

# Quantitative Analysis of Facial Expression for Medical Doctors

Akemi Oe, Yoshitoshi Murata  
 Graduate School of Software and Information Science  
 Iwate Prefectural University  
 Iwate, Japan  
 e-mails: akemioe@gmail.com, y-murata@iwate-pu.ac.jp

**Abstract**— Establishing trust between a patient and a doctor depends as much on their relationship as on the doctor's medical abilities. An important factor 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 by comparison between human evaluation and analysis of the computer emotion analysis system.

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

## I. INTRODUCTION

Patient satisfaction is an important component of medical care [1]. 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 [2][3]. Many studies and reviews have shown that the main determinant of patient satisfaction is patient-doctor relationship [4]-[8] and that patient satisfaction is higher when the patient communicates with a doctor having strong nonverbal communication ability [9][10]. However, 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 the computer emotion analysis system. We then asked potential patients to evaluate the appropriateness of the facial expressions on a five-point scale. We clarify a facial expression found according to the scene by a doctor by comparing both.

The facial expression required for a doctor may be influenced by the patient's condition, treatment scene, culture, medical department, gender. As the first step, we focused on

appropriate facial expressions of young medical doctors for greeting patients in the general ward of a hospital.

After reviewing related works in Section II, our facial expression analysis system is explained in Section III. We describe the evaluation experiment in Section IV, and analyze facial expression for recorded videos in Section V. We conclude with a summary of the key points and a mention of future work in Section VI.

## II. RELATED WORK

### A. Medical Interviews

Medical interviews have traditionally focused on gathering relevant information from patients [11]. Nowadays, the focus has expanded to building a trusting relationship, sharing decision-making, responding to the patient's emotional state, supporting actions related to the patient's condition and treatment, so the doctor must have a wider range of communication skills [12]. These skills include "looking at a patient not as a case but as a human being" [13] and "building and maintaining a good relationship between doctor and patient" [14]. 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 [13][15], empathic [13][15]-[17], and friendly [15] and giving the impression of being human [16].

"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 [9][18][19]. 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 "likes" and "dislikes," Mehrabian [20] 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 [21] 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 gestures, 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 [22] [23].

### 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 [24] 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. To realize the above functions, the developed 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 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 "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%.

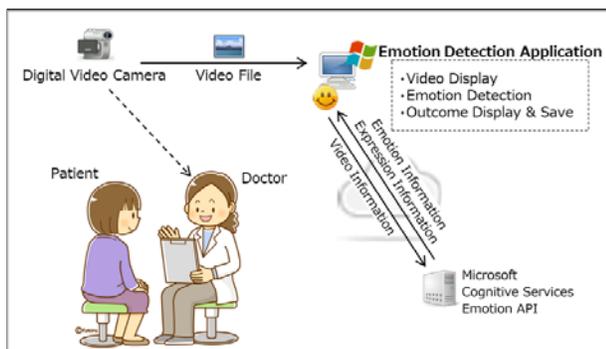


Figure 1. Configuration of video image-based emotion analysis system.

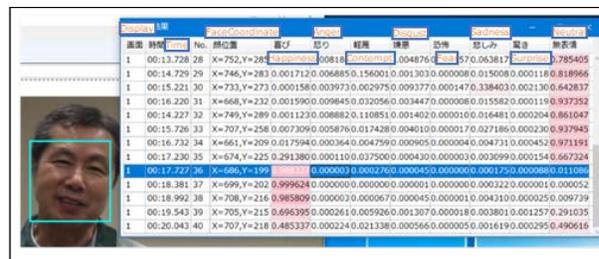


Figure 2. Detection result window.

### IV. EVALUATION EXPERIMENT

One way to analyze the facial expressions of veteran doctors would be to clarify facial expressions appropriate for doctors. However, their facial expression would not be always right. And, since 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 which medical students think suitable. This time, we targeted the situation when they greet patients in the general ward of a hospital. We videotaped their greeting for model patients to evaluate and identified appropriate facial expressions. Although evaluation by actual patients is best, it would have been difficult to request their participation. Hence, we asked general healthy adults who had hospitalization in the past or would have ones in the future. At the same time, we used computerized facial expression analysis to identify suitable facial expressions, as introduced in section III.

#### A. Experimental Conditions

1) *Doctor participants*: Seven medical students (4 females, 3 males; 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 presented to the doctor participants along with the following explanation. "The pictures 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 badly and is suffering pain. After looking at each picture, please greet the patient as a doctor for about 5 seconds or so." This process was repeated 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'



Figure 3. Conditions portrayed by role-playing patient.

previous findings. On the second day, foregoing 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 research is not to find most appropriate facial expressions, but acceptable ones for most patients. Therefore, we think not many doctors are needed as participants. In this paper, we consider the meaning of appropriate to be the same as acceptable.

**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 not at all 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 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 score of 4 or 5, these would be unacceptable values for patients, in the first evaluation, except for one score-4 recording. The 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 they 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
<b>Bright</b>																
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
<b>Expressionless</b>																
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
<b>in Pain</b>																
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	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 COMPUTER EVALUATION

Video-ID	Score					avg
	1	2	3	4	5	
<b>Bright</b>						
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
<b>Expressionless</b>						
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
<b>in Pain</b>						
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 the emotion analysis system.

A. Facial expressions appropriate for "bright patient"

1) 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 computer. 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 we could not get permission.

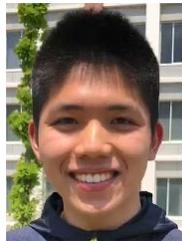


Figure 4. Facial expression of student corresponding to video B-3.

TABLE III. COMPUTER ANALYSIS RESULT 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 RESULT 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 RESULT 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 RESULT 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 "expressionless patient" as subjectively evaluated were analyzed from the point of view of what emotions appear in the facial expressions as identified by computer. 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 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 the reason for the high evaluation.

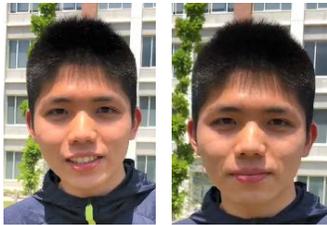


Figure 5. Facial expression of student corresponding to video E-1 (left: first half; right: second half).

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	0.01	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 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	0.95	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

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 by computer. 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.

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, 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 VIDEO P-1 (3RD-RANKED FACIAL EXPRESSION FOR "PATIENT IN PAIN")

Time	Happiness	Anger	Contempt	Disgust	Fear	Sadness	Surprise	Neutral
00:00.0	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

VI. CONCLUSION

Our quantitative analysis of medical student’s facial expressions when greeting an adult patient to be medically evaluated in the general ward of a hospital revealed which facial expressions are most acceptable. 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 in bad physical condition suffering pain, the most acceptable facial expression is "neutral" with a little "sadness" or "surprise."

We think appropriate facial expressions required for a medical doctor would be different for the treatment department, generation, gender and culture. We plan to clarify their influence in future work. In addition, we are developing a training system based on our findings to learn acceptable expressions.

REFERENCES

[1] A. Donabedian, *The Definition of Quality and Approaches to Its Assessment*. Ann Arbor, MI: Health Administration Press, 1980.

[2] S. H. Kaplan, S. Greenfield, and W. E. Ware, Jr, "Assessing the effects of physician-patient interactions on the outcomes of chronic disease," *Med. Care*, vol. 27, pp. S110–S127, March 1989.

[3] L. M. Noble, A. Kubacki, J. Martin, and M. Lloyd, "The effect of professional skills training on patient-centredness and confidence in communicating with patients," *Med. Educ.*, vol. 41, pp. 432–440, May 2007.

[4] J. A. Hall, D. L. Roter, and N. R. Katz, "Meta-analysis of correlates of provider behavior in medical encounters," *Med. Care*, vol. 26, pp. 657–675, July 1988.

[5] J. A. Hall, J. A. Harrigan, and R. Rosenthal, "Nonverbal behavior in clinician-patient interaction," *Appl. Prev. Psychol.*, vol. 4, pp. 21–37, Winter 1995.

[6] L. M. Ong, J. C. de Haes, A. M. Hoos, and F. B. Lammes, "Doctor-patient communication: A review of the literature," *Soc. Sci. Med.*, vol. 40, pp. 903–918, April 1995.

[7] T. L. Thompson, "Interpersonal communication and health care," in *Handbook of Interpersonal Communication*, 2nd ed., M. L. Knapp and G. R. Miller, Eds. Thousand Oaks, CA: Sage, pp. 696–725, 1994.

[8] S. Williams, J. Weinman, J. and J. Dale, "Doctor-patient communication and patient satisfaction: A review," *Family Practice*, vol. 15, pp. 480–492, October 1998.

[9] M. R. DiMatteo, A. Taranta, H. S. Friedman, and L. M. Prince, "Predicting patient satisfaction from physicians’ nonverbal

communication skills," *Med. Care*, vol. 18, pp. 376–387, April 1980.

[10] M. R. DiMatteo, R. D. Hays, and L. M. Prince, "Relationship of physicians’ nonverbal communication skill to patient satisfaction, appointment noncompliance, and physician workload," *Health Psychol.*, vol. 5, pp. 581–594, 1986.

[11] J. Bird, S. A. and Cohen-Cole, "The three-function model of the medical interview. An educational device," *Advances in Psychosomatic Medicine.*, vol. 20, pp. 65–88, 1990.

[12] H. de Haes and J. Bensing, "Endpoints in medical communication research, proposing a framework of functions and outcomes," *Patient Educ. Couns.*, vol. 74, pp. 287–294, March 2009.

[13] Z. Ben-Sira, "Affective and instrumental components in the physician-patient relationship: An additional dimension of interaction theory," *J. Health Soc. Behav.*, vol. 21, pp. 170–180, June 1980.

[14] M. K. Buller and D. B. Buller, "Physicians’ communication style and patient satisfaction," *J. Health Soc. Behav.*, vol. 28, pp. 375–388, December 1987.

[15] B. M. Korsch and V. F. Negrete, "Doctor-patient communication," In *Physician-patient Communication: Readings and Recommendations*, G. Henderson, Ed. Springfield, IL: Charles C. Thomas, pp. 29–40, 1981.

[16] S. J. Williams and M. Calnan, "Convergence and divergence: Assessing criteria of consumer satisfaction across general practice, dental and hospital care settings," *Soc. Sci. Med.*, vol. 33, pp. 707–716, 1991.

[17] R. C. Wasserman, T. S. Inui, R. D. Barriatua, W. B. Carter, and P. Lippincott, "Pediatric clinicians’ support for parents makes a difference: An outcome-based analysis of clinician-parent interaction," *Pediatrics*, vol. 74, pp. 1047–1053, December 1984.

[18] H. S. Friedman, M. R. DiMatteo, and A. Taranta, "A study of the relationship between individual differences in nonverbal expressiveness and factors of personality and social interaction," *J. Res. Pers.*, vol. 14, pp. 351–364, September 1980.

[19] J. Bensing, "Doctor-patient communication and the quality of care," *Soc. Sci. Med.*, vol. 32, pp. 1301–1310, 1991.

[20] A. Mehrabian, "Communication without words," *Psychol. Today*, vol. 2, pp. 52–55, 1968.

[21] R. L. Birdwhistell, *Kinesics and Context: Essays on Body Motion Communication*. Philadelphia: University of Pennsylvania Press, 1970.

[22] H. S. Friedman "Nonverbal communication between patients and medical practitioners," *J. Soc. Issues*, vol. 35, pp. 82–99, Winter 1979.

[23] M. R. DiMatteo, L. M. Prince, and R. Hays, "Nonverbal communication in the medical context: The physician-patient relationship," In *Nonverbal Communication in the Clinical Context*, P. D. Blanck, R. Buck, and R. Rosenthal, Eds. University Park, PA: Pennsylvania State University Press, pp. 74–98, 1986.

[24] Microsoft Emotion API. [Online]. Available from: <https://azure.microsoft.com/en-us/services/cognitive-services/emotion/> 2018.07.06