Identification of Appropriate Facial Expressions for Medical Doctors

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Abstract— **Establishing trust between a patient and a doctor depends as much on their relationship as on the doctor's medical abilities. One of important factors in building and maintaining a relationship is whether the doctor produces facial expressions appropriate to the patient's condition. The purpose of this study is to identify facial expressions appropriate to various patient conditions. We focused on the greetings given by young doctors at the beginning of medical interviews of adult patients in the general ward of a hospital. Images of a role-playing patient portraying one of three physical conditions were shown to seven student doctors, who were then videotaped as they greeted the "patient." We identified appropriate facial expressions for each condition on the basis of both human evaluation and computer-aided facial expression emotion analysis. We also identified an appropriate facial expression when a young doctor auscultates a patient and clarified differences in the evaluation of facial expressions due to the gender and age of the evaluators. Finally, we clarified facial expressions required for pediatricians.**

Keywords-doctor-patient interaction; facial expression; nonverbal communication.

I. INTRODUCTION

We study facial expressions required for young medical doctors, and presented research results in the international conference of Global Health 2018 [1]. In this paper, we introduce differences due to the gender and age of the patients and facial expression required for pediatricians in addition to the paper presented in the Global Health 2018.

Patient satisfaction is one of important components of medical care [2]. Improving patient satisfaction enhances trust and the relationship between patient and doctor, which leads to stronger adherence to the prescribed protocol, such as taking medicine, and to enhanced therapeutic effect [3][4]. Many studies and reviews have shown that the main determinant of patient satisfaction is the doctor-patient relationship [5]–[9] and that patient satisfaction is higher when the patient communicates with a doctor having strong nonverbal communication ability [10][11]. Unfortunately, inexperienced young doctors and medical students often have trouble producing appropriate facial expressions when greeting a patient. The first author of this paper, a lecturer on medical communication, often hears young doctors complaining that, though they intend to smile, patients say that they seem to be angry.

In this study, we identified appropriate facial expressions for a doctor by using quantitative analysis. We videotaped medical students' facial expressions when they greeted a patient and analyzed the recorded videos using computer-aided facial expression emotion analysis. We then asked potential patients to evaluate the appropriateness of the facial expressions on a five-point scale. We then identified facial expressions appropriate for doctors for three patient conditions.

The facial expression required for a doctor may be influenced by the patient's condition, the environment in which treatment is provided, culture, the medical department, and both patient's and doctor's gender. As the first step, we focused on appropriate facial expressions for young medical doctors when greeting patients in the general ward of a hospital. Also, as a typical medical treatment situation, we focused on appropriate facial expressions when young medical doctors auscultate a patient. We clarified the difference in the evaluation on facial expressions due to gender differences and age differences among evaluators. Finally, using computer-aided facial expression emotion analysis, we analyzed the facial expressions produced by two pediatricians when shown photographs of pediatric patients in three different conditions.

After reviewing related work in Section II, we explain our facial expression analysis system in Section III. We describe our evaluation experiment in Section IV and analyze facial expressions in recorded videos in Section V. Gender and age-specific differences among evaluators are discussed in Section VI, and appropriate facial expressions for pediatricians are presented in Section VII. We conclude with a summary of the key points in Section VIII.

II. RELATED WORK

The medical interview is important for a doctor not only to get relevant information from the patient but also to build a good relationship with the patient. Therefore, we review existing research related to medical interviews in this section. In addition, since our work focuses on facial expressions, we also review research on nonverbal communication.

A. Medical Interviews

Medical interviews have traditionally focused on gathering relevant information from patients [12]. Nowadays, the focus has expanded to building a trusting relationship, sharing decision-making, responding to the patient's

emotional state, and supporting actions related to the patient's condition and treatment, so the doctor must have a wider range of communication skills [13]. These skills include "looking at a patient not as a case but as a human being" [14] and "building and maintaining a good relationship between doctor and patient" [15]. It has been shown that such skills have a greater effect on patient satisfaction than the doctor's medical skills, the medicine prescribed, the information provided, the questions asked, the advice given, and the instructions given. In particular, a patient's satisfaction is positively related to the doctor being warm [14][16], empathic [14][16]–[18], and friendly [16] and giving the impression of being human [17].

"Nonverbal communication" is a means of communicating these emotional aspects. Patient satisfaction is higher when the doctor has a strong ability to express his or her emotions and to read the emotions of others by nonverbal communication such as through facial expressions, gaze, posture, and tone of voice [10][19][20]. In short, a doctor's nonverbal communication is an important aspect of patient care.

B. Nonverbal Communication

Facial expression plays a large role in nonverbal communication. For emotional messages such as "like" and "dislike," Mehrabian [21] estimated that 7% of the message is carried by the language content, 38% is carried by the voice and sound quality, and 55% is carried by the facial expression and gestures. Birdwhistell [22] argued that 35% of the message is carried by the language content while the remaining 65% is carried by the expression, the way of talking, the gesturing, etc. Therefore, it is useful to clarify the appropriate facial expressions for doctors to have when communicating with patients, especially patients who are sensitive to a doctor's nonverbal behavior due to anxiety [23][24].

Differences in non-verbal expressions due to cultural background have also been pointed out. North American countries such as the United States and Canada and Western European countries such as the Netherlands, Italy, and Belgium are individualistic cultures, whereas Japan is considered to be a collectivist culture located at the opposite extreme. People living in collectivist cultures tend to be cautious about nonverbal expression [25]. Comparative cultural research on facial expression recognition in the UK, Italy, and Japan revealed no significant difference in cognitive ability between Japan and the other two countries while the expressions produced by Japanese tended to be ambiguous and difficult to recognize [26]. Other research has shown that women have better facial expression cognitive abilities than men [27]–[31].

Studies on the effects of age on facial expression recognition have focused on infants and disabled children, but recent studies have focused on elderly people as well. These studies have shown that elderly people consistently have trouble recognizing "anger," "sadness," and "fear" while their recognition abilities for "happiness," "surprise," and "disgust" do not exhibit a consistent tendency [32][33].

A comparison study between young and elderly people revealed that young people have a higher propensity to evaluate photographs of expressionless faces as showing "anger" than elderly people [34].

III. FACIAL EXPRESSION ANALYSIS SYSTEM

To identify appropriate facial expressions, we developed a system that quantitatively analyzes changes in facial expression. It is based on the Cognitive Services Emotion API [35] provided by Microsoft's Azure cloud service. The concept of the system is illustrated in Figure 1. The doctor's facial image during a patient interview is recorded in a video file. The file is sent to the Cognitive Services Emotion API, which provides feedback on the position coordinates of the doctor's face and the ratio by emotion. The system comprises Microsoft.ProjectOxford.Emotion.dll which corresponds to the Emotion API on Azure, Newtonsoft.Json.dll which handles the file in JSON format, Parakeet.dll which processes the movie file, and Parakeet.Logging.dll which passes the facial expression analysis received from the Emotion API as a log file to a PC for real-time display. We developed Parakeet.dll, Parakeet.Logging.dll, and LogViewerWPF.exe.

Our facial expression emotion analysis system calculates the ratio for seven emotions ("happiness," "anger," "contempt," "disgust," "fear," "sadness," and "surprise") reflected in the input video image and for "neutral." The total for all emotions is 1, and the value for "neutral" is obtained by subtracting the total value for the seven emotions from 1.

The detection result window is shown in Figure 2. Each row shows the results for the emotion corresponding to one facial expression. The rows are in time series order, with the latest set of results in the bottom row. Clicking the display command on the menu highlights the detection results for the specified face. Selecting a line by using the mouse or keyboard causes the corresponding video to play.

The cells corresponding to each emotional value are highlighted in "pink." If the value = 1, the cells are the darkest pink, and if the value = 0, the cells have no color. For example, if the emotional value is 0.8, the color density is 80%.
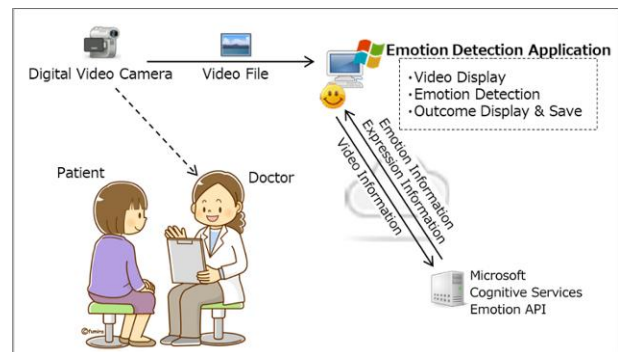

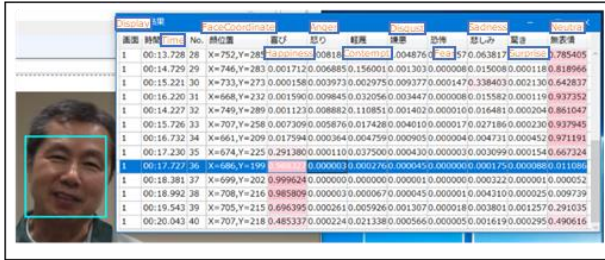Figure 1. Configuration of video image-based emotion analysis system.

Figure 2.   Detection result window.

IV.   EVALUATION EXPERIMENT

One way to analyze the facial expressions of veteran doctors would be to identify facial expressions appropriate for doctors. However, their facial expressions would not always be appropriate. Since many young physicians have trouble producing appropriate facial expressions when greeting a patient, we chose to identify facial expressions that would be acceptable for most patients including potential patients from facial expressions thought to be suitable by medical students. We targeted the situation, in which they greet patients in the general ward of a hospital. We videotaped their greeting for model patients to be evaluated and identified appropriate facial expressions. Although evaluation by actual patients is best, it would have been difficult to request their participation. We thus asked generally healthy adults who been hospitalized in the past or would be in the future to play the role of the patient. We used the computer-aided facial expression emotion analysis to identify suitable facial expressions, as introduced in Section III.

A.   Experimental Conditions

1)   Doctor participants: Seven medical students (4 women, 3 men; average age 22.5 years).

2)   Patient conditions: Although the actual condition of hospitalized patients varies widely among patients, we had a role-playing patient portray only three conditions, as shown in Figure 3: a patient who feels physically healthy (a "bright patient"), one whose physical condition is unknown (an "expressionless patient"), and one who feels badly and is suffering pain (a "patient in pain").

3)   Video recording: The three photographs in Figure 3 were shown to the doctor participants along with the following explanation. "The photographs you will see show a patient you visit during regular morning rounds in a hospital. They are of the same patient, but his condition is different in each picture. In the first one, he feels physically healthy; in the second one, his physical condition is unknown; and in the third one, he feels ill and is suffering pain. After looking at each photograph, "Please greet the patient as a doctor for about 5 seconds or so." This process was repeated 5 days later using three of the students and the same photographs. On the first day, all students greeted the

patient as they thought best. Before the process on the second day, the three selected students received coaching based on the authors' previous findings. On the second day, the three students greeted the patient again. We recorded their greetings (30 recordings in total) and used them for our evaluation of facial expressions.

The purpose of this experiment was not to identify the most appropriate facial expressions but simply ones that would be acceptable for most patients, so having a large group of doctors was not needed. In this paper, we consider "appropriate" to mean "acceptable."

Figure 3.   Conditions portrayed by role-playing patient.

B.   Subjective Evaluation

To make the subjective evaluation more effective, we first had 16 people view and evaluate each video recording and removed the ones, in which the student's facial expression was judged to be unacceptable. We then had 31 other people view and evaluate the remaining recordings.

1)   First subjective evaluation: We showed the video recordings to 5 men and 11 women (average age 46) without sound. We asked them to judge whether the doctor's facial expression was appropriate for the situation on a 5-point scale ("1 completely appropriate," "2 somewhat appropriate," "3 neutral," "4 not so appropriate," "5 inappropriate"). We also asked them to comment on anything they felt or noticed. We showed the recordings without sound because we wanted them to focus on appropriate facial expressions in medical communication situations, and emotion is easier to read from speech than from facial expressions. The results are shown in Table I.

2)   Second subjective evaluation: For the second subjective evaluation, we eliminated the recordings with a score of 4 or 5 in the first evaluation, except for one score-4 recording, because the facial expressions for those recordings would be unacceptable for patients. One score-4 recording was kept because otherwise there would have been only three recordings for the "patient in pain." The videos used were B-1 to B-6 for the "bright patient" (shown in blue in Table I), E-1, E-2, E-3, E-4, and E-8 for the "expressionless patient" (shown in gray), and P-1 to P-4 and P-8 for the "patient in pain" (shown in yellow).

We showed these videos to 17 men and 14 women (average age 35.9) without sound. We asked them to judge whether the doctor's facial expression was appropriate for the patient's condition on the same 5-point scale. We again asked them to also comment on anything they felt or noticed. The results are shown in Table II. As in the first evaluation, we showed the videos without sound so that the participants would focus their attention on the facial expressions.

TABLE I. RESULTS OF FIRST SUBJECTIVE EVALUATION

	Video-ID	F51	F67	F65	M54	F59	F58	F57	M48	F55	F50	F20	F27	F24	M34	M34	M32
Bright	B-1	1			2			1	2	1	1	2	2	1	1	2	1
	B-2	1	2	2	2	1	1	1	2	1	1	2	1	1	2	2	1
	B-3	1			2			2	2	1	1	2	2	1	2	1	1
	B-4	1	2	1	2	1	1	2	1	2	2	1	2	2	2	2	1
	B-5							1	1	2	1	2	2	1	2	2	2
	B-6							2	2	2	1	2	2	2	2	2	1
	B-7	1			4			3	1	1	1	2	3	2	2	2	1
	B-8	1	2	1	2	1	2	3	2	2	3	2	2	2	4	4	2
	B-9	1	1	2	4	3	2	2	4	2	4	2	2	3	3	2	3
	B-10	2			2			2	4	1	2	2	3	3	4	3	4
Expressionless	E-1	1			2			3	1	2	1	3	3	1	2	1	2
	E-2	1			2			2	2	3	1	2	3	2	2	2	2
	E-3							2	3	2	2	2	2	2	2	2	1
	E-4							2	3	2	2	2	2	2	2	2	1
	E-5	1			2			3	2	1	1	3	4	2	2	2	2
	E-6	1	2	2	2	4	2	2	2	4	2	2	2	2	2	2	1
	E-7	1	2	3	2	1	2	1	4	3	4	3	1	3	3	2	2
	E-8	2	2	1	2	3	1	2	2	2	3	3	2	3	3	3	3
	E-9	2	3	2	3	4	3	2	1	3	2	3	2	3	3	4	1
	E-10	2			2			3	4	1	2	3	3	3	4	2	4
in Pain	P-1							2	2	1	2	2	2	3	2	2	1
	P-2	1			2			2	3	1	1	3	1	2	3	2	2
	P-3							1	1	1	2	2	2	3	3	3	2
	P-4	2			2			1	1	2	2	2	4	2	2	2	3
	P-5	2	2	2	2	2	2	2	3	3	2	1	3	4	2	2	4
	P-6	2	2	2	2	2	2	2	3	3	2	1	3	4	2	2	4
	P-7	2	2	2	4	2	3	2	2	3	2	1	2	4	4	3	3
	P-8	2			2			3	2	3	2	3	3	3	4	2	2
	P-9	1	2	3	4	2	3	4	3	3	3	4	2	5	4	4	1
	P-10	2			4			4	4	2	2	4	3	3	2	3	4

TABLE II. RESULTS OF SECOND SUBJECTIVE EVALUATION

	Video-ID	Score					avg.
		1	2	3	4	5	
Bright	B-2	9	17	4	1	0	1.9
	B-4	13	8	9	1	0	1.9
	B-3	7	10	12	2	0	2.3
	B-5	2	15	13	1	0	2.4
	B-6	5	8	16	2	0	2.5
	B-1	3	9	16	3	0	2.6
Expressionless	E-1	4	10	14	3	0	2.5
	E-3	5	5	19	2	0	2.6
	E-4	4	6	18	3	0	2.6
	E-8	3	5	22	0	1	2.7
	E-2	1	6	13	11	0	3.1
in Pain	P-4	10	8	9	4	0	2.2
	P-3	5	8	16	2	0	2.5
	P-1	3	9	13	5	1	2.7
	P-8	2	10	8	10	1	2.9
	P-2	0	4	14	11	2	3.4

V. QUANTITATIVE ANALYSIS

In addition to the two subjective evaluations, the emotions represented by the facial expressions in the 16 highest ranked videos were identified using our facial expression emotion analysis system.

A. Facial expressions appropriate for "bright patient"

The three top-ranked videos for "bright patient" as subjectively evaluated were analyzed from the point of view of what emotions appear in the facial expressions, as identified by the facial expression emotion analysis. Tables III, IV, and V show the results. Table VI shows the results for video B-10, which was evaluated as low.The cells in the tables corresponding to 0 or more and less than 0.2 are shown in blue, 0.2 or more and less than 0.4 in green, 0.4 or more and less than 0.6 in yellow, 0.6 or more and less than 0.8 in orange, and 0.8 or more in red. A representative facial expression is shown in Figure 4. Images of the students corresponding to videos B-2 and B-4 are not shown because permission could not be obtained.

Figure 4. Facial expression of student corresponding to video B-3.

TABLE III. COMPUTER ANALYSIS RESULTS FOR VIDEO B-2 (TOP-RANKED FACIAL EXPRESSION FOR "BRIGHT PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.04
00:00.7	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.05
00:01.1	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.10
00:01.6	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:04.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE IV. COMPUTER ANALYSIS RESULTS FOR VIDEO B-4 (2ND-RANKED FACIAL EXPRESSION FOR "BRIGHT PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.83	0.00	0.01	0.01	0.00	0.00	0.00	0.16
00:00.7	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.01
00:01.1	0.98	0.00	0.00	0.01	0.00	0.00	0.00	0.01
00:01.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.2	0.97	0.00	0.00	0.02	0.00	0.00	0.01	0.00
00:03.7	0.95	0.00	0.00	0.01	0.00	0.00	0.00	0.04
00:04.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:04.8	0.99	0.00	0.00	0.01	0.00	0.00	0.00	0.00
00:05.4	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:06.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:06.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:06.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE V.   COMPUTER ANALYSIS RESULTS FOR VIDEO B-3
(3RD-RANKED FACIAL EXPRESSION FOR "BRIGHT PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:00.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.7	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:02.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.9	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE VI.   COMPUTER ANALYSIS RESULTS FOR VIDEO B-10
(LOW-RANKED FACIAL EXPRESSION FOR "BRIGHT PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:00.6	0.00	0.00	0.00	0.00	0.03	0.02	0.50	0.45
00:01.1	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.97
00:01.6	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.99
00:02.1	0.00	0.00	0.00	0.00	0.01	0.10	0.03	0.85
00:02.6	0.00	0.00	0.00	0.00	0.06	0.00	0.49	0.44
00:03.1	0.02	0.00	0.02	0.00	0.00	0.03	0.01	0.92
00:03.6	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.98
00:04.1	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.96
00:04.7	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.97

The facial expression for "bright patient" was "constant happiness" (expressed more as a laugh rather than simply a smile) for the three top-ranked videos. The lower evaluated video, B-10, was mostly "neutral," and it was judged as showing "nervousness," "no expression," "scary eye," etc., which explains why it received a low evaluation.

B. Facial expressions appropriate for "expressionless patient"

The three top-ranked videos for the "expressionless patient" as subjectively evaluated were analyzed from the point of view of what emotions appear in the facial expressions as identified using our facial expression emotion analysis system. Tables VII, VIII, and IX show the results. Table X shows the results for video E-8, which was evaluated as low.

As shown in Figure 5, the image representing the first half of video E-1 is largely "happiness" (expressed as a smile) and "neutral" in the second half (mainly expressionless). The 2nd- and 3rd-ranked videos were mostly "neutral." The lower evaluated video, E-8, was mostly "happiness," which was judged not to be serious enough. It is thought that this is because medical students cannot judge whether an "expressionless patient" is in a good or bad physical condition due to the lack of expression. Since the patient's condition could be bad, an expression showing "happiness" was judged by some as inappropriate. The "neutral" expressions shown in the 2nd- and 3rd-ranked videos were apparently judged as having little effect on the patient. The top-ranked video showed a natural greeting starting with a smile and then transitioning to "neutral" as the "doctor" learned about the patient's condition, which is considered to be a reasonable explanation for the high evaluation.

C. Facial expressions appropriate for "patient in pain"

The three top-ranked videos for "patient in pain" as subjectively evaluated were analyzed from the point of view of what emotions appear in the facial expressions as identified using our facial expression emotion analysis system. Tables XI, XII, and XIII show the results. The expression in the top-ranked video is shown in Figure 6. Table XIV shows the results for video P-10, which was evaluated low.

Figure 5.   Facial expression of student corresponding to video E-1 (left: first half; right: second half).

TABLE VII.   COMPUTER ANALYSIS RESULTS FOR VIDEO E-1
(TOP-RANKED FACIAL EXPRESSION FOR "EXPRESSIONLESS PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.34
00:00.7	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.29
00:01.2	0.79	0.00	0.01	0.00	0.00	0.00	0.00	0.20
00:01.6	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.06
00:02.2	0.35	0.00	0.01	0.00	0.00	0.00	0.00	0.63
00:02.7	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.07
00:03.2	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.76
00:03.8	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.70
00:04.0	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.59

TABLE VIII.   COMPUTER ANALYSIS RESULTS FOR VIDEO E-3
(2ND-RANKED FACIAL EXPRESSION FOR "EXPRESSIONLESS PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.7	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.93
00:01.1	0.00	0.00	0.00	0.00	0.00	0.06	0.02	0.92
00:01.6	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.96
00:02.2	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.92
00:02.6	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.66
00:00.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:03.2	0.00	0.00	0.01	0.02	0.00	0.13	0.00	0.84
00:03.6	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.94
00:03.0	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.92

TABLE IX.   COMPUTER ANALYSIS RESULTS FOR VIDEO E-4
(3RD-RANKED FACIAL EXPRESSION FOR "EXPRESSIONLESS PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.96
00:01.6	0.00	0.00	0.00	0.00	0.02	0.01	0.34	0.63
00:02.1	0.00	0.00	0.00	0.00	0.03	0.01	0.35	0.60
00:02.6	0.00	0.00	0.00	0.00	0.08	0.02	0.37	0.52
00:03.1	0.00	0.00	0.00	0.00	0.05	0.05	0.24	0.65
00:03.6	0.03	0.00	0.02	0.00	0.00	0.03	0.01	0.91
00:04.1	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.96

TABLE X. COMPUTER ANALYSIS RESULTS FOR VIDEO E-8 (LOW-RANKED FACIAL EXPRESSION FOR "EXPRESSIONLESS PATIENT")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.0	0.81	0.00	0.00	0.00	0.00	0.00	0.00	0.19
00:00.5	0.60	0.00	0.01	0.00	0.00	0.00	0.05	0.34
00:01.0	0.81	0.00	0.00	0.01	0.00	0.00	0.09	0.09
00:01.6	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.03
00:02.0	0.95	0.00	0.00	0.00	0.00	0.00	0.01	0.04
00:02.5	0.96	0.00	0.00	0.01	0.00	0.00	0.00	0.03
00:03.0	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.01
00:03.7	0.91	0.00	0.02	0.01	0.00	0.00	0.00	0.07
00:04.0	0.87	0.00	0.04	0.01	0.00	0.00	0.00	0.08

The expressions in the higher ranked videos are mainly "neutral," with "surprise," "sadness," or "fear" gradually appearing in some. There was virtually no expression of "happiness," "anger," or "disgust" except for the third frame of video P-1. In contrast, the expression in the lower ranked video, P-10, was mostly "happiness," resulting in comments such as "the grinning made me feel uncomfortable" and "the doctor seemed to be smiling faintly." These comments explain the low evaluation.

Figure 6. Facial expression of student corresponding to video P-4.

TABLE XI. COMPUTER ANALYSIS RESULTS FOR VIDEO P-4 (TOP-RANKED FACIAL EXPRESSION FOR "PATIENT IN PAIN")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.7	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.93
00:01.1	0.00	0.00	0.00	0.00	0.00	0.06	0.02	0.92
00:01.6	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.96
00:02.2	0.00	0.00	0.00	0.00	0.00	0.08	0.01	0.92
00:02.6	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.66
00:00.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:03.2	0.00	0.01	0.02	0.00	0.00	0.13	0.00	0.84
00:03.6	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.94
00:03.0	0.00	0.00	0.01	0.00	0.00	0.06	0.00	0.92

TABLE XII. COMPUTER ANALYSIS RESULTS FOR VIDEO P-3 (2ND-RANKED FACIAL EXPRESSION FOR "PATIENT IN PAIN")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.96
00:01.6	0.00	0.00	0.00	0.00	0.02	0.01	0.34	0.63
00:02.1	0.00	0.00	0.00	0.00	0.03	0.01	0.35	0.60
00:02.6	0.00	0.00	0.00	0.00	0.08	0.02	0.37	0.52
00:03.1	0.00	0.00	0.00	0.00	0.05	0.05	0.24	0.65
00:03.6	0.03	0.00	0.02	0.00	0.00	0.03	0.01	0.91
00:04.1	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.96

TABLE XIII. COMPUTER ANALYSIS RESULTS FOR P-1 (3RD-RANKED FACIAL EXPRESSION FOR "PATIENT IN PAIN")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.00	0.00	0.00	0.00	0.00	0.02	0.05	0.93
00:00.6	0.01	0.00	0.00	0.00	0.00	0.00	0.06	0.93
00:01.1	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.73
00:01.6	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.98
00:02.1	0.00	0.00	0.00	0.00	0.01	0.09	0.09	0.81
00:02.6	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.94
00:03.2	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.96
00:03.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:04.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:04.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:05.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
00:05.0	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.98

TABLE XIV. COMPUTER ANALYSIS RESULTS FOR VIDEO P-10 (LOW-RANKED FACIAL EXPRESSION FOR "PATIENT IN PAIN")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:00.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.5	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.17
00:02.0	0.95	0.00	0.00	0.00	0.00	0.00	0.00	0.05
00:02.5	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.01
00:03.0	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.5	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.01
00:04.1	0.58	0.00	0.00	0.00	0.00	0.00	0.00	0.41
00:04.7	0.24	0.00	0.04	0.00	0.00	0.00	0.00	0.72

D. Facial expressions appropriate for "auscultation"

To identify facial expressions appropriate for a doctor performing auscultation, videos were created and evaluated using the following procedure.

Step 1: Take photograph of patient being auscultated (Figure 7).

Step 2: Record videos of two medical doctors producing facial expressions they thought appropriate for the patient.

Step 3: Analyze videos using computer-aided facial expression emotion analysis system.

Step 4: Have ten potential patients evaluate doctors' facial expressions on 3-point scale (1: appropriate, 2: neutral, 3: inappropriate).

Figure 7. Role-playing patient being auscultated.

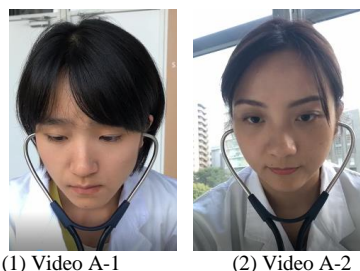(1) Video A-1   (2) Video A-2

Figure 8.   Medical students performing auscultation.

TABLE XV.   COMPUTER ANALYSIS RESULTS FOR VIDEO A-1.

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:00.6	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.96
00:01.1	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.97
00:01.6	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.93
00:02.1	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.98
00:02.6	0.01	0.00	0.00	0.00	0.00	0.00	0.01	0.98
00:03.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:03.6	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.99
00:04.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:04.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:05.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:05.6	0.12	0.01	0.01	0.00	0.00	0.04	0.00	0.81
00:05.6	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.98
00:06.2	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.97
00:06.7	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:07.3	0.01	0.00	0.00	0.00	0.00	0.01	0.00	0.98
00:07.8	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.93

TABLE XVI.   COMPUTER ANALYSIS RESULTS FOR VIDEO A-2.

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.00	0.03	0.00	0.00	0.00	0.04	0.00	0.92
00:00.6	0.00	0.03	0.01	0.00	0.00	0.01	0.00	0.94
00:01.1	0.00	0.03	0.02	0.00	0.00	0.01	0.00	0.94
00:01.6	0.00	0.03	0.01	0.00	0.00	0.01	0.00	0.94
00:02.1	0.00	0.03	0.01	0.00	0.00	0.02	0.00	0.94
00:02.6	0.00	0.06	0.01	0.00	0.00	0.02	0.00	0.91
00:03.2	0.00	0.07	0.02	0.00	0.00	0.01	0.00	0.90
00:03.7	0.00	0.03	0.03	0.00	0.00	0.04	0.00	0.90
00:04.2	0.00	0.01	0.05	0.00	0.00	0.05	0.00	0.89
00:04.7	0.00	0.01	0.04	0.00	0.00	0.03	0.00	0.91
00:05.2	0.00	0.02	0.02	0.00	0.00	0.03	0.00	0.91
00:05.7	0.00	0.02	0.03	0.00	0.00	0.02	0.00	0.92
00:06.2	0.00	0.02	0.02	0.00	0.00	0.03	0.00	0.93
00:06.7	0.00	0.01	0.03	0.00	0.00	0.02	0.00	0.93
00:07.3	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.96
00:07.7	0.00	0.00	0.01	0.00	0.00	0.03	0.00	0.96
00:08.3	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.94

TABLE XVII.   RESULTS OF SUBJECTIVE EVALUATION.

Video-ID	Score			avg.
	1	2	3	
A-1	10	0	0	1.0
A-2	9	1	0	1.1

As shown in Tables XV and XVI, the results of the facial expression emotion analysis were mostly "neutral." As shown in Table XVII, the potential patients felt that the facial expressions in Figure 8 were appropriate.

The potential patients felt that the facial expressions in the two videos were mainly "neutral," meaning that they felt that the doctor was performing the auscultation in a serious manner.

VI.   GENDER AND AGE-SPECIFIC DIFFERENCES AMONG EVALUATORS

To investigate the difference in evaluation by gender and age of the evaluator, we made videos of a man and a woman playing the role of a doctor and producing expressions in accordance with the findings reported above.

A.   Video creation of model doctors

As described in the previous section, acceptable expressions were identified for four situations. For patients who feel physically healthy, the most acceptable facial expression is "continuous happiness" (expressed more as a laugh rather than simply a smile). For patients without a facial expression, the most acceptable facial expression is initially "happiness" (expressed as a smile) and then "neutral" (without expression). For patients feeling ill and suffering pain, the most acceptable facial expression is "neutral" with a little "sadness" or "surprise." For patients being auscultated, the most acceptable facial expression is "continuous neutral" (expressed as serious). We recorded video of the two "doctors" as they produced these expressions (Figures 9–12).
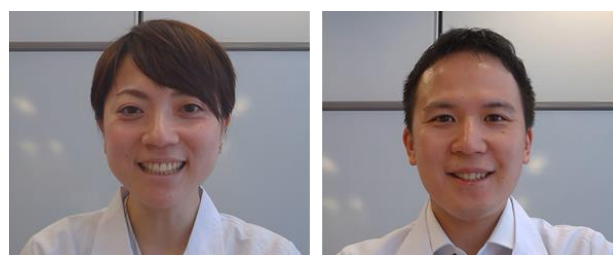
(1) Female "doctor"   (2) Male "doctor"

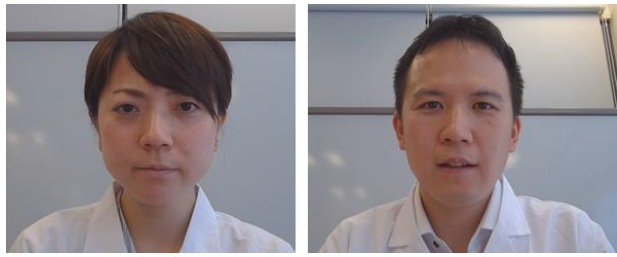Figure 9.   Appropriate facial expressions for bright patiets.

(1) Female "doctor" (start)   (2) Female "doctor" (half-way)

(3) Male "doctor" (start)   (4) Male "doctor" (half-way)

Figure 10. Appropriate facial expressions for expressionless patiets.

(1) Female "doctor"   (2) Male "doctor"

Figure 11. Appropriate facial expressions for patiets in pain.

(1) Female "doctor"   (2) Male "doctor"

Figure 12. Appropriate facial expressions for auscultation.

We showed the videos without sound to 32 men and 47 women (average age 46.7), as detailed in Table XVIII. We asked these evaluators to judge whether the doctor's facial expression was appropriate for the situation on a 3-point scale ("1: appropriate," "2: neutral," "3: inappropriate").

TABLE XVIII.   BREAKDOWN OF EVALUATORS

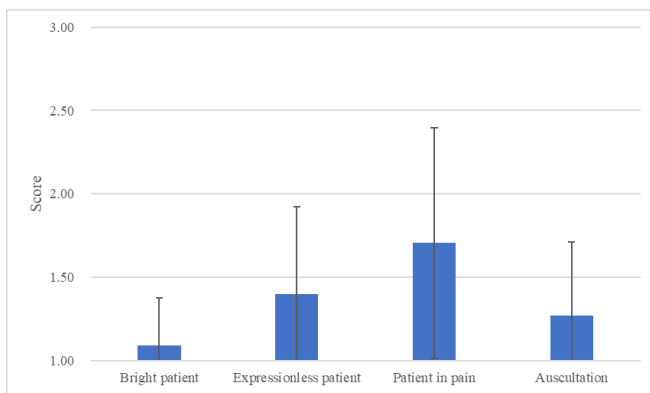|	20s	30s	40s	50s	60s	70s	Total
Female	7	5	6	11	10	8	47
Male	11	7	5	5	2	2	32
Total	18	12	11	16	12	10	79

Figure 13. Average score and standard deviation for each condition.

We also asked them to comment on anything they felt or noticed. We showed the videos without sound so that they would focus their attention on the facial expressions. As shown in Figure 13, the expressions for the "bright patient" were judged to be the most appropriate while those for the "patient in pain" were judged to be the most inappropriate. This latter result may be because the "patients" produced a variety of facial expressions for the "patient in pain" situation. This is consistent with the results of the first experiment, in which facial expressions appropriate for doctors were identified (Table I).

B.   Differences in evaluation by gender

Looking at the evaluation results in Figure 14 for the "bright patient" by evaluator gender, we see that there was little difference between the male and female evaluators. None of the evaluators gave a score of 3 ("inappropriate") while 91.5% of the female evaluators and 90.3% of the male evaluators gave a score of 1 ("appropriate").

The expressions for the "expressionless patient" were judged quite differently: 71.0% of the male evaluators and 56.4% of the female evaluators gave a score of 1 ("appropriate"), 42.6% of the female evaluators and 25.8% of the male evaluators gave a score of 2 ("neutral"), and 1.1% of the female evaluators and 3.2% of the male evaluators gave a score of 3 ("inappropriate"). In short, the female evaluators were more critical in their evaluations, which conforms to the results of previous studies showing that women are better at reading facial expressions [26]–[30].

The expressions for the "patient in pain" were also judged quite differently, with the female evaluators again being more critical: 56.5% of the male evaluators and 34.0% of the female evaluators gave a score of 1 ("appropriate"), 51.1% of the female evaluators and 32.3% of the male evaluators gave a score of 2 ("neutral)," and 14.9% of the female evaluators and 11.3% of the male evaluators gave a score of 3 ("inappropriate"). These results also conform to the results of previous studies showing that women are better at reading facial expressions [26]–[30].

The expressions for "Auscultation" were judged a bit differently, with the male evaluators being slightly more critical. None of the evaluators gave a score of 3 ("inappropriate"; 76.0% of the female evaluators and 70.7% of the male evaluators gave a score of 1 ("appropriate"). This difference by gender is within an acceptable error range.

These results totally indicate that women are more likely to be sensitive to facial expressions than men.

C.   Differences in evaluation by age

The average evaluation scores by evaluator age are plotted in Figures 15–22. The number of evaluators in each age group is shown in Table XVIII.

For the "bright patient," while there was some variance by age, the male and female evaluators of all ages mostly gave scores of 1 ("appropriate"). Therefore, evaluator age had little effect on the score for the "bright patient."

For the "expressionless patient," the female evaluators were somewhat critical overall. Although there was some

variation by age, it is hard to assign a reason for this due to the small number of evaluators in each age group.

For the "patient in pain," there was a tendency for the individual differences for both the male and female evaluators to be critical. The evaluators in their 20s tended to give better scores (average score of 1.33 vs. overall average score of 1.75). This may be because patients in their 20s are less concerned with a doctor's facial expression, as reflected in the comment from one of the evaluators in the 20s group: "I have never minded the doctor's facial expression."

For "Auscultation," the male and female evaluators in their 30s were more critical (average score of 1.64 vs. overall average score of 1.28). They were also more critical for the "expressionless patient" (average score of 1.71 vs. overall average score of 1.41).

These results indicate that age was not an important factor in the evaluations; however, we plan to investigate this further in experiments using more evaluators.
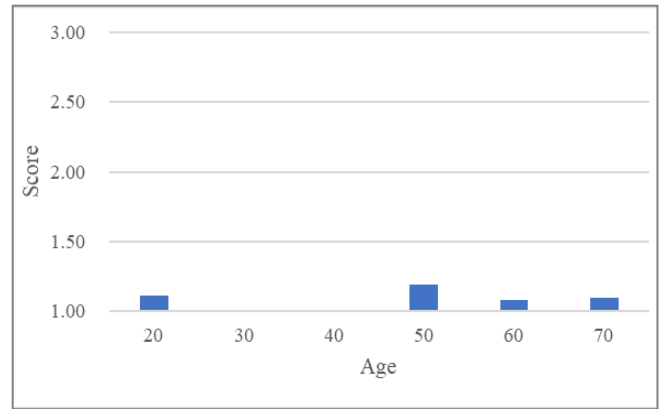

Figure 16. Average scores by age for female evaluators for "bright patient."
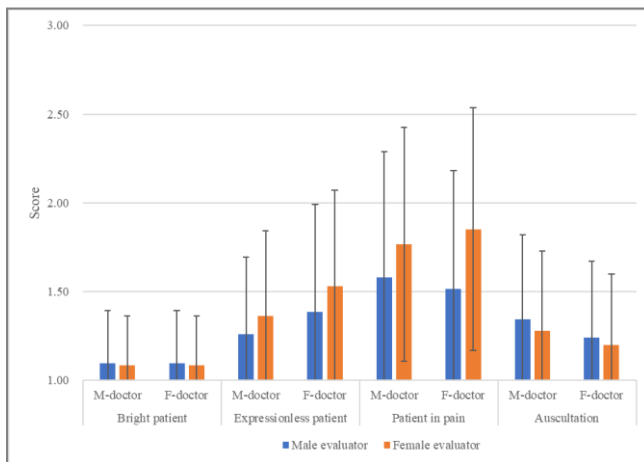

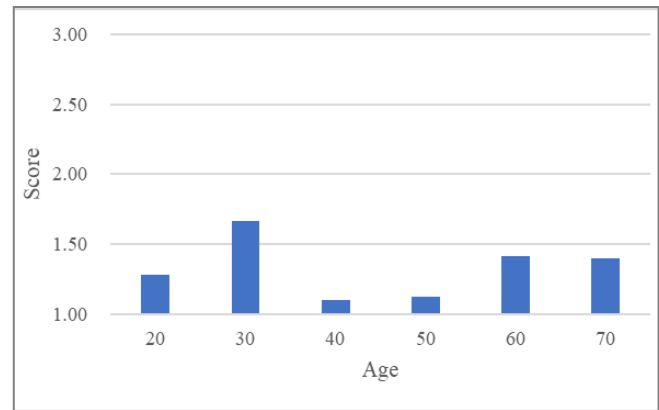Figure 14. Average evaluation scores and standard deviation by gender.

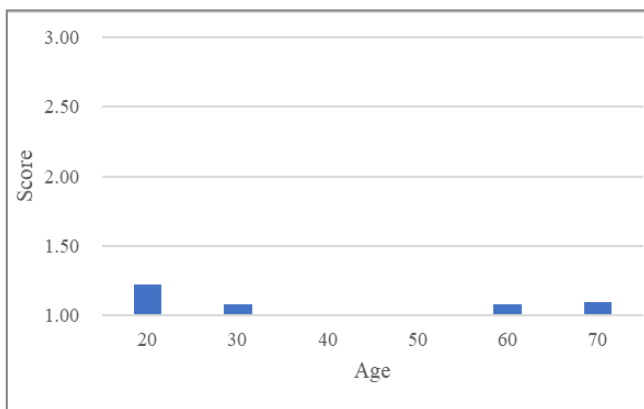Figure 17. Average scores by age for male evaluators for "expressionless patient.

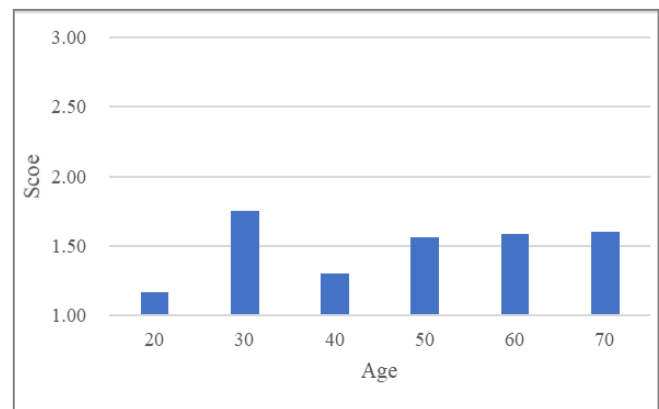Figure 15. Average scores by age for male evaluators for "bright patient."

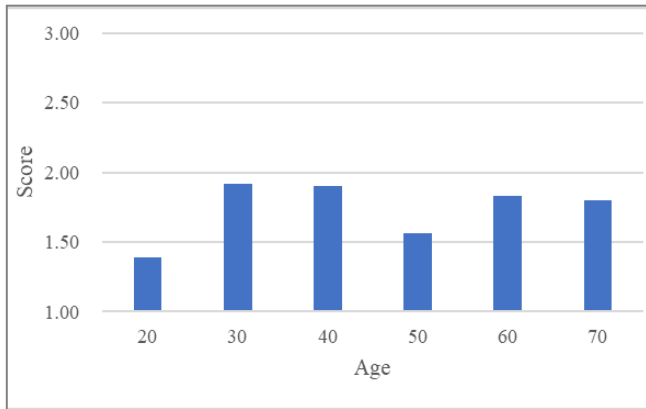Figure 18. Average scores by age for female evaluators for "expressionless patient."

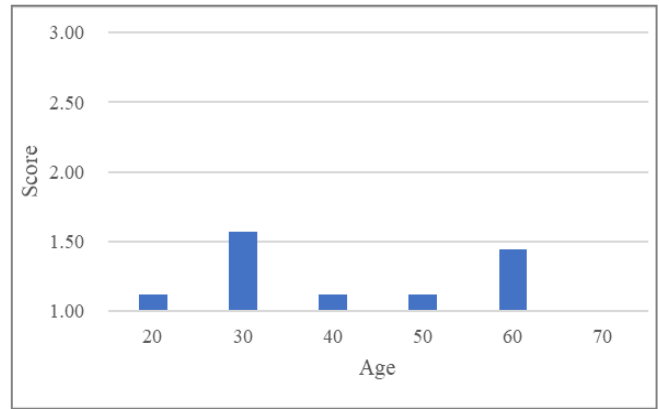Figure 19. Average scores by age for male evaluators for "patient in pain."

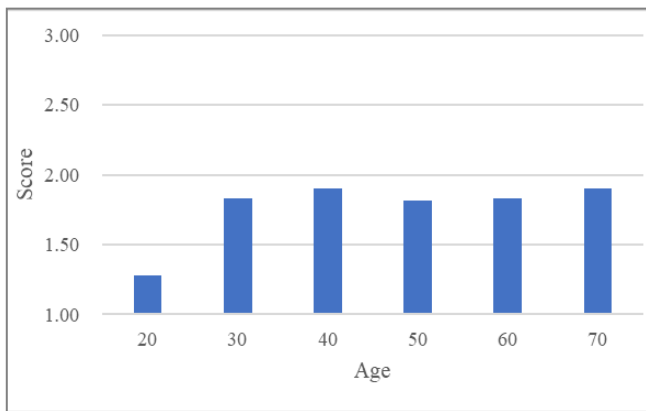Figure 22. Average scores by age for female evaluators for "Ausculation."

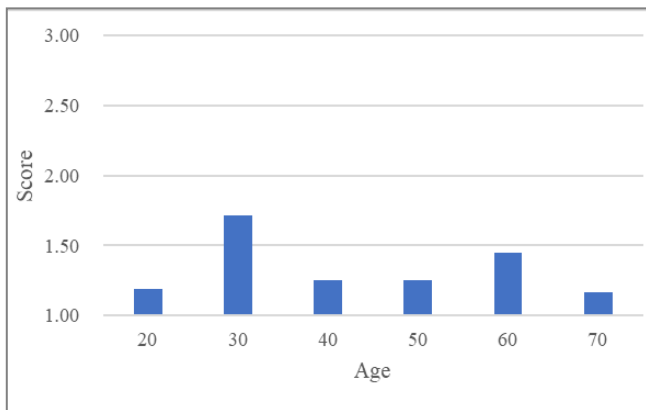Figure 20. Average scores by age for female evaluators for "patient in pain."

Figure 21. Average scores by age for male evaluators for "Ausculation."

VII.   PEDIATRICIAN'S FACIAL EXPRESSIONS

The expressions appropriate for pediatric patients likely differ from ones appropriate for adult patientss. Due to an influenza outbreak, we were able to get cooperation from only two doctors in this part of our study. We used our computer-aided facial expression emotion analysis system to analyze the facial expressions they produced when shown photographs of pediatric patients in three different conditions.

A.   Experimental procedure

To identify facial expressions appropriate for greeting hospitalized pediatric patients in the same three conditions described above ("bright patient," "expressionless patient," and "patient in pain"), we used the following procedure.

Step 1: We photographed role-playing pediatric patients as they produced expressions for each of the conditions. (The photographs of the 8-year-olds are not included here for privacy reasons.)

Step 2: We recorded video of the two doctors as they produced facial expressions they thought appropriate for each photograph.

Step 3: We analyzed the emotion shown by their expressions by using computer-aided facial expression emotion analysis.

B.   Results

The results of the facial expression emotion analysis for the two pediatricians are shown in Tables XIX–XXI.

For the "bright patient," the appropriate facial expression for adult patients was "happiness" while the pediatricians produced expressions covering both "happiness" and "neutral," which created a pleasant smiley feeling.

For the "expressionless patient," the appropriate expressions for adult patients were first "happiness" and then "neutral," whereas the pediatricians produced "neutral" expressions.

For the "patient in pain," the appropriate facial expression for adult patients was "neutral," whereas the pediatricians first produced a "neutral" expression and then a "happiness" expression. Thus, for pediatric patients with a

bright expression, the pediatricians greet them with a natural expression. For expressionless pediatric patients, they are expressionless, like the patient. Unlike doctors for adults, the most important facial expression for pediatric physicians was found to be the final encouraging smile as part of speaking naturally to pediatric patients in pain.

TABLE XIX. COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS' FACIAL EXPRESSIONS FOR "BRIGHT PATIENT"

(1) PEDIATRICIAN_1

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.0	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.96
00:00.5	0.12	0.00	0.02	0.01	0.00	0.02	0.01	0.83
00:01.0	0.12	0.00	0.03	0.00	0.00	0.00	0.00	0.84
00:01.5	0.54	0.00	0.01	0.00	0.00	0.00	0.01	0.43
00:02.0	0.58	0.00	0.02	0.01	0.00	0.01	0.01	0.36
00:02.5	0.06	0.00	0.01	0.00	0.00	0.01	0.02	0.90
00:03.0	0.08	0.00	0.01	0.00	0.00	0.01	0.02	0.87
00:03.5	0.15	0.00	0.01	0.00	0.00	0.01	0.01	0.82
00:04.0	0.49	0.00	0.01	0.01	0.00	0.01	0.01	0.48
00:04.5	0.60	0.00	0.01	0.00	0.00	0.00	0.01	0.37
00:05.0	0.15	0.00	0.07	0.01	0.00	0.01	0.02	0.75
00:05.5	0.24	0.00	0.01	0.00	0.00	0.00	0.01	0.74
00:06.0	0.37	0.00	0.01	0.00	0.00	0.01	0.00	0.60

(2) PEDIATRICIAN_2

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.5	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.98
00:00.9	0.06	0.00	0.01	0.00	0.00	0.00	0.31	0.61
00:01.5	0.03	0.01	0.02	0.01	0.00	0.02	0.05	0.85
00:02.1	0.22	0.00	0.05	0.01	0.00	0.02	0.01	0.69
00:02.6	0.30	0.00	0.02	0.01	0.00	0.01	0.00	0.67
00:00.0	0.00	0.00	0.01	0.02	0.00	0.19	0.01	0.78
00:03.1	0.30	0.00	0.01	0.00	0.00	0.00	0.01	0.68
00:03.6	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50

TABLE XX. COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS' FACIAL EXPRESSIONS FOR "EXPRESSIONLESS PATIENT"

(1) PEDIATRICIAN_1

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.96
00:00.6	0.08	0.00	0.01	0.00	0.00	0.00	0.00	0.91
00:01.1	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.92
00:01.6	0.03	0.00	0.01	0.00	0.00	0.01	0.00	0.95
00:02.1	0.04	0.00	0.00	0.00	0.00	0.02	0.01	0.92
00:02.6	0.02	0.00	0.01	0.00	0.00	0.01	0.00	0.96
00:03.1	0.11	0.00	0.01	0.00	0.00	0.01	0.01	0.87
00:03.6	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.93
00:04.1	0.10	0.00	0.01	0.00	0.00	0.01	0.02	0.85
00:04.6	0.10	0.00	0.00	0.00	0.00	0.01	0.02	0.86
00:05.1	0.10	0.00	0.01	0.00	0.00	0.00	0.01	0.87
00:05.6	0.04	0.00	0.01	0.01	0.00	0.04	0.01	0.88
00:06.1	0.06	0.00	0.01	0.00	0.00	0.01	0.01	0.90

(2) PEDIATRICIAN_2

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.05	0.00	0.01	0.00	0.00	0.01	0.00	0.93
00:00.6	0.07	0.00	0.01	0.00	0.00	0.01	0.00	0.92
00:01.1	0.06	0.00	0.01	0.01	0.00	0.01	0.01	0.90
00:01.6	0.01	0.00	0.01	0.00	0.00	0.04	0.01	0.92
00:02.1	0.02	0.00	0.01	0.00	0.00	0.02	0.01	0.93
00:02.7	0.01	0.00	0.01	0.00	0.00	0.04	0.01	0.93
00:03.3	0.02	0.01	0.01	0.02	0.00	0.03	0.01	0.89
00:03.7	0.00	0.01	0.03	0.03	0.00	0.12	0.01	0.81
00:04.2	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.98

TABLE XXI. COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS' FACIAL EXPRESSIONS FOR "PATIENT IN PAIN"

(1) PEDIATRICIAN_1

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.0	0.08	0.00	0.01	0.00	0.00	0.01	0.01	0.90
00:00.5	0.02	0.00	0.00	0.00	0.00	0.01	0.00	0.97
00:01.0	0.05	0.00	0.01	0.00	0.00	0.01	0.01	0.93
00:01.5	0.05	0.00	0.01	0.01	0.00	0.01	0.01	0.93
00:02.0	0.04	0.00	0.03	0.00	0.00	0.00	0.01	0.92
00:02.5	0.08	0.00	0.01	0.00	0.00	0.00	0.01	0.90
00:03.0	0.26	0.00	0.02	0.01	0.00	0.02	0.01	0.69
00:03.5	0.17	0.00	0.01	0.00	0.00	0.01	0.01	0.80
00:04.0	0.45	0.00	0.02	0.01	0.00	0.00	0.00	0.52
00:04.5	0.50	0.00	0.01	0.01	0.00	0.00	0.00	0.47
00:05.0	0.53	0.00	0.01	0.01	0.00	0.00	0.00	0.44
00:05.5	0.65	0.00	0.01	0.01	0.00	0.00	0.00	0.32
00:06.0	0.43	0.00	0.02	0.01	0.00	0.01	0.01	0.52
00:06.0	0.45	0.00	0.03	0.02	0.00	0.02	0.00	0.48

(2) PEDIATRICIAN_2

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99
00:00.6	0.03	0.01	0.01	0.01	0.00	0.01	0.13	0.80
00:01.1	0.29	0.00	0.04	0.00	0.00	0.00	0.00	0.66
00:01.6	0.01	0.01	0.07	0.03	0.00	0.06	0.03	0.79
00:02.2	0.02	0.00	0.01	0.01	0.00	0.01	0.02	0.94
00:02.7	0.03	0.00	0.01	0.01	0.00	0.06	0.00	0.88
00:03.3	0.25	0.00	0.01	0.00	0.00	0.00	0.01	0.73
00:03.8	0.07	0.00	0.03	0.00	0.00	0.04	0.00	0.86
00:04.3	0.21	0.00	0.01	0.00	0.00	0.00	0.00	0.76
00:04.8	0.10	0.00	0.04	0.01	0.00	0.03	0.00	0.82
00:05.4	0.83	0.00	0.01	0.00	0.00	0.08	0.00	0.09
00:06.0	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.07
00:06.5	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.02

VIII. CONCLUSION

Our quantitative analysis of medical student facial expressions when greeting an adult patient to be medically evaluated in the general ward of a hospital revealed acceptable facial expressions. For patients who feel physically healthy, the most acceptable facial expression is "continuous happiness" (expressed more as a laugh than simply as a smile). For patients without a facial expression, the most acceptable facial expression is initially "happiness" (expressed as a smile) and then "neutral" (without expression). For patients suffering pain, the most acceptable facial expression is "neutral" with a little "sadness" or "surprise." During auscultation, the most acceptable facial expression is always "neutral."

There was no significant difference in facial expression required by the doctor depending on the gender and age of the patient.

Analysis of the facial expressions produced by two pediatricians showed that they produced expressions covering both "happiness" and "neutral" when greeting pediatric patients who had a bright expression and produced a neutral expression when greeting expressionless pediatric patients. Most importantly, they need to encourage pediatric patients in pain by ending with a smile.

Although appropriate facial expressions may differ between doctors in different countries due to cultural differences, we believe that the proposed method for identifying appropriate facial expressions is useful in any country.

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