Journal of Research and Applications in Mechanical Engineering
ISSN: 2229-2152 (Print); 2697-424x (Online)
(2021) Vol. 9, No. 2, Paper No. JRAME-21-9-015
[DOI: 10.14456/jrame.2021.15]

Research Article

A PROPOSAL FOR THE STRESS ASSESSMENT OF ONLINE EDUCATION BASED ON THE USE OF A WEARABLE DEVICE

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Received 21 December 2020
Revised 12 February 2021
Accepted 18 February 2021

ABSTRACT:
The COVID-19 pandemic has forced educational institutions worldwide to shift to online education. In Japan, a questionnaire on online education was conducted at many universities. A survey on team-based classes at Kogakuin University revealed that about 70% of the students were not satisfied with the team-based performance assignments required by the university. Online communication seems to generate dissatisfaction, and whether text-based research can be accurately assessed in Eastern regions (including Japan) due to their high context culture is questionable. Therefore, this study proposed an evaluation using wearable devices and the application of physiological psychology. It reported a near 20-fold difference in the number of skin conductance responses above 3μS between working alone and making an online call, and it was observed that many more active short-term responses occurred when making an online call. This result shows an essential factor for designing online education.

Keywords: *Educational engineering, Physiological psychology, Team working, Team education, Online education, Online communication*

1. INTRODUCTION

Due to the impact of COVID-19, the world has been forced to switch to online education. Online education has been attracting attention since before 2020, and high schools based on this approach are gaining traction in Japan. In addition, a significant trend in the education sector is the recent development of globalization and information technology, which has led to a shift from traditional passive learning to “active learning” [1]. Although numerous studies have focused on online communication, most of them are based on questionnaires and text-based data. For example, in a case study using Skype for online intercultural exchange [2], some students felt that synchronous communication with video was unfamiliar to them, and they felt confused and embarrassed to talk to each other; however, asynchronous communication with text certainly provided a sense of presence that was not present in synchronous communication. This was concluded with reference to the comments in the end-of-semester report. According to Tseng and Yeh [3], students who enjoy working in groups are more likely to have good relationships and trust with team members. On the other hand, the questionable behavior of team members (poor communication and low personal accountability) was a negative factor in their teamwork experience. The results of the quantitative analysis confirmed that teamwork trust was significantly correlated with two of the critical trust-building factors demonstrated by team members: familiarity with members and team cohesion [3]. A text-based study of the questionnaire was conducted.

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However, questionnaires are subjective evaluations, and it is questionable whether they can be assessed appropriately in Japanese contextual culture [4]. Physiological psychology is a method used to measure stress objectively. Kusserow, Amft, and Tröster [5] deployed wearable sensors to monitor speakers, musicians on stage, Olympic ski jumpers, and ordinary people to quantify stress arousal in a variety of situations. Therefore, this study proposes the use of physiological psychology methods to more accurately measure communication barriers and stress in online education.

2. STATE OF ONLINE EDUCATION IN UNIVERSITY EDUCATION

Due to the COVID-19 pandemic, Japanese university education moved to online platforms. In Japan, the new academic year starts in April; therefore, many universities finish their first semester in August. Students were surveyed about online education by universities and major media outlets. According to a survey with 7,224 responses from Senshu University [6], many students felt that online education was beneficial, with 86.9%, or 6,279 students saying that "it eliminates the time spent commuting to school and moving around within the school building" as an advantage of taking online classes. In addition, 64.5% of the respondents said that they were able to review materials and listen to audio recordings, making it easier for them to prepare and review, and 62.6% said they could study at their own pace. On the other hand, the results of the survey also revealed various difficulties that students faced during the COVID-19 pandemic. When asked about the disadvantages of online classes, 67.8% of the 6,944 total responses (4,705 students) responded that there were too many assignments, and 56.5% (3,925 students) responded that they were worried about not having any friends. In response to the question "Please tell us what problems (other than the communication environment) you have with web-based classes," about 35,000 students responded that, apart from physical fatigue or tiredness in the eyes, they had difficulty maintaining concentration and communicating with the teacher ("Fig. 1") [7].

In addition, we have been focusing on massive open online courses (MOOCs) offered by Harvard University and the Massachusetts Institute of Technology (MIT) via the edX platform; these are being used as an old business model, which is different from what was envisioned in the review papers on higher education becoming online learning [8]. One of the reasons for this is that the low completion rate of MOOCs has not improved in six years [9]. Looking closely, 52% of those enrolled in the course never enter the courseware, and a generally high attrition rate is maintained in the first two weeks of the course [9]. It has also been noted that the challenges of online learning are particularly acute for the most vulnerable populations, including first-generation college students, students from low-income families, and students from minority groups [10]. While recent studies have examined online and text message-based interventions to support these students, most research suggests that person-to-person connections through advisors, tutors, and peer groups provide the most important student support [11].

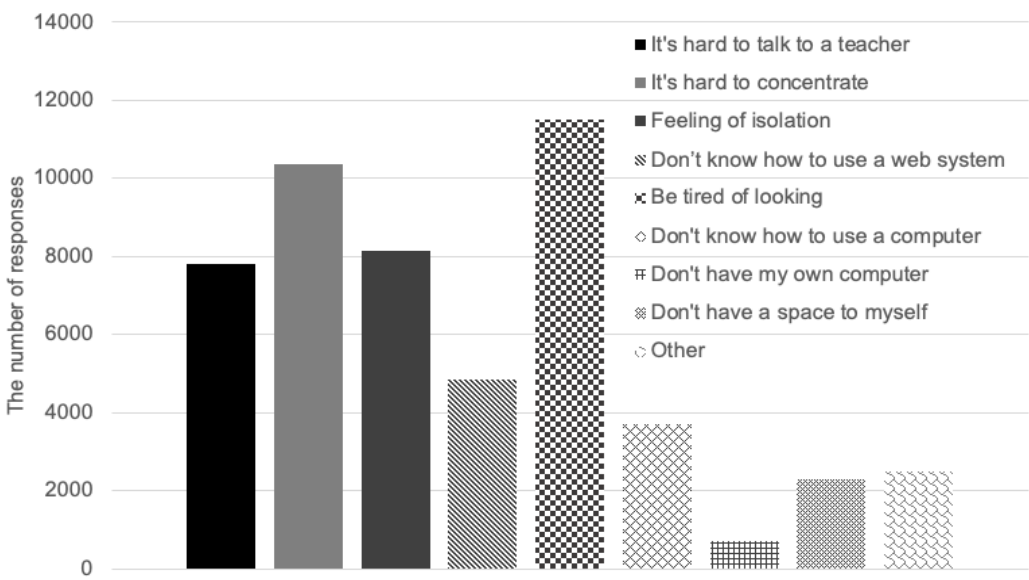

Fig. 1. Responses to question "Please tell us what problems (other than the communication environment) you have with web-based classes" [7].

3. SURVEY OF CASES OF BASED ON ONLINE TEAMWORK EDUCATION

Due to the development of the IT society, Japan has seen a trend of shifting from conventional passive education based on lectures to active education based on student teams ("Fig. 2"). The introduction of interdisciplinary teamwork education in Japanese engineering education has been discussed and implemented for about 10 years to comply with the global engineering education standards, as stated by ABET and others. The Japan Accreditation Board for Engineering Education has proposed that students should foster the ability of being team members as well as leaders. It is suggested that "Japanese engineering students should acquire the ability to interact with people of diverse cultures, values, and interests, and to collaborate with people from a wide range of specialties, which is necessary when working in a globalized world" [12]. As mentioned in the previous section, a questionnaire survey revealed the harmful effects of the lack of communication as a disadvantage of online education. Therefore, a survey was conducted in a teamwork class of third-year students at the Department of Mechanical and Systems Engineering, Faculty of Engineering, Kogakuin University. In this class, students performed individual report exercises on four themes of mechanical engineering systems in advance, and they were then assigned to one theme. The project was divided into two teams of five to six students per team for a month. Communication was mainly voice-based using Google Meet and accompanied by text communication using Slack and LINE. After the class, a questionnaire was administered to the students, asking: "If this teamwork assignment was done in real life at the university, do you think your submissions would be better?" ("Fig. 3"). Of the 94 respondents, 70% answered "Yes" to the question "Do you agree?". The same respondents were asked to give a brief example of the difficulties they experienced in teamwork. Table 1 shows examples of the negative effects of online work.

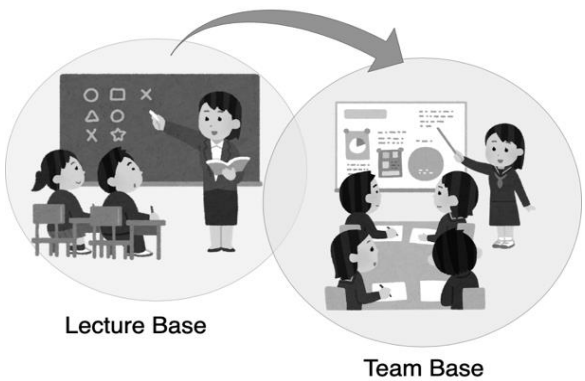

Fig. 2. Changing trends in education.

Table 1: Responses to "Please give a brief example of difficulties you experienced in teamwork".

Because it was not a face-to-face class, it was not possible to ask questions immediately. In addition, it was difficult to communicate with my fellow students because we did not meet in person.
There was a point where I felt it was difficult to explain in words alone, and it was more difficult to get people to understand me than in person.
I felt that it was difficult to share our opinions because we were not able to meet in person.
I found the difference between face-to-face and remote communication to be difficult. In the face-to-face situation, when the other party is looking up something or working on something, I could tell by looking but not on the phone, so I had to look up the same thing. I also felt that there were many disadvantages, such as the difficulty in communicating in text alone and the need for lag and time.
Because I didn't know the team members very well and couldn't meet them, I couldn't talk to them casually, and because I think others felt the same way, it was difficult to share and connect with them.
Since I didn't know the faces of the team members and the teacher in charge, I couldn't read their expressions, so I was especially cautious during discussions. Since we couldn't discuss face-to-face, there was a slight gap between conversations, and there were many times when someone would interrupt a call when someone else was speaking, making it difficult for them to express their opinion, or only the two of them would play catch-up.
There were times when I couldn't feel free to say what I thought because I wasn't face-to-face with them.
During the discussion, I often had trouble understanding the other person's reaction to the online discussion. Therefore, I paid attention to the way we listened to each other and tried to make sure that everyone could speak. There were a few times when the points of discussion were vague.

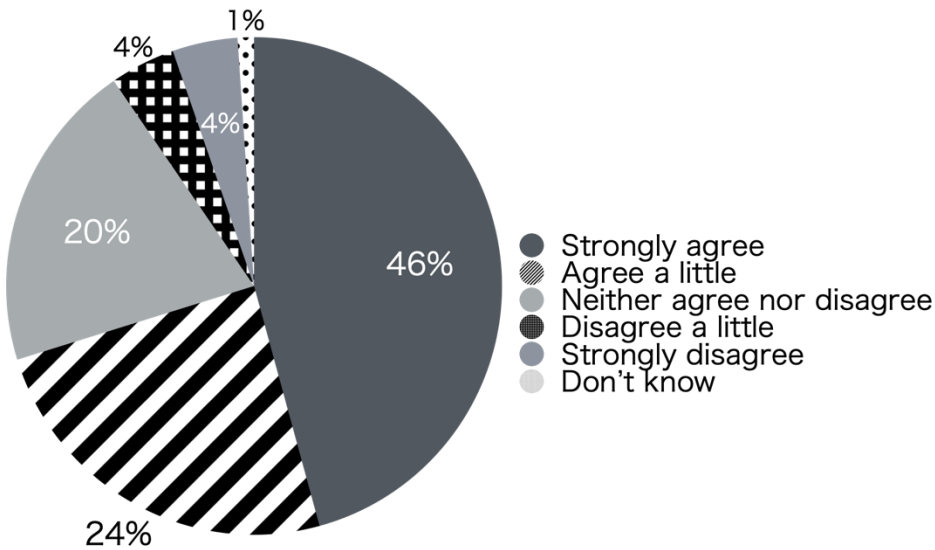

Fig. 3. Responses to "If you were to conduct this teamwork task at the university, do you think your submissions would be better than the previous ones?".

These results suggest that the obstacles caused by lack of online communication emerge more clearly in lectures that are teamwork-driven rather than knowledge-based. We also concluded that many people believe that offline communication is still superior, even in today's world of improved information technology. It is difficult to decipher from the questionnaires and other forms of text where specific communication barriers have occurred because it is not in real time. Therefore, we believe that there is a need for objective evaluation using other indicators. We also believe that, if we can pinpoint where the obstacles occur, we can improve online education.

4. A Proposal for Stress Evaluation by Conducting EDA Analysis Using Wearable Devices

4.1 What is EDA and Classification of EDA

The discipline of physiological psychology is an indicator of stress assessment. It is a field that straddles physiology and psychology, studying the correspondence between the psychological and physiological functions of behavior [13]. The field of physiological psychology is diverse, and a variety of biological responses have been measured and evaluated [13]. Of all biological reactions, only those that are relevant to psychological phenomena are subject to physiological psychology. In addition, because the subjects are humans, biological responses that can be measured in a noninvasive, nonsurgical manner are the subject of physiological psychology research [13]. Biological responses can be broadly divided into two categories: central nervous system (CNS) activity and peripheral nervous system (PNS) activity. The present study proposes an electrodermal activity (EDA) that is relatively easy to analyze and can be measured using an inexpensive device. In other studies conducted by the author, there was a change of 10-20 μS in the values of the EDA between relaxing and performing a simple calculation, and it could be concluded that the simple calculation caused the psychological change. We propose to use the same measurement system in the present study. There are several measurement methods in EDA ("Fig. 4" shows their list).

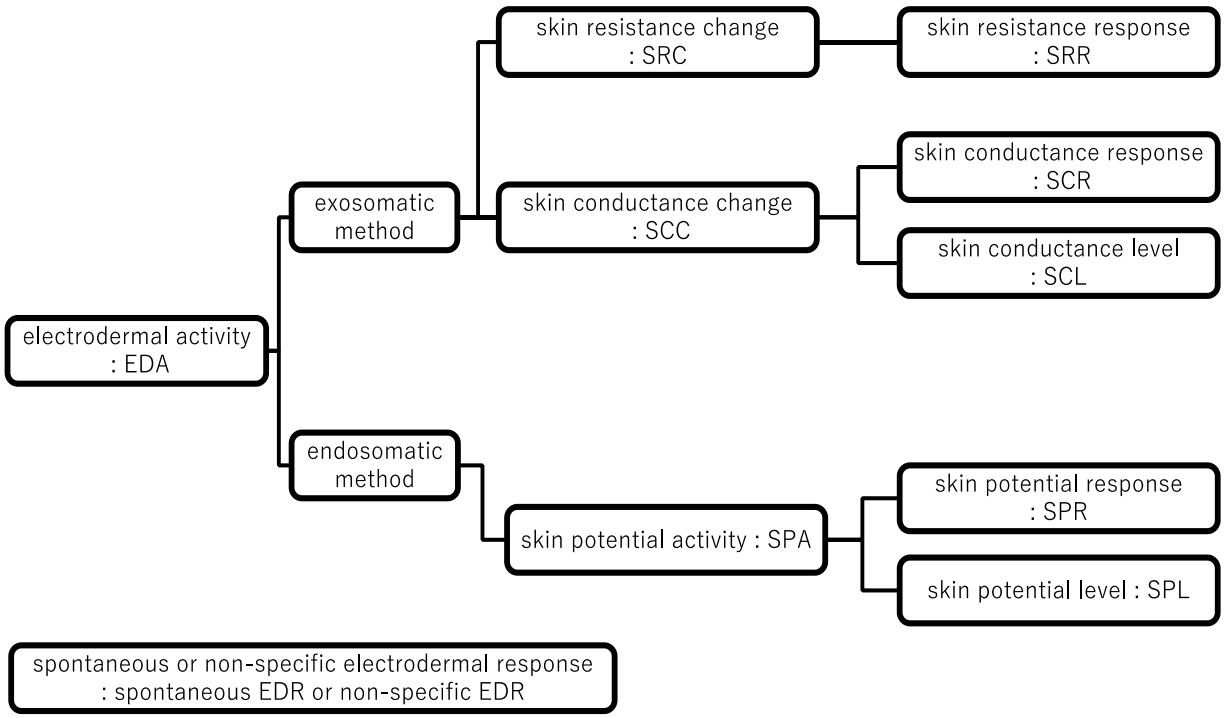

Fig. 4. Classification of EDA [13].

In this study, we used skin conductance change (SCR), which is inexpensive, easy to obtain, and has a simple analysis method as described below [13]. The changes are usually measured as amplitude values.

Although a considerable number of studies have focused on the unit of measurement of SCR, the use of change in conductance is now recommended [14].

The SCR amplitude is calculated from the resistance (R) at the rise of the reaction and the resistance (R') at the top of the reaction using equation (1):

$$\Delta C = \frac{1}{R'} - \frac{1}{R} \tag{1}$$

The unit (micro siemens: μS) is calculated as follows.

4.2 Measurement device to be used

The measurement device is the E4 wristband—a wearable device made by Empatica. The device is approximately the same size as an Apple Watch and can be worn like a wristwatch. The measurement data are stored in the device, and after the measurement is finished, the data can be imported into a batch in CSV format on a PC. The data can also be viewed in graph form on an official platform. “Fig. 5” shows the mounting position and block diagram.

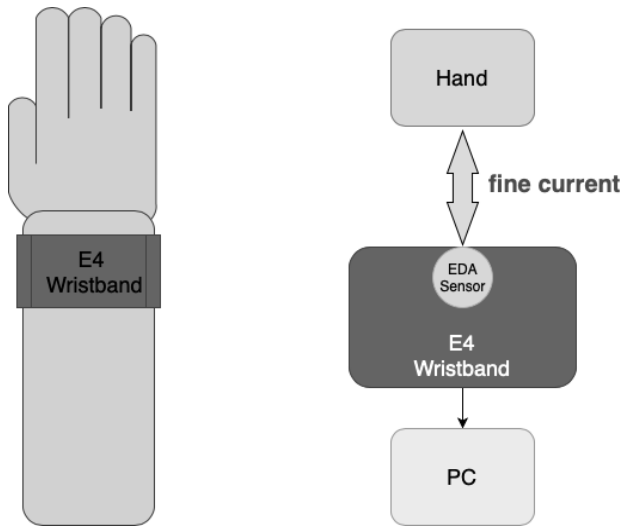

Fig. 5. Device mounting position and block diagram.

5. MEASURING THE EFFECTS OF ONLINE CONVERSATIONS ON EDA.

First, we must measure the impact of online conversations on the EDA. If we find the differences in EDA between working alone offline and talking to someone online, we will see an intervention in the psyche from the online conversation. We also must check whether communication can be inferred from the waveforms during the conversation. Therefore, we conducted an experiment to measure EDA based on the following requirements. Fig. 6 shows the overall image of the experimental environment.

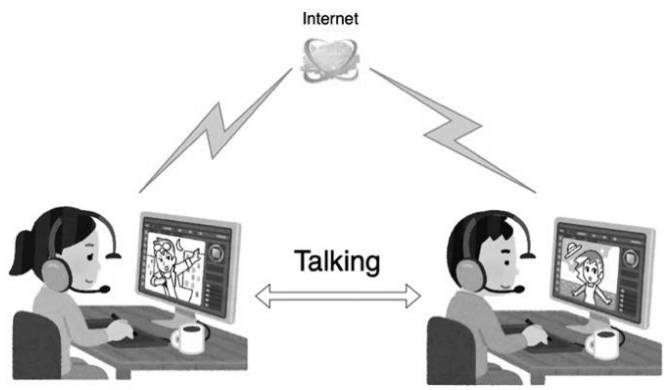

Fig. 6. Overview of the experimental environment.

(1) We measured EDA by working creatively for 30 min.
(2) In Case 1, we measured the response when the user worked alone.
(3) In Case 2, we measured the response when the user talked to someone else on the online chat room (while the chatting partner was doing the same task).

The skin conductance change:SCC results for Case 1 are shown in “Fig. 7”. The skin conductance change:SCC results for Case 2 are shown in “Fig. 8”. The skin conductance response:SCR results obtained from Equation 1 of Case 1 are shown in “Fig. 9”. The skin conductance response:SCR results obtained from Equation 1 of Case 2 are shown in “Fig. 10”.

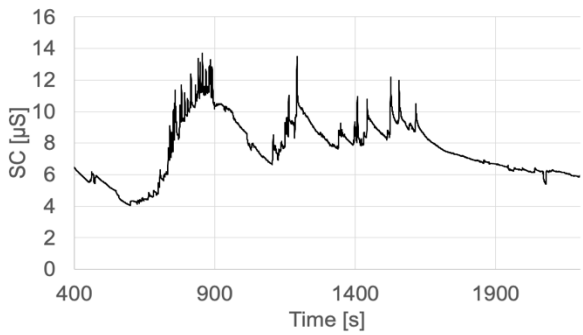

Fig. 7. SC of Case 1 (user worked alone).

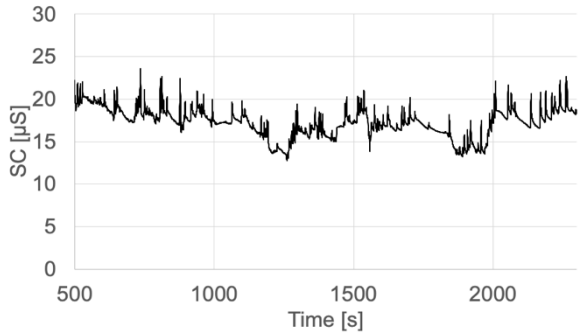

Fig. 8. SC of Case 2 (user worked on line with someone).

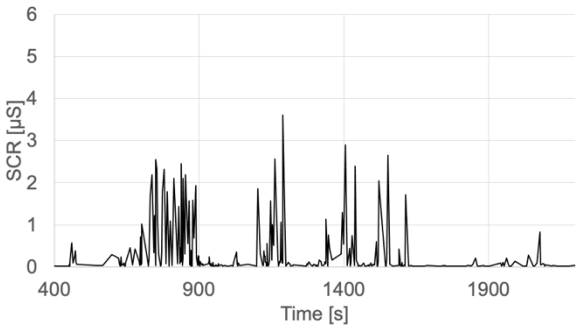

Fig. 9. SCR of Case 1.

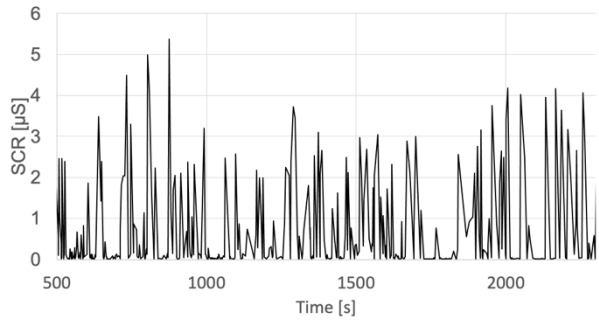

Fig. 10. SCR of Case 2

Table 2: Number of specific points. [Threshold: SCR > $3\mu S$]

Case	Number of reactions
1	1
2	22

The number of specific points is shown in Table 2. Comparing Case 1 and Case 2, we can frequently observe small peaks in EDA in the latter. The results of Case 1 show two large peaks that refer to the period from about 650 to 900 seconds, and from about 1100 to 1300 seconds, and the other peaks are relatively calm. This seems to be a response to the stress that one feels during work. The other two peaks may be due to the fact that the work is creative; therefore, it sometimes stops during the experiment. At the same time, the subjects also answered that they felt irritation subjectively. On the other hand, in Case 2, an active EDA response can be observed, which is considered to be simultaneously mediated by the conversation and the task itself. During the experiment, the subject laughed or hid their eyebrows when asking questions, and so on. Subjectively, the subjects answered that they did not feel more stressed than in Case 1. It can also be seen that, when comparing the number of responses above $3\mu S$, Case 1 and Case 2 show a near 20-fold difference, indicating that the latter produces a more active short-term response. However, looking at the responses of EDA itself, we can conclude that the influence of the conversation on EDA is significant; therefore, it is difficult to determine the response of EDA alone. Consequently, it is also difficult to evaluate the stress of personal work by EDA alone because the stress of personal work can be read easily. At the same time, if the user does not participate in the conversation, the response may be similar to Case 1. If so, we think that we can visualize where less communication occurs. In this experiment, because we observed the participants during the experiment, we could see many psychological changes during the conversation.

6. DISCUSSION

This study questions the use of questionnaires to analyse online education and proposes an objective evaluation using physiological psychology methods. We found more detailed and active responses when participants worked while making online calls than when they worked alone. This suggests that EDA can be used to objectively evaluate the degree to which emotional changes occur. On the other hand, it is also true that it is difficult to link biological reactions and psychology. In this study, we experimented on a single subject because of the difficulty of unifying the number

of equipment and the experimental environment; however, in the future, we would like to increase the number of subjects and that of equipment and observe the trend. Our hypothesis is that we will see a more active EDA response when we are actively communicating, and a sluggish EDA response when communication is sluggish. Because there may be differences between experiments with a few students and those with large numbers of students, we believe that a comparison between small and large groups of students could be adapted to actual classes. In our previous study [15], we were able to decipher the psychological changes during scene switching (from the relaxation section to the working calculation problem section) using the SCL. In this paper, we proposed that the SCR and SCL can be used to evaluate online education because we were able to measure the degree of conversation activity using the SCR. It is difficult to solve the problem fundamentally through questionnaires because of the subjective nature of the survey. Although there is a need for objective evaluation of the biological responses, it is difficult to determine causality from a single response; therefore, the solution to this problem is considered in this paper as follows.

As EDA is easy to measure and is less invasive, we aim to continue using it to conduct the measurement. We also aim to introduce other biological responses and measurement methods to supplement EDA information. Specifically, we aim to improve the reliability of objective evaluation by incorporating changes in heart rate, which is also easy to measure using a wearable device; an emotional analysis of facial expressions using video recording and cloud service AI; and an analysis of conversation data by voice transcription, which can be measured from multiple angles.

NOMENCLATURE

ΔC	change in skin conductance, μS
R	skin resistance, μΩ
R'	skin resistance after the infinitesimal time, μΩ

ACKNOWLEDGMENT

This work was partially supported by JSPS KAKENHI Grant Number 20K03213.

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