

## Facial-Expression Training Application 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 the important factors in building and maintaining a relationship is whether the doctor produces facial expressions appropriate for the patient’s condition. We developed a facial-expression training application for medical students and tested its effectiveness as a training tool. In this application, the Microsoft Cognitive Services Emotion API is used to analyze the patient’s facial expression. Prior to developing this application, we studied what kind of facial expressions were appropriate for a doctor greeting or treating an adult patient. We focused on four situations. Three of them are greeting situations when a doctor begins a patient interview in the general ward of a hospital. The fourth is when a doctor examines a patient by placing a stethoscope to a patient’s chest, i.e., auscultation. We also identified appropriate facial expressions for doctors treating pediatric patients. To verify the training application’s effectiveness, the facial expressions before and after learning with the application were evaluated by potential patients or mothers of potential pediatric patients. The results demonstrated the application’s utility.

**Keywords**—*doctor-patient interaction; facial expression; nonverbal communication; facial-expression training application.*

### I. INTRODUCTION

We study facial expressions appropriate for young medical doctors and develop facial-expression training applications for medical students, one of which was presented at eTELEMED 2019 [1]. We have also identified appropriate facial expressions for when a doctor greets a patient at the beginning of a medical interview in the general ward of a hospital [2].

Patient satisfaction is an important component of medical care [3]. Improving patient satisfaction enhances trust and the relationship between patient and doctor, which leads to stronger adherence to prescribed protocol, such as taking medicine, and to enhanced therapeutic effects [4][5]. Many studies and reviews have shown that the main determinant of patient satisfaction is the patient-doctor relationship [6]–[10] and that patient satisfaction is higher when the patient communicates with a doctor who has strong nonverbal-communication skills [11][12]. However, young inexperienced 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 angry.

In response to these complaints, we developed a facial-expression training application that physicians can use for independent study. In this application, the Microsoft Cognitive Services Emotion API is used to analyze the doctor’s facial expression. This application uses the results of our study on acceptable expressions for doctors as model doctor expressions [2]. These model expressions are standards to compare with those of learners using the application. To verify the effectiveness of the application, learners’ facial expressions before and after learning with the application were evaluated by potential patients. The evaluation results confirmed the utility of the application.

After introducing related work in Section II, acceptable expressions required for doctors are explained in Section III. The system of the facial-expression training application is introduced in Section IV. We discuss the results of our experiments in Section V. Section VI gives our conclusion, and Section VII considers future work.

### II. RELATED WORK

This study focuses on facial expressions, we review research on nonverbal communication and research related to learning facial expressions.

#### A. Nonverbal Communication

Medical interviews have traditionally focused on gathering relevant information from patients [13]. In contemporary medicine, 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; this requires the doctor to have a wide range of communication skills [14]. These skills include “looking at a patient not as a case but as a human being” [15] and “building and maintaining a good relationship between doctor and patient” [16]. 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, and the advice and instructions given. In particular, a patient’s satisfaction is positively related to the doctor being warm [15]–[17], empathic [15][17]–[19], friendly [17], and giving the impression of being human [18].

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

### B. Learning Facial Expressions

Natural, unconscious facial expressions can be seen in humans from infancy [21], but eventually conscious expressions appear. Conscious expressions might also be thought of as “false” expressions. These expressions are skills that form the basis of more complicated expressive behaviors, such as emotional expressions performed in accordance with rules in communication situations [22].

Facial expressions as expressions of emotion are thought to be founded in an understanding of emotions, and there are many developmental studies about understanding emotions. However, studies about learning facial expressions are mostly focused on social-skills training for children with developmental disabilities, and there are not many studies for adults.

In one study, participants were required to express other people's facial expressions by recalling emotions and showing photos of faces with emotions, the showing photos effect was shown about “anger” [23].

In research to develop a smile-training system with the goal of training participants to produce celebrity-like smiles (a facial expression recognized as attractive) [24], researchers created a smile-fitted deformation considering the characteristics of a celebrity-like smile in participants' expressionless faces. As a result of training, participants were able to express a smile highly likely to be recognized as attractive by others.

From the above, it is clear that presenting appropriate facial-expression images is effective for facial-expression training as both a method of expressing emotions and a learning method.

## III. ACCEPTABLE FACIAL EXPRESSIONS

The most acceptable facial expressions for doctors when they greet adult patients at the beginning of a medical interview and when auscultating adult patients in the general ward of a hospital were identified. Because the requirements when treating children are quite different from those when treating adults, the most appropriate facial expressions for three types of pediatric patients were also identified.

### A. Acceptable Facial Expression for Adult Patients

A previous study [2] has revealed what are considered acceptable facial expressions for a doctor in accordance with the patient's condition. One way to analyze appropriate facial expressions for doctors is to define the facial expressions of experienced doctors. However, their facial expressions are not always deemed appropriate. Also, because many young physicians have trouble presenting appropriate facial expressions when greeting a patient, we chose to find facial expressions that would be acceptable for most patients,

including potential patients, from facial expressions that medical students think are suitable. We chose greeting patients in the general ward of a hospital as the target situation.

The procedure was as follows. The participant role-playing the patient portrayed three conditions, as shown in Figure 1: 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”). We photographed these role-played conditions. Then, a plurality of medical students greeted the three photographs with the facial expressions that each student deemed appropriate, and we recorded video of them doing so. Although evaluation by actual patients is best, it would have been difficult to request their participation. We asked generally healthy adults who been hospitalized in the past or would be in the future to evaluate the videos. 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 (Tables I and II).

Comparing an evaluation by adults and analytical results from a computer of the medical student's greeting movies revealed what were considered the acceptable facial expressions in accordance with the patient's condition.



Figure 1. Conditions portrayed by role-playing adult patient.

The acceptable facial expressions when a young doctor greets an adult patient who is hospitalized in a general ward are as follows;

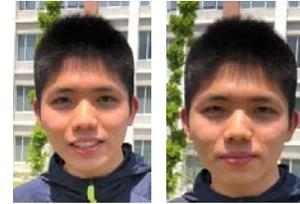
- For patients who feel physically healthy, the most acceptable facial expression is Figure 2: “continuous happiness” (expressed more as a laugh rather than simply a smile).
- For patients without a facial expression, the most acceptable facial expression is Figure 3: initially “happiness” (expressed as a smile) and then “neutrality” (expressionlessness).
- For patients in bad physical condition suffering pain, the most acceptable facial expression is Figure 4: “neutrality” with a little “sadness” or “surprise.”

The cells in Figures 2–4 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. The total for all emotions is 1, and the value for neutrality is obtained by subtracting the total value for the seven emotions from 1.

TABLE I. RESULTS OF FIRST SUBJECTIVE EVALUATION

Video-ID	Score															
	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	3	1	2	3	2	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	3	2	3	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	4	2	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

F=female M=male



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

Figure 3. Acceptable facial expression for adult patients without a facial expression.



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	0.68
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

Figure 4. Acceptable facial expression for adult patients in bad physical condition suffering pain.

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



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

Figure 2. Acceptable facial expression for adult patients who feel physically healthy.

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 5).
- Step 2: Record videos of two medical doctors producing facial expressions they thought appropriate for the patient (Figure 6).
- 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).

As shown in Tables III and IV, the results of the facial-expression-emotion analysis are mostly "neutral." As shown in Table V, the potential patients feel that the facial expressions in Figure 6 are appropriate. The potential

patients feel that the facial expressions in the two videos are mainly "neutral," meaning that they feel that the doctor is performing the auscultation in a serious manner.



Figure 5. Role-playing patient being auscultated.



Figure 6. Medical students performing auscultation.

TABLE III. 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 IV. 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 V. 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

B. Acceptable Facial Expression for Pediatric Patients

The expressions appropriate for pediatric patients likely differ from ones appropriate for adult patients. We were able to get cooperation from seven doctors in this part of our study (Table VI). 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.

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: Take photograph of a role-playing pediatric patient (8-year-old) as she produced expressions for each of the conditions (Figure 7).
- Step 2: Record video of the seven doctors as they produced facial expressions they thought appropriate for each photograph.
- Step 3: Analyzed the emotion shown by their expressions by using computer-aided facial-expression-emotion analysis.
- Step 4: Have evaluation from eleven mothers who has children.

Although the evaluation by children is best, it would have been difficult to request them. We asked mothers who have children.

The results of computer analysis were used to divide the facial expressions of seven pediatricians into three groups.

- Group 1 (Pediatricians 1, 2, 4): for bright pediatric patients who feel physically healthy—"continuous happiness" (expressed with a bright smile). For pediatric patients without a facial expression—"neutral" (expressionlessness). For pediatric patients in bad physical condition suffering pain—"neutral" with a little "surprise" (expressed with a pained expression).

TABLE VI. PROFILES OF PEDIATRICIANS.

	Age	Gender	Number of Years of Experience
Pediatrician 1	30	F	2
Pediatrician 2	33	F	5
Pediatrician 3	35	M	6
Pediatrician 4	39	F	11
Pediatrician 5	40	M	15
Pediatrician 6	55	M	29
Pediatrician 7	64	M	39



Figure 7. Conditions portrayed by role-playing pediatric patient.

- Group 2 (Pediatricians 3, 5): for bright pediatric patients—“neutral and happiness” (expressed with a natural smile). For pediatric patients without a facial expression—“neutral” (expressionlessness). For pediatric patients in bad physical condition suffering pain—initially “neutral” (expressionlessness) and then “happiness” (expressed with a smile).

- Group 3 (Pediatricians 6, 7); for bright pediatric patients—“happiness” (expressed with a natural smile). For pediatric patients without a facial expression—almost “happiness” (expressed with a smile). For pediatric patients in bad physical condition suffering pain—initially “neutral” (expressionlessness) and then “happiness” (expressed with an encouraging smile).

The facial expressions of Pediatrician 4 (Tables VII–IX), Pediatrician 5 (Tables X–XII), and Pediatrician 6 (Tables XIII–XV) were selected as representative ones for the corresponding groups.

TABLE VII. GROUP 1 (PEDIATRICIAN 4): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “BRIGHT PATIENT”

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.71	0.00	0.00	0.00	0.00	0.01	0.00	0.28
00:02.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:01.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:04.2	0.93	0.00	0.00	0.00	0.00	0.00	0.00	0.07
00:03.2	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.04

TABLE VIII. GROUP 1 (PEDIATRICIAN 4): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “EXPRESSIONLESS PATIENT”

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.1	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.91
00:01.2	0.15	0.00	0.00	0.00	0.00	0.00	0.01	0.83
00:02.2	0.92	0.00	0.00	0.00	0.00	0.00	0.01	0.07
00:03.2	0.16	0.00	0.00	0.00	0.00	0.00	0.28	0.56
00:04.3	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.96

TABLE IX. GROUP 1 (PEDIATRICIAN 4): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “PATIENT IN PAIN”

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:01.2	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.51
00:02.2	0.00	0.00	0.01	0.00	0.00	0.01	0.02	0.97
00:03.2	0.02	0.00	0.00	0.00	0.00	0.01	0.14	0.82
00:00.1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.99
00:04.2	0.17	0.00	0.00	0.00	0.00	0.00	0.30	0.52
00:05.2	0.01	0.00	0.00	0.00	0.00	0.00	0.03	0.96

TABLE X. GROUP 2 (PEDIATRICIAN 5): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “BRIGHT PATIENT”

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.5	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.98
00:00.9	0.06	0.00	0.01	0.00	0.00	0.01	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	0.00	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 XI. GROUP 2 (PEDIATRICIAN 5): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “EXPRESSIONLESS PATIENT”

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	0.00	0.81
00:04.2	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.98

TABLE XII. GROUP 2 (PEDIATRICIAN 5): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS 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	0.00	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

TABLE XIII. GROUP 3 (PEDIATRICIAN 6): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “BRIGHT PATIENT”

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.4	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.55
00:01.1	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.20
00:01.8	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.23
00:02.4	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:04.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:05.2	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE XIV. GROUP 3 (PEDIATRICIAN 6): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS’ FACIAL EXPRESSIONS FOR “EXPRESSIONLESS PATIENT”

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.4	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.68
00:01.1	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.40
00:01.8	0.96	0.00	0.01	0.00	0.00	0.00	0.00	0.03
00:02.5	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.03
00:03.1	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:03.8	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
00:04.5	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

TABLE XV. GROUP 3 (PEDIATRICIAN 6): COMPUTER ANALYSIS RESULTS FOR PEDIATRICIANS' FACIAL EXPRESSIONS FOR "PATIENT IN PAIN"

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.4	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.69
00:01.1	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.81
00:01.7	0.65	0.00	0.00	0.00	0.00	0.00	0.00	0.35
00:02.4	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.14
00:03.0	0.92	0.00	0.00	0.00	0.00	0.00	0.00	0.08
00:03.7	0.98	0.00	0.00	0.00	0.00	0.00	0.00	0.02
00:04.3	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

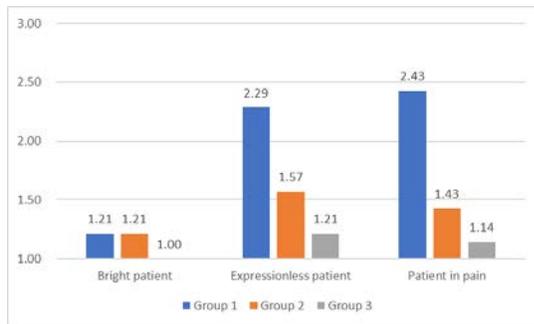


Figure 8. Average score for each condition.

The appropriateness of those expressions was evaluated by 14 mothers who had children between the ages of 2 and 12. They did this by watching videos of the expressions and scoring them on a scale (1: appropriate, 2: neutral, 3: inappropriate).

As shown in Figure 8, the representative facial expressions for the Group 3 pediatricians were evaluated overall as the most appropriate for pediatric patients. As shown in Table VI, the doctor who made the expressions had 29 years of experience. The expressions are shown in Figures 9–11.

For bright pediatric patients, the average score was good for all three groups. The most appropriate facial expression was the same as that for adult patients, a bright smile expressing “happiness.” For pediatric patients without a facial expression, a smile held longer than for adults was the most appropriate facial expression. For pediatric patients in bad physical condition suffering pain, an initially “neutral” expression and then an encouraging smile expressing “happiness” was the most appropriate facial expression.

The biggest difference in the appropriate expression between adult and pediatric patients was for patients in bad physical condition suffering pain. As expressed by two of the mothers, if a child is feeling pain and the pediatrician has a pained expression, the child will tend to cry. Another factor is that children are more likely to be scared by something than adults. It is also possible that an expression of encouragement from the pediatrician reassures the child.

We asked an experienced pediatrician (Pediatrician 7) to describe the biggest difference between responding to adults and responding to children. He replied that adults are more often told the truth when the news is bad while it is important to give children hope of being cured. Thus the



Figure 9. Acceptable facial expression for pediatric patients who feel physically healthy.



Figure 10. Acceptable facial expression for pediatric patients without a facial expression.



Figure 11. Acceptable facial expression for pediatric patients in bad physical condition suffering pain.

appropriate facial expression for a “patient in pain” differs greatly between adults and children.

#### IV. FACIAL-EXPRESSION TRAINING APPLICATION SYSTEM

The system of the facial-expression training application is introduced in this section.

##### A. Requirements and Design Concept

Learners study in the following order so that the appropriate facial expressions can be learned efficiently and repeatedly. When starting, to enable learners to notice what their facial expressions are before training, the system has them greet with expressions that they think are suitable without any specific instructions.

Step 1: A learner chooses one of the model patients.

- Step 2: The learner greets the model patient with a facial expression that the learner thinks appropriate, and this greeting is recorded.
- Step 3: A video of the model doctor greeting the patient with the appropriate facial expression and analysis data are displayed, and important points to notice about the appropriate facial expressions are introduced.
- Step 4: The video recorded in Step 2 and its analysis data are displayed.
- Step 5: The learner repeats from Steps 2 to 4 until satisfied.
- Step 6: If the learner is satisfied, the learner selects a patient with a different condition and returns to Step 1.

In the developed system, in addition to being able to check the facial expressions the learner performed by recording them as a video, the learner can also check the quality of his or her expression on a frame-by-frame basis. Each learner can save images as learning data and facial-expression analysis results by applying security processing because these data and analysis results are important as research data.

**B. System Configuration**

We developed and used a system that quantitatively analyzes changes in facial expression. It is based on the Cognitive Services Emotion API [25] provided by Microsoft's Azure cloud service, and a facial-expression-emotion detection system for video images. Microsoft Emotion API corresponds to multiple races. 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 neutrality. The total for all emotions is 1, and the value for neutrality is obtained by subtracting the total value for the seven emotions from 1. The configuration of this application is as shown in Figure 12. A video camera is controlled by the Open CV [26]. Recorded video data are converted the Motion-JPEG, and send to the Cognitive Services Emotion API.

First, the learner selects a patient to be a training partner in Figure 13. After clicking the recording button, the learner talks to the model patient. When the greeting and consultation is over, the learner clicks the stop button followed by the next button in Figure 14.

The emotional values of the model doctor's facial expression are displayed. By selecting a timeline, the corresponding facial expression is displayed in Figure 15.

The emotional values of the learner's facial expression are displayed. By selecting a timeline, the corresponding facial expression is displayed in Figure 16.

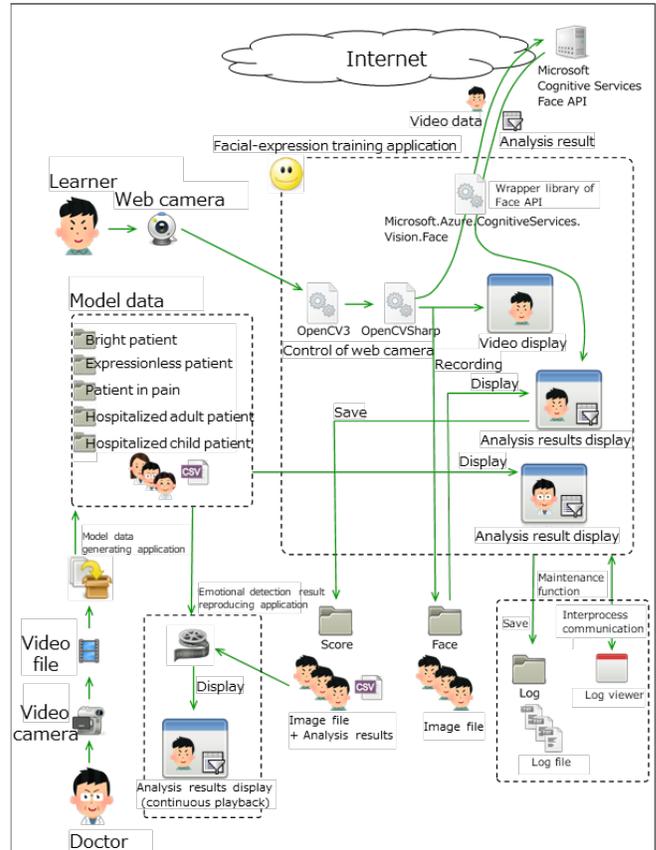


Figure 12. Configuration of facial-expression training application.

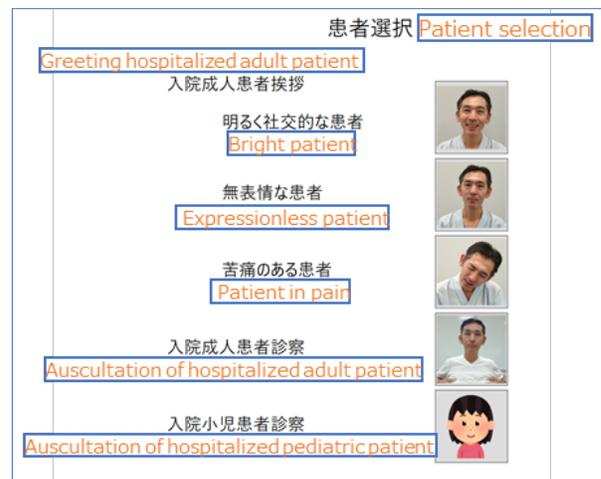


Figure 13. Step 1: Patient-selection screen.



Figure 14. Step 2: Learner greets and examines patient while screen is recorded.

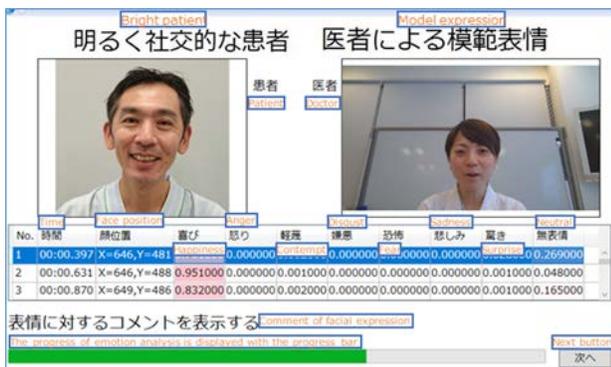


Figure 15. Step 3: Model doctor's appropriate facial expression and analysis results.

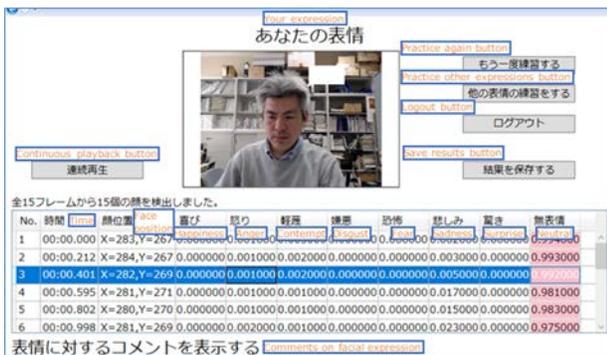


Figure 16. Step 4: Analysis of image taken in Step 2.

### C. Model Doctors

Videos of model doctors were prepared with the following procedure. In a previous study [2], the acceptable doctors' expressions for the patients were measured and selected. The model doctors (one male and one female) reproduced the acceptable facial expressions, and their reproductions were recorded as videos. Seventy-nine people evaluated these videos of Figures 17–21 and confirmed that they were appropriate, so we adopted them as the model doctor videos.



(1) Woman (2) Man

Figure 17. Model doctor's appropriate facial expression for bright patients.



(1) Woman (start) (2) Woman (half-way)  
(3) Man (start) (4) Man (half-way)

Figure 18. Model doctor's appropriate facial expression for expressionless patients.



(1) Woman (2) Man

Figure 19. Model doctor's appropriate facial expression for patients in pain.



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

Figure 20. Appropriate facial expressions for auscultation.



(1) Female “doctor” (2) Male “doctor”  
Figure 21. Appropriate facial expressions for Pediatric patient.

## V. EVALUATION

In order to examine the effect of our facial-expression training application, the facial expressions of six participants before and after practice were evaluated.

### A. Experiment

Six participants including three medical students played doctors and greeted patients with facial expressions that they thought appropriate for each condition of Figure 13. The application recorded them (before training), the participants repeated the facial-expressions training so that they could approximate the analysis results of the model doctors. After practice, we recorded their facial expressions again (after training). Although evaluation by actual patients is best, it would have been difficult to request actual patients’ participation. Hence, we asked 30 general healthy adults who had been hospitalized in the past or would be in the future. We showed the video recordings (before and after training) to 10 men and 20 women (average age 41.0 years) without sound. We asked them to judge whether the doctor’s facial expression was appropriate for the condition on a 3-point scale (1: appropriate, 2: neutral, 3: not appropriate). We asked them to also comment on anything they felt or noticed. We showed the recordings without sound because we wanted them to focus on the appropriate facial expressions in medical communication conditions, and emotion is easier to read from speech than from facial expressions.

### B. Effects of Training

The graph of Figures 22–25 showing the result of the rating before and after the training is as follows.

In order to examine the effects of training with the application, we conducted 2 (using the application: before and after)  $\times$  6 (doctors) two-way analysis of variance with the evaluation results as the dependent under four conditions. The results showed a significant difference at the 1% level under all conditions (in order from condition 1,  $F(59, 295) = 3.19, P < .01$ ;  $F(59, 295) = 4.51, P < .01$ ;  $F(59, 295) = 4.52, P < .01$ ;  $F(59, 177) = 5.26, P < .01$ ).

We consider the effectiveness of this application to have been confirmed because the evaluation scores improved with use of the application under all conditions. We also

noticed the following two points during the experiment. The first point is that the evaluation for “patients in pain” was different for each person. Most persons regarded the doctor’s serious expression as empathy and evaluated that as adequate. However, a few persons felt that the doctor’s expression caused unease and worry, and that person evaluated the expression as not adequate. Therefore, the model expressions for patients in pain may not be limited to one type. The second point is that the facial expressions practiced in the application are unnatural for a few persons. By training in the application, people playing the role of doctor created expressions close to those of the model doctor’s videos, and accordingly the evaluation score rose. However, when a facial expression that the participants learned was far from facial expressions that they always do, a few evaluators felt that the expression looked like “a pretended expression” or “artificial expression.”

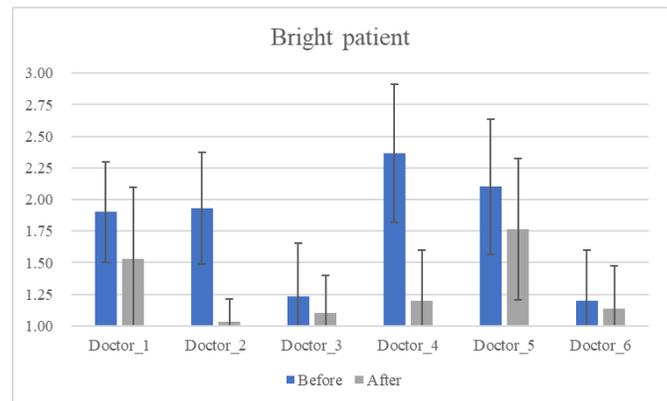


Figure 22. Average and standard deviation of each doctor’s evaluation score for bright patients.

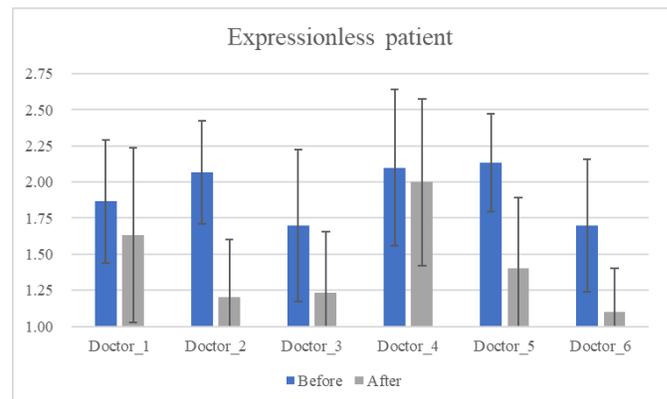


Figure 23. Average and standard deviation of each doctor’s evaluation score for expressionless patients.

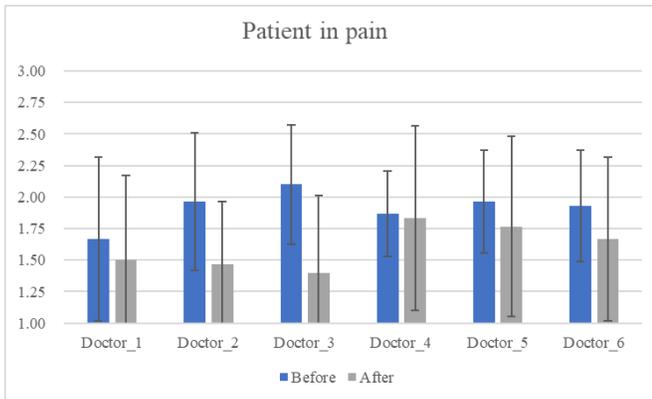


Figure 24. Average and standard deviation of each doctor's evaluation score for patients in pain.

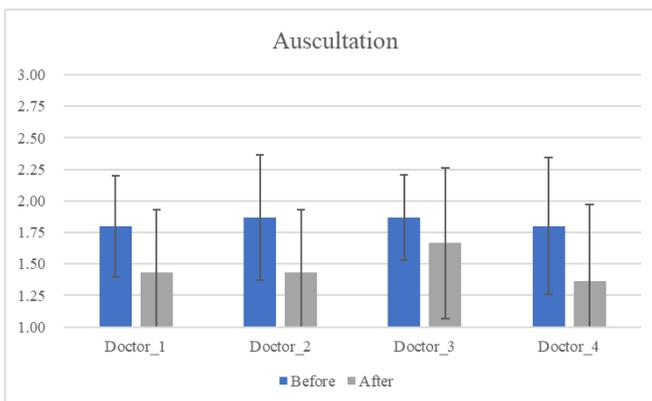


Figure 25. Average and standard deviation of each doctor's evaluation score for auscultation.

## VI. CONCLUSION

Our quantitative analysis of medical student facial expressions when greeting adult patients and pediatric patients at the beginning of a medical interview in the general ward of a hospital revealed acceptable facial expressions. For adult patients who feel physically healthy, the most acceptable facial expression is "continuous happiness" (expressed more as a laugh than simply as a smile). For pediatric patients who feel physically healthy, the most acceptable facial expression is "happiness" (a natural smile). For adult patients without a facial expression, the most acceptable facial expression is initially "happiness" (expressed as a smile) and then "neutral" (without expression). On the other hand, for pediatric patients without a facial expression, the most acceptable facial expression is almost "happiness" (expressed as a longer smile). For adult patients suffering pain, the most acceptable facial expression is "neutral" with a little "sadness" or "surprise." On the other hand, for pediatric patients suffering pain, the most acceptable facial expression is initially "neutral"

(expressionlessness) and then "happiness" (expressed as an encouraging smile).

During auscultation, the most acceptable facial expression is always "neutral."

We developed a facial-expression training application that physicians can use for independent study. Six participants practiced using this application to express appropriate facial expressions. To verify the effectiveness of this application, the facial expressions that participants made before and after training with it were evaluated by 30 people. On the basis of the results, we consider the usefulness of the facial-expression training application to be verified. We think most learners could express their facial expression naturally by practicing repeatedly.

In the future, we will improve the application so that the on-screen instructions will guide the learner's expressions more properly.

Given the importance of smiles when people interact with each other in many countries or cultures, smiles on "bright patients" in this study are expected to be widely effective.

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