ORIGINAL

Proposal for a measurement protocol for nurses' empathic communication competencies using gaze tracking, voice analysis technology, and digital video data

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Abstract : This study aimed to propose a measurement protocol for visualizing nurses' empathic communication competencies using gaze-tracking, voice-analysis, and digital video. This study was conducted at University A from June to November 2019 and two nursing students in their 20s. The scenario simulated nurses' empathic listening to patients discuss their health. Data were collected using a gaze analysis device (Tobii Eye Tracker 4C), a voice analysis device (WavePad FFT), and a digital video camera. Gaze data were categorized into 16 facial and upper-body regions and visualized on the horizontal and vertical axes using scatter plots. Verbal communication lasted 4 min 59 s, with 24,222 valid data points recorded from the subjects' gazes within the effective range. Subjects' "focus of gaze" was more frequently on the lower right face (36.51%), upper right face (33.93%), lower left face (13.01%), and upper left face (8.31%), 94% of the gaze was directed at the other person's face. Voice analysis revealed initial sound pressure levels between -18 to -12 dB, increasing beyond -6 dB with laughter and frequent utterances. The proposed measurement protocol allowed the visual and numerical identification of nurses' expressed empathy and emotions toward the patient by voice, gaze, and digital video recorded data. J. Med. Invest. 72 : 419-424, August, 2025

INTRODUCTION

Communication in healthcare and nursing is important for building trusting relationships with patients. Nursing textbooks emphasize the importance of verbal and nonverbal messages and describe the attitudes required to build strong interpersonal relationships when communicating with patients (1). Sixty-five percent of human communication is nonverbal, and it is dominated by speech, gestures, and facial expressions (2). In particular, gaze and tone of voice influence a speaker's persuasiveness (3, 4). A study using gaze and voice analysis in nursing examined the differences between experienced nurses and nursing students when observing postoperative patients walking (5). It also analyzed differences in gaze between outstanding nurses and students when administering intravenous injections (6). Although some studies have analyzed the relationship between nurses' perceptions of voice, silence, and burnout (7), no studies have measured and evaluated sound pressure in nursing communication.

A caring perspective is essential for providing interpersonal care. Actively listening to what another person has to say and intentionally communicating are important for gaining a deeper understanding of one's experiences (8, 9). However, the most effective ways to communicate with patients or adjust nurses' gaze and voice to suit them have not yet been identified in the medical field.

In particular, the gaze analysis device (Tobii Eye Tracker 4C) (10) used in this study is a gaze tracking device used in computer

games ; no previous studies have used it to analyze human communication. Since it is possible to measure gaze without attaching it to the body, it is possible to collect gaze data in a form that is close to actual clinical communication. No studies that have used such a device in an interdisciplinary manner with engineering researchers to identify "empathy" for patients for improving the quality of healthcare.

This study is novel in that it incorporates many variables, such as the use of a gaze analysis device, voice analysis tool, and digital video data to conceptualize the gaze and voice analysis data. This represents an attempt to quantify the competencies of nurses that have previously been difficult to visualize. Gaze and voice analysis can be used to quantify, analyze, and evaluate nurses' communication, and we believe that this approach can be applied to education on building trusting relationships with patients.

There is no method available for quantifying and visualizing communication between nurses and patients, and this study proposes a protocol that makes this possible. The effectiveness of the proposed protocol is demonstrated by showing examples of quantified and visualized communication using the proposed protocol.

This study aimed to propose a measurement protocol for visualizing nurses' empathic communication competencies using gaze tracking, voice analysis technology, and digital video data.

METHODS

Study period

June to November 2019

Subjects

Two university students in their 20s are studying nursing. These student nurses have completed all the clinical training

required for the national nursing exam.

Data collection

Subjects were assigned to play the roles of a nurse and a patient, and data were collected using an eye gaze analysis device, voice analysis software, and digital video recording of the scene in which the nurse empathetically asked the patient about their "current health condition." The nurse wore a white coat, and the patient wore a hospital gown. Each communication session lasted 15-30 minutes to avoid burdening the subjects. The survey was conducted in a private room (30-40 m²) set to 19°C ± 2°C (humidity 40-60%) in winter, as listed in a nursing technique textbook as the comfort zone. Tobii Eye Tracker 4C (Tobii Technologies) (sampling frequency : 90Hz) was used to detect the nurse's gaze. For voice analysis, WavePad FFT analysis software was used to measure the sound pressure (in decibels) during the conversation.

Initial measurement protocol

In the initial phase of the experiment, data were collected using the following protocol as shown in Figure 1 :
i) The gaze analysis device was set in front of the nurse to measure the nurse's gaze position.
ii) At the start of the conversation, the nurse was asked to start by introducing herself and saying hello to ease tension.
iii) The patient was asked to answer questions from the patient's perspective.
iv) Gaze analysis, voice recording for voice analysis, and digital video recording were synchronized.
v) The nurse's gaze and voice were analyzed separately for each data set.
vi) Based on the video recordings, gazes in scenes where the nurse was thought to have shown empathy or expressed emotion were identified, and the gaze analysis results were compared with sound pressure.

Data Analysis Method

The program used to identify the gaze coordinates detects and records the gaze using the coordinates of the resolution (2736 × 1824) of the screen of a personal computer (PC) connected to the gaze analysis device. The program was developed by Professor Kai and colleagues from the Department of Mechanical Engineering, School of Engineering, Tokai University. The program also recorded the time at which the gaze was detected.

For the analysis, the gaze detection data were exported to Microsoft Excel as (X, Y) coordinate data, categorized into 16 areas of the face and upper body, and used to create a scatter plot showing which part of the gaze was placed.

The WavePad FFT analysis software (NCH Software) was used to measure the sound pressure (in decibels) during the conversation for the voice analysis.

Digital video recordings were used to confirm the situation during gaze and voice analyses.

Ethical Considerations

Participation in this study was based on an individual's voluntary and written consent. The subjects were informed that there would be no disadvantages if they refused to participate in the study. This study was approved by the Ethics Committee of Tokushima University Hospital (approval number : 3568).

RESULTS

The duration of empathic communication was 4 min 59 s. Among these, there were 24,222 valid pieces of data in which the gaze was within the analysis range. The most common gaze points were on the lower right side of the patient's face (36.51%), followed by the upper right side (33.93%), the lower left side (13.01%), and the upper left side (8.31%). A total of 91.76% of the gaze points were on areas including the face, and 8.24% were on parts of the face other than the patient's face (Figure 2).

Voice analysis showed that two persons repeated questions and answers immediately after the start of communication, and the conversation was mainly at around -18 to -12 dB. However, in the scene where the nurse and patient laughed aloud, the conversation frequently exceeds the -6 dB line, and the amount of speech from both sides increases (Figure 3).

In the laughing scene, the patient said, "I have atopic dermatitis, but my eyes have never itched." He immediately corrected
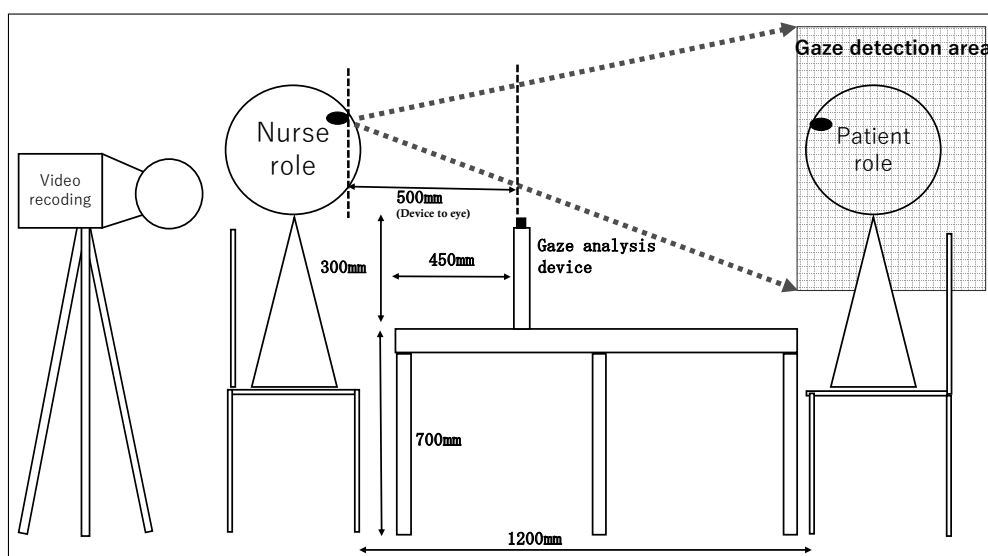

Figure 1.　Initial measurement protocol

himself, "I am sorry, I experienced some itching." "I understood that your thought," to which the nurse responded with empathy.

Next, we analyzed only the gazes of the nurse when she showed understanding and agreement with the patient and an empathetic attitude. As a result, the total number of data points over 30 seconds was 1,191, of which 1,124 (94.37%) were directed toward the area around the face (Figure 4).

First, the patient's upper body (head and chest) is divided into 16 areas, and gaze data can be used to understand which areas the nurse looks at and how frequently they look at them during a conversation. In addition, the voice data can be used to understand the pitch of the voice, the speed of the conversation, and when the volume of the voice is high. Furthermore, the video data can be used to understand the attitude of the nurse and patient during the conversation and the atmosphere of the situation. These data are synchronized, so by integrating them, it is possible to understand where the nurse was looking at any given moment, how loud the voice was at that time, what the attitude
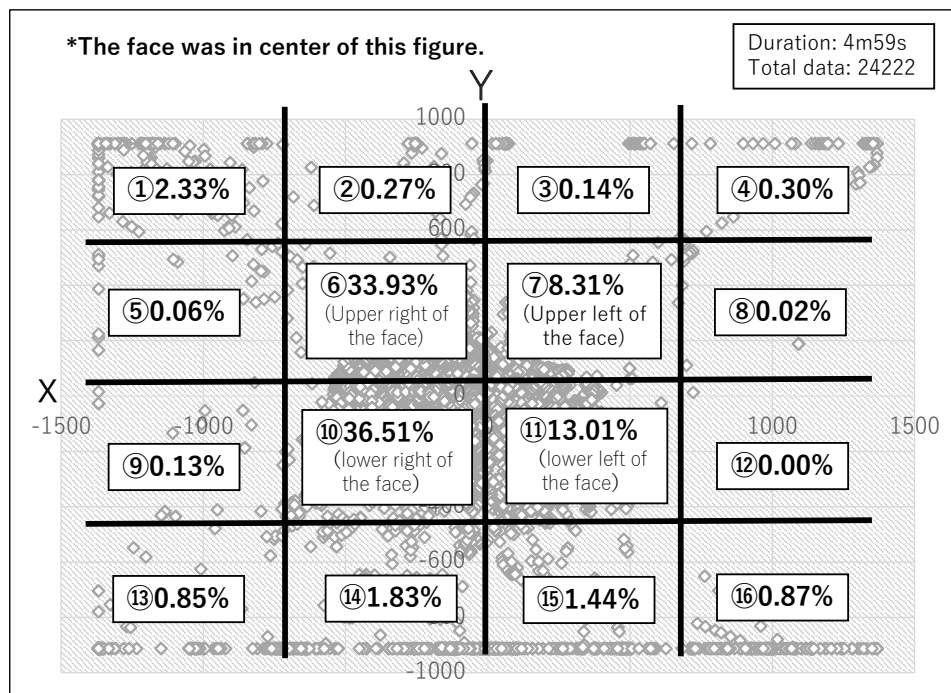

Figure 2.   Percentage distribution of the nurse's gaze directed toward the patient's face
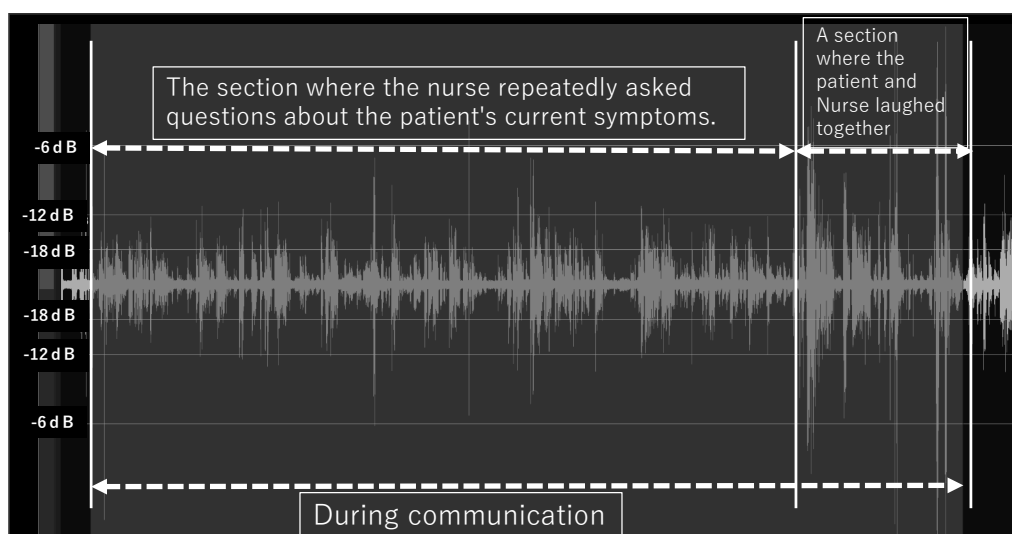

Figure 3.   Results of voice analysis during conversation

of the nurse and patient was, and what the atmosphere of the conversation was.

Where the nurse's gaze is at the moment the patient speaks or laughs is effective in understanding the nurse's feelings and empathy toward the patient, and it is possible to reconfirm the validity of those feelings and empathy from the atmosphere of the situation and the attitude of both parties using video data. Therefore, the proposed measurement protocol makes it possible to numerically identify the empathy and emotions expressed by the nurse toward the patient through voice, gaze, and digital video analysis.

DISCUSSION

The results of the gaze analysis showed that nurses' gazes were most often directed toward the lower right part of the patient's face, followed by the upper right part. During approximately five minutes of empathic communication, 94% of the nurses' gazes were directed at four areas, including the patient's face. Marconi, *et al.* (11) reported that cognitive activity (imagination, internal dialogue, and memory) influences the direction of eye movement. Thus, a given cognitive activity could cause the gaze to move in a certain direction, a brief, instinctive and unconscious movement. It was considered that the nurses were
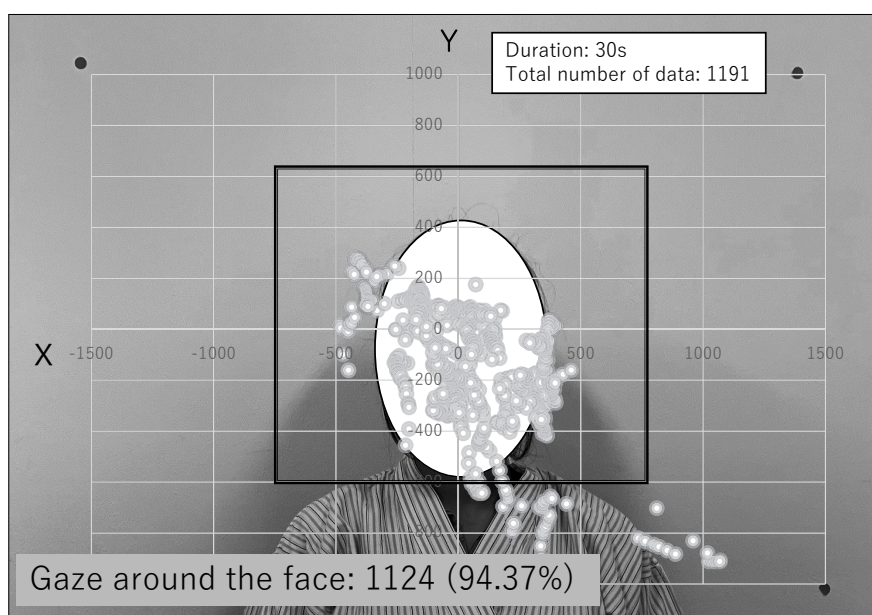

Figure 4.   Results of the analysis regarding the nurse's gaze when understanding, agreeing, and empathizing with the patient
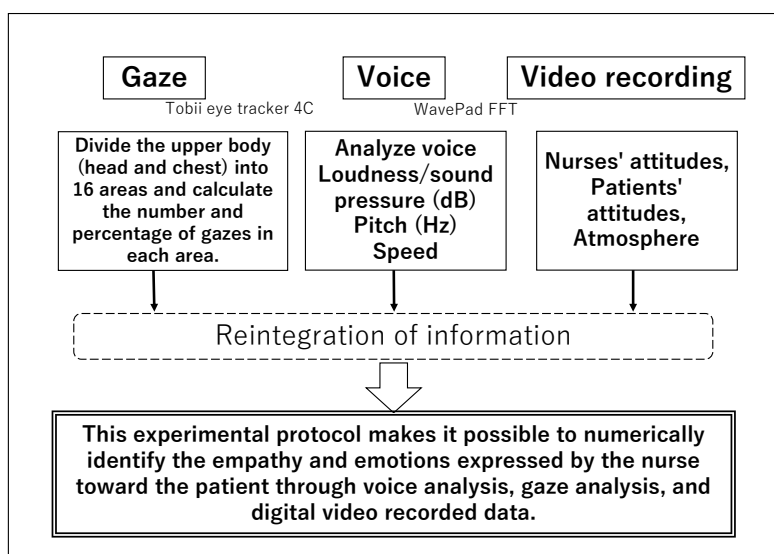

Figure 5.   Revised measurement protocol for visualizing communication using gaze and voice analyses

talking while paying attention to their words.

Many textbooks used in nursing education state that the key points of communication include making eye contact with the patient and observing facial expressions. In this study, the nurses also focused their gaze on the face of the patient, suggesting that they were intentionally directing their gaze at the patient's face and trying to make eye contact to show that they were listening attentively and empathizing with the patient's experiences and stories.

However, an analysis of the gaze patterns of specialists and medical students in medical interviews showed that specialists made eye contact with patients less frequently (12). The specialists' tendency to make less frequent eye contact with patients is thought to be because they communicate with the patient while observing their overall condition ; in medical situations, averting one's gaze can sometimes be an effective form of communication. This layer suggests that exposure to a speaker's gaze for a long time can make another person feel dominated. Appropriately averting one's gaze is thought to create a relaxed environment without intimidating the other person and is therefore considered an important communication technique for nurses (13). Good communication fosters empathy, promotes patient understanding, and provides specialized care. As a result, empathetic nurse-patient communication reduces fear and concern (14). Therefore, quantitatively measuring the gaze is considered extremely meaningful, as in this study.

Next, we considered the results of the voice analysis. Initially, when they were communicating face-to-face, the conversation was in the -18 to -12 dB range, and the video recording showed they were speaking in low voices. Previous research that analyzed good-speaking techniques from politicians' speeches showed that a good speaker is trustworthy, expressive, powerful, and involved and that being insecure, hesitant, and monotonous leads to the opposite impression (15). In medical communication, it can be assumed that speaking fluently and clearly gives the impression that one is a good conversationalist and leads to drawing out the patient's opinions and thoughts. In this communication experiment, the level fluctuated between -18 and -12 dB until the end but frequently exceeded -6 dB from the point where both the nurse and patient laughed. When they laugh, the patient describes their symptoms and immediately corrects them, and the nurse responds empathetically, showing understanding and agreement by saying, "I see." The instruction manual for WavePad (16) states that sound amplification doubles for every 6 dB increase in sound pressure level (dB), so it is thought that the perceived volume doubled. Through laughter, people's voices became louder, and they spoke more, which was thought to impact trust formation. A study on nurse communication showed that effective communication ensures good medical care for patients, allows patients to express their opinions, and provides them with comfortable nursing care (17).

Previous studies have shown that people form impressions within a few seconds or minutes of meeting each other (18) ; however, research also states that people's first impressions change within 20 minutes during job interviews (19). The same holds for medical care, and we can infer that the degree of trust formation changes depending on the development of subsequent communications. In this study, the patients began talking about their current symptoms, and after the nurse showed agreement and a respectful attitude, the volume of their voices increased, and the number of utterances increased on both sides. This suggests that keeping basic techniques in mind and demonstrating an empathetic attitude are important in medical communication to determine the patient's symptoms and find opportunities to intervene.

Based on the results of voice analysis, an analysis of only the gaze in scenes in which the nurse showed understanding and agreement with the patient and displayed an empathetic attitude revealed that 94% of the gaze was directed around the face, which was thought to indicate that the nurse was trying to understand the patient. In particular, changes in sound pressure are considered a source of information for understanding trust between the two parties. Furthermore, to determine whether emotions were expressed during conversations, it was thought that considering the situation in light of video recordings would provide a more accurate understanding. However, in a previous study in which patients with terminally ill diseases were interviewed about "sympathy" and "empathy," it was found that not only the nurse's positive attitude of involvement but also empathy and compassion were beneficial, with compassion being the most preferred and impactful (20). Therefore, we found that it would be difficult to analyze empathy in a true sense unless it included not only the nurse's gaze and voice but also the patient's subjective judgment, as in this study. The proposed measurement protocol and system are believed to be extremely useful for nursing students to confirm where they should look when talking to patients, whether they are actually looking at the patient properly when talking, and for practicing looking at the patient while talking.

LIMITATIONS OF THIS STUDY AND THE FUTURE STUDIES

In this study, it cannot be denied that the fact that the subjects knew each other may have influenced the data obtained. In medical and nursing interview methods, the nurse is often not directly in front of the patient but rather stands at 45 ° or directly to the side, depending on the content to be interviewed. Future research should be conducted in situations as similar to a clinical setting as possible, depending on the performance of the equipment used. It was unfortunate that the subjects were limited to students due to experimental constraints related to the spread of COVID, including the inability to involve professional nurses, who were already under heavy strain, and the need to avoid exposing elderly individuals to potential infection. We believe the uniqueness of each subject and their situation plays a significant role in communication. In addition to increasing the number of cases, we plan to conduct multicenter studies with patients and nurses from elderly care facilities and chronic care hospitals. Since individual variations exist, conducting experiments on different subjects in the future and examining the effectiveness and applicability of the proposed protocol in detail are necessary.

If gaze and voice analysis technology can be effectively used to improve nurses' therapeutic communication skills, such experienced nurses' competencies visualized by numerical values can be applied in in-service education. For this study to be effectively used in clinical practice and nurse education, it is necessary to measure both the patient's perspective and the nurse's gaze. The protocols should also be refined as the number of cases increases. Future research can implement the proposed measurement protocol to verify the appropriateness of combining gaze and voice analysis to measure nurses' empathic comprehension competencies.

CONCLUSION

During empathic communication, the nurse's "focus of gaze" was more frequently on the lower right face of the patient (36.51%), upper right face (33.93%), the lower left face (13.01%), and the upper left face (8.31%), and 94% of the gaze was directed at the other person's face. Voice analysis revealed initial sound

pressure levels between -18 to -12 dB, increasing beyond -6 dB with laughter and frequent utterances. This study demonstrated how gaze patterns and voice modulation influence empathetic interactions in nursing, which can enhance clinical training and patient care strategies.

The proposed measurement protocol shown in Figure 5 allowed the visual and numerical identification of nurses' expressed empathy and emotions toward the patient by voice analysis, gaze analysis, and digital video recorded data.

CONFLICT OF INTEREST

The authors (HI, YK, TT) declare no conflicts of interest associated with this manuscript.

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