Q6 to the "Depression," Q7-Q9 to the "Fatigue," Q10-Q12 to the "Vigor," Q13-Q15 to the "Anger," and Q16-Q18 to the "Confusion" subscales. The STAI State Anxiety Scale and TMS respective question items are shown in Tables 2 and 3.

3. Results

Twenty subjects participated in this experiment. Eighteen subjects were male and two were female, with a mean age of 22.45 years and a standard deviation of 0.86. Of the 20 subjects, 17 had experience with VR and seven had experienced with job interviews.

With respect to the experimental data, the data obtained were considered as within-subjects factors and were analyzed. The analysis was based on the difference in scores of the total scores of each subscale of the STAI state anxiety and TMS before and after the interview with each avatar; after confirming normality using the Shapiro-Wilk test, the paired *t*-test was used to test for significant differences. For the convenience of the graphs that appear in the following sections, we refer to "normal face - normal skin" as Avatar 1, "normal face - red skin" as Avatar 2, "angry face - normal skin" as Avatar 3, and "angry face - red skin" as Avatar 4, based on the condition of the interviewer avatar.

3.1. STAI state anxiety

A box-and-whisker diagram representing the amount of change in STAI state anxiety total scores before and after the interview with each avatar is shown in Figure 6.

Based on the amount of change in STAI state anxiety total scores before and after the interview with each

avatar, a Shapiro-Wilk test was conducted and found to be normal in all conditions ($p > 0.05$), so a paired t-test was conducted, resulting in a strong significant difference in the Avatar 4 ($t = -3.5621$, $p < 0.01$; $df = 19$) condition, very strong significant differences in the Avatar 2 ($t = -4.44$, $p < 0.001$; $df = 19$) and Avatar 3 ($t = -5.1278$, $p < 0.001$; $df = 19$) conditions.

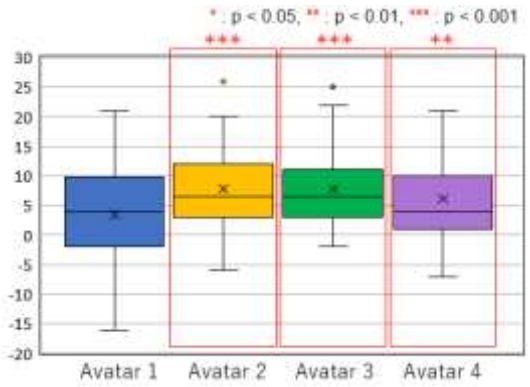
A one-way analysis of variance was performed to compare the change in STAI state anxiety total scores across each avatar condition, but multiple comparisons were not performed because no significant differences were obtained ($F_{(3.76)} = 1.392$, $p > 0.05$).

3.2. TMS

Figure 7 shows a box-and-whisker plot of the change in the total score of each TMS subscale before and after the interview with each avatar.

Table 2
STAI State Anxiety Scale Questions

Q1	I feel calm
Q2	I feel secure
Q3	I am tense
Q4	I feel strained
Q5	I feel at ease
Q6	I feel upset
Q7	I am presently worrying over possible misfortunes
Q8	I feel satisfied
Q9	I feel frightened
Q10	I feel comfortable
Q11	I feel self-confident
Q12	I feel nervous
Q13	I am jittery
Q14	I feel indecisive
Q15	I am relaxed
Q16	I feel content
Q17	I am worried
Q18	I feel confused
Q19	I feel steady
Q20	I feel pleasant



Q1	Tense
Q2	Restless
Q3	On edge
Q4	Hopeless
Q5	Sad
Q6	Gloomy
Q7	Exhausted
Q8	Fatigued
Q9	Tired
Q10	Energetic
Q11	Lively
Q12	Active
Q13	Grouchy
Q14	Anger
Q15	Peeved
Q16	Uncertain About Things
Q17	Unable to Concentrate
Q18	Bewildered

Table 3
TMS Questions

Figure 6: The box-and-whisker plot of the change in STAI state anxiety total scores

The paired t-tests were conducted based on the amount of change in the total score of each TMS subscale before and after the interview with each avatar. The results showed significant differences in the "Tension" scale in the Avatar 4 condition ($t = -2.5944$, $p < 0.05$; $df = 19$) and in the "Depression" scale in the Avatar 1 condition ($t = -2.5166$, $p < 0.05$; $df = 19$); for the "Vigor" scale, strong significant differences were obtained for Avatar 2 ($t = 2.9066$, $p < 0.01$; $df = 19$) and Avatar 3 ($t = 3.2259$, $p < 0.01$; $df = 19$), and very strong significant differences were obtained for Avatar 4 ($t = 3.9428$, $p < 0.001$; $df = 19$); for the "Anger" scale, strong significant difference were obtained for Avatar 3 ($t = -2.6569$, $p < 0.01$, $df = 19$), and significant differences were obtained for Avatar 1 ($t = -2.7407$, $p < 0.05$; $df = 19$) and Avatar 2 ($t = -2.3424$, $p < 0.05$; $df = 19$). No significant differences were found in the scores of the other scales.

One-way ANOVAs were conducted to compare the change in total scores for each TMS subscale across each avatar condition but multiple comparisons were not performed because no significant differences were obtained for all scales: "Tension" ($F_{(3.76)} = 0.083$, $p > 0.05$), "Depression" ($F_{(3.76)} = 0.456$, $p > 0.05$), "Fatigue" ($F_{(3.76)} = 0.322$, $p > 0.05$), "Vigor" ($F_{(3.76)} = 1.293$, $p > 0.05$), "Anger" ($F_{(3.76)} = 0.641$, $p > 0.05$), and "Confusion" ($F_{(3.76)} = 0.877$, $p > 0.05$).

4. Discussion

4.1. STAI state anxiety

We compared the Avatar 1 and Avatar 2 conditions. Since significant differences were obtained in the Avatar 2 condition, it was possible that the redder skin color made subjects more anxious when the interviewer avatar had a normal face. With regard to their impression of the interviewer avatar's appearance in the questionnaire administered during the experiment, some subjects responded to the Avatar 2 condition that they thought the interviewer avatar was angry because his face turned red, suggesting that the redder skin even in the normal face condition affected the subjects' perception of interviewer's anger.

Next, since strong significant differences were obtained for both Avatar 3 and Avatar 4, it was possible that subjects felt strongly anxious feelings when the interviewer avatar's facial expression was angry. In addition, the Avatar 3 condition might have made the subjects felt more strongly anxious, since the *p*-value in the paired *t*-test was the lowest and a very strong significant difference was obtained for Avatar 3. Comparing these two avatars, here again, with regard to impressions of the interviewer avatar's appearance, some subjects had the impression that the interviewer avatar with an angry face and red face was angry and scary, while others could see that he was angry with furrowed brow, but his skin suddenly turned red, giving the impression that he was more surprised than scared.

Based on the above, the STAI analysis suggested that subjects might feel more strongly anxious when the interviewer avatar blush for normal faces and do not blush for angry faces. However, in the post-experiment questionnaire asking whether the color of the interviewer avatar's face or facial expression was more important for the perception of interviewer's anger, 8 of the 20 subjects answered that facial expression was more important, 5 answered that facial color was more important, and 7 answered that both were important. It was difficult to give a clear answer as to whether facial expression or complexion had more influence on anger perception based on the STAI results alone.

4.2. TMS

Next, we proceed with a discussion of each TMS scales. The experimental results showed that significant differences were obtained in the "Depression" scale in the Avatar 1 condition and in the "Vigor" scale in the conditions except for Avatar 1. For Depression, Avatar 1 had the least effect on anxiety based on the STAI results, suggesting that the subjects felt depressed because they could not answer the questions well rather than because they were anxious about the interviewer avatar. Regarding "Vigor," most subjects had negative impressions of their interactions with the interviewer avatar, and said that the interviewer avatar had a coercive attitude and that the interview felt like a pressure interview, which made them anxious. Since this study aimed to train subjects to interview with a negative interviewer which had affected their anxiety in previous studies [8, 9],

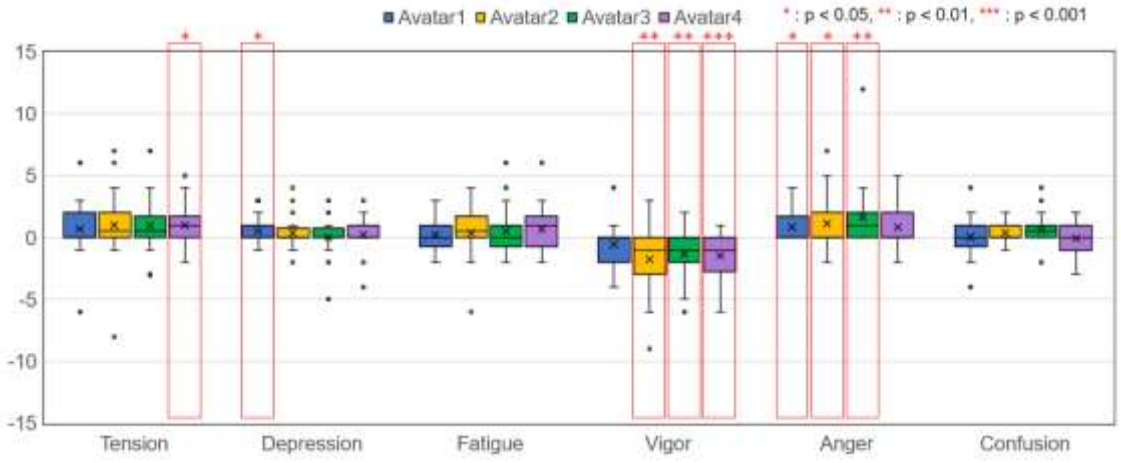


Figure 7: The box-and-whisker plot of the change in the total score of each TMS subscale

we believed that we were able to replicate this to some extent in this regard. In other words, in this experiment, the subjects' vitality after the experiment was reduced due to the effects of the interview with the coercive and negative interviewer avatar. Next, with respect to the "Tension" and "Anger" scales, subjects felt anger in all

but Avatar 4, and tension only in Avatar 4. Therefore, in Avatar 4, subjects might have been more tense than angry with the interviewer. Considering the STAI results, it was possible that the interviewer avatar with an angry face and red skin had the most significant effect on the subjects' tension and anxiety during this interview training.

5. Conclusion

In recent years, people have shifted their communication to online, and job interviews, which are important and anxiety-provoking for many students, are no exception. The VR interview training is a tool to assist such anxious students and has been the subject of much research. However, there was no clarification regarding the effects on interviewees' perception of interviewer's anger when they were interviewed with the interviewer avatar who blushed or had angry facial expressions and intentionally made them feel tense or anxious. Therefore, in this study, we investigated and measured anxiety and mood changes before and after communication with each avatar using four types of avatars whose facial colors and expressions changed according to the subject's responses in interview training, and investigated which of the changes in the interviewer avatar's facial color and expression was more effective for the perception of anger.

In the task, the interviewer avatar, which was to perform negative attitudes and statements to the subjects' responses, intentionally reproduced an intimidating interview by changing its facial color and expression in response to the situation.

The experimental results indicated that the interaction between facial color and expression might be an important factor in the interviewee's perception of interviewer's anger.

Future prospects include the development of more effective interview training by incorporating real-time facial expression changes through facial tracking and physiological indicators such as heart rate and pupils.

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