



WHITE PAPER

COOPERATIVE EXPERIMENT & VERIFICATION

POOR CONFERENCING AUDIO CAUSES STRESS

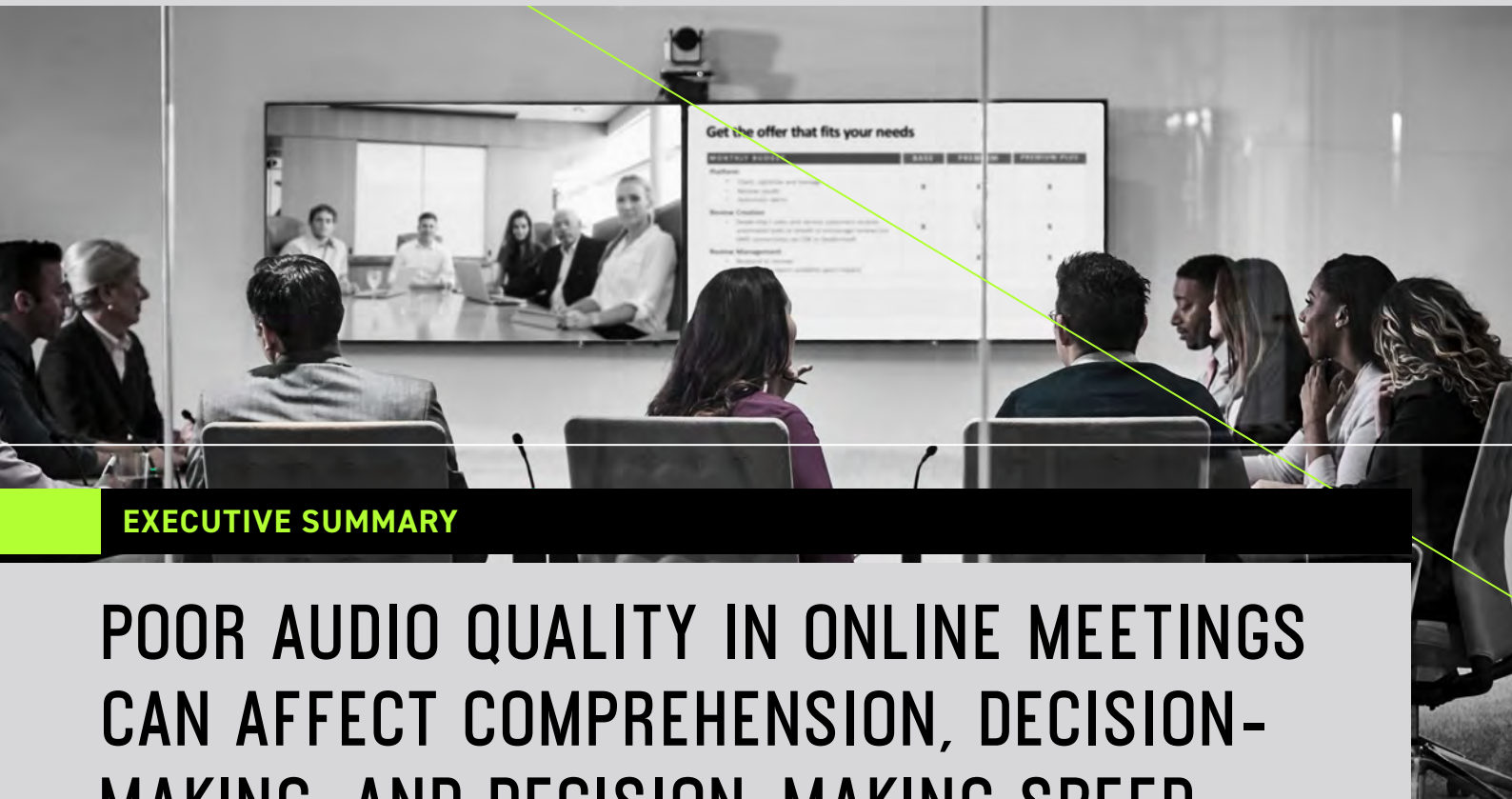
VERIFICATION ON THE BIOLOGICAL STRESS RESPONSE
DEPENDING ON CONFERENCING AUDIO QUALITY

POOR CONFERENCING AUDIO CAUSES STRESS

VERIFICATION ON THE BIOLOGICAL STRESS RESPONSE DEPENDING ON CONFERENCING AUDIO QUALITY

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EXECUTIVE SUMMARY

POOR AUDIO QUALITY IN ONLINE MEETINGS CAN AFFECT COMPREHENSION, DECISION-MAKING, AND DECISION-MAKING SPEED

The use of online meetings increased rapidly due to the impact of COVID-19. While keeping businesses up and running during the pandemic, these online meetings saw many complaints about the decrease in audio quality compared to conventional face-to-face meetings. This was due to aspects of the meeting environment, such as the devices used and the network quality. More recently, "hybrid meetings" combining face-to-face and online meetings have become mainstream. These involve teams gathered in a conference room along with employees working remotely at home and in other locations. This new style of meeting, however, has created another problem as people joining remotely struggle to make out what their colleagues in the conference room are saying.

The kind of impact of poor audio quality in meetings is becoming clear through a variety of studies, but it is not yet clear exactly what type of stress this causes for meeting participants.

To find answers, the Neuro Innovation Unit of NTT Data Institute of Management Consulting and the audio manufacturer Shure put together a team to undertake an experiment using high-quality audio and low-quality audio from meetings.

In this experiment, we performed listening and writing tests. We also verified what kind of stress participants in the experiment suffered by measuring a variety of biological stress responses. The results of this revealed the following:

- 1 **In addition to being unable to understand the content, meetings with poor audio quality cause stress for the participants.**
- 2 **The cause of this stress may be due to the particularly increased load on cognitive functions, which, if sustained, may lead to deterioration in the cognitive functions required for participation in meetings, such as comprehension, judgment ability, and response speed.**
- 3 **The stress from not being able to understand the content accumulates throughout the meeting.**

There is generally a limit to the amount of information that humans can process through cognitive functions such as attention, understanding, and judgment. As such, in some situations, the processing of other essential information is inhibited through the selective processing of high-priority information. In this case, it can be assumed that the excessive load of processing audio information inhibits other information processing, such as understanding meeting content and making judgments. Here, we collectively refer to these phenomena as a load on cognitive functions.



Figure1. Pulse (RRI)

An increase in RRI indicates a slowing of the beat. This indicates that the poor audio of the meeting puts stress on the cognitive function.

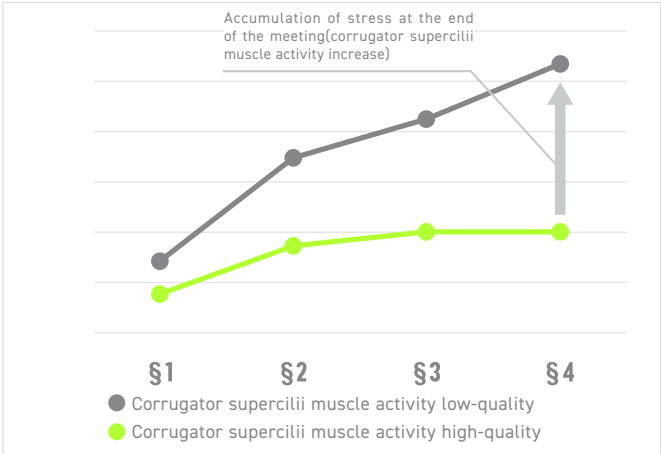


Figure2. Corrugator Supercilii Muscle

Corrugator muscle is known to be activated by unpleasant emotions and stress, and it shows under poor conferencing audio. On top of that, the activation continues to accumulate towards the end of the meeting.

The proper use of audio devices that improve audio quality may reduce the stress caused by online meetings and improve the work environment and productivity.

We hope that the information contained in this white paper will be of use to all those involved in managing and improving employee communication environments and meeting facilities.

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About the Neuro Innovation Unit of NTT Data Institute of Management Consulting

The Neuro Innovation Unit is one of only a small number of specialized teams around the world dedicated to consulting in the field of neuroscience, a field which has undergone remarkable development in recent years.

The unit collects and disseminates information from a global perspective, supports research and business development corresponding to customer needs, promotes industry-academia collaboration, and offers solutions. In addition to R&D and marketing, the unit also helps clients to strengthen their competitiveness and achieve high added value for their businesses in areas such as medicine and healthcare, education, and human resources and management.

About Shure

Founded in 1925, Shure is a manufacturer of audio equipment that is driven by passion and relentless inquiry and has always produced high-quality microphones and audio devices throughout its history. As an innovator in the audio field, Shure has played a role in many of the 20th century's most iconic concerts, speeches and other historic moments, and provides microphones, headphones, software, and conference solutions offering excellent performance and reliability for everything from boardrooms to stadiums. Shure continues to set the global standard for the industry.

MORE DETAILS

<https://www.shure.com/en-US/conferencing-meetings>





WHAT WE KNOW FROM OTHER STUDIES

Companies in the US and Europe have long recognized that online meetings can lead to success in business and have increasingly incorporated them into their business.

Taking Japan as a representative example of a global phenomenon, the introduction of these online meetings received a massive boost from the impact of COVID-19. One survey found* that at least 70% of businesspeople in Japan had been recommended or instructed by their company to work remotely. The national government and local governments also promoted and supported remote working through remote working subsidies and other such measures.

When online meetings were first introduced, many positive aspects such as reduced travel time and expenses and improved work styles were realized, but over the course of time, problems and issues unique to online meetings have also been pointed out.

For example, problems like not being able to establish a connection prior to a conversation due to issues such as network connection or application trouble simply do not occur in face-to-face communication.

We must also not overlook the fact that it is difficult to read the emotions and responses of participants in online meetings. It is generally considered that both visual and aural information is important in meetings.

Many people may feel, among other things, that visual information in online meetings cannot be shared due to limitations such as camera on/off status, performance, screen size, and angle of view. Further, poor visibility can make it difficult for remote participants to know who is speaking in a conference room in which there are many people.

But what about aural information? We often hear comments about it being difficult to make out what is being said, and there are a variety of factors behind this. According to a survey previously conducted by Shure in the United States, the most common complaints about audio in online meetings include background noise (51%), echo (43%), audio interruption (40%), and the audio quality itself making things difficult to hear (40%). (Figure 3)

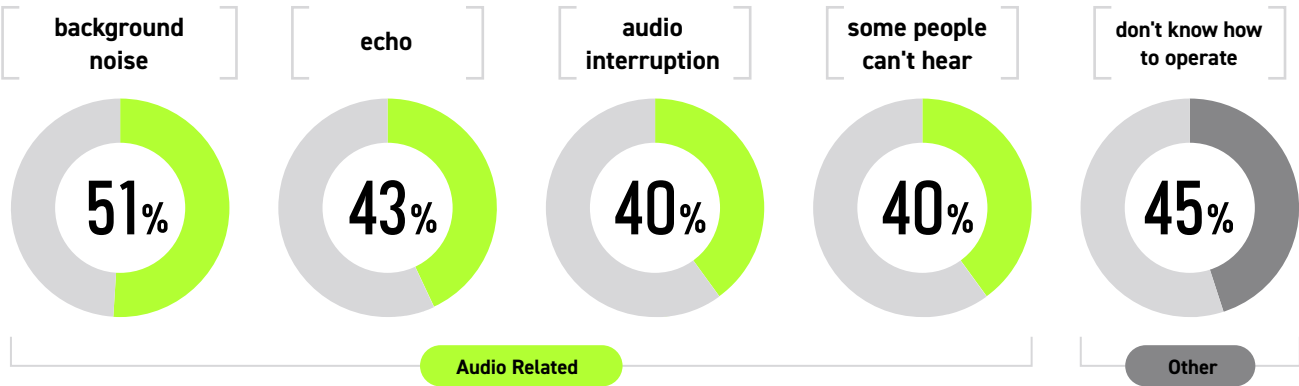


Figure 3. Complaints at meetings TOP5

82%

of business representatives experienced negative impacts from poor audio quality

MORE THAN 1/3

of employees say audio problems lead to lower job satisfaction



More than 80% of respondents said they experienced negative impacts from poor audio quality, with more than one-third of respondents saying they had suffered reduced job satisfaction.

The important fact to note here is that while video quality is important, audio quality is critical in meetings. Over the course of many years, people have become used to communicating and holding meetings by phone. In these instances, a successful outcome is achieved with audio information, even in the absence of visual information. The same normally doesn't hold true the other way round.

In a past survey, the percentage of respondents who said that online meetings were better when the image is improved stood at 19%, whereas the percentage of people who said that meeting productivity improves massively when the audio is perfect was 81% (Figure 4).

Thus, insufficient audio quality in online meetings creates practical inconveniences, such as meeting delays, rescheduling, and making a poor impression on individual customers. At the same time, this unsatisfactory situation creates stress for both speakers and listeners, the accumulation of which can potentially result in reduced productivity and work engagement, and this is often heard from people on the ground. However, this stress has almost never been subject to a scientific quantitative assessment.

As such, the project team conducted an experiment to measure biological stress response and quantitatively assess stress levels to determine if listeners experience stress due to differences in audio quality in meetings. This report sets out the results of the experiment.

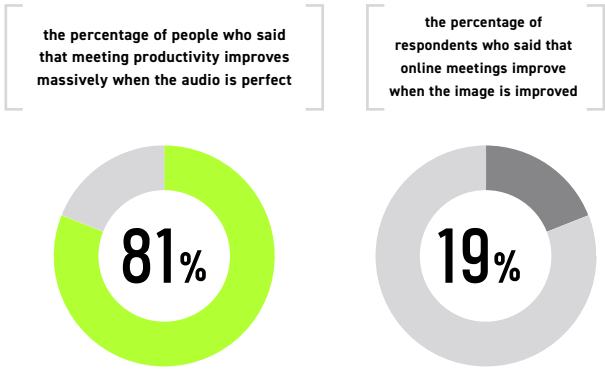


Figure 4. Image VS Audio (U.S. Survey Results)

*Source: Corona Shock & Corporate Communication Urgent Survey of 1,500 People | CCL | Nikkei BP Consulting (nikkeibp.co.jp)

OVERVIEW OF STRESS ASSESSMENT EXPERIMENT

LISTENING TO AND SUMMARIZING AUDIO FROM DIFFERENT MEETINGS, AND THE BIOLOGICAL RESPONSE MEASUREMENT

Meeting Audio Data

First, in order to verify the impact on stress of differences in audio quality at meetings, we created two types of meeting audio data with different audio quality using high-quality audio from public online symposia available on the internet.

For high-quality audio, we used a speaker to simulate the person speaking and set up a high-quality boundary mic (Shure MXA310) in its immediate vicinity, and then recorded the audio data from the symposia in order to appropriately replicate an online meeting environment.

For low-quality audio, we set up the type of camera with a mic that is generally used for meetings approximately 6.3 m/20,7 ft away from the speaker simulating the person speaking, and in the middle placed two acrylic partitions along with an air circulator set to low-speed mode. This setup was used to record the audio in the worst possible online meeting environment as actually witnessed by Shure in the course of the many on-site surveys it has conducted for its customers (see Appendix for details).

The original recording of each symposium was carefully edited to reduce the length to one and a half to two minutes, and to select audio-only sections containing no visual aids, such as slide share. From the seven online symposia, we created a total of 20 meeting samples.

We then created both high-quality and low-quality versions of each meeting sample, for a total of 20 pairs or 40 audio clips.

And in order to eliminate the impact of volume, we adjusted the 40 audio clips so that the average volume was equal.

The participants in the experiment were 10 male and 10 female company employees who take part in online meetings on a daily basis. The age range was 26 to 49, and all participants were right-handed with normal hearing capabilities.

The participants were given an explanation, and after being fitted with measuring instruments, they cycled through steps 1 to 4 below 20 times (Figure 5).

Participants

1. Rest: 1 minute
2. Listening to meeting audio: 1.5–2 minutes
3. Writing down a summary of the content: 20 seconds
4. Responses to the survey

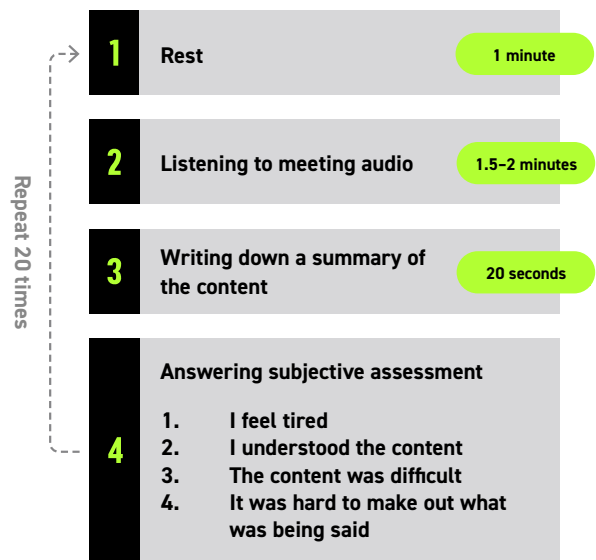


Figure 5. Overview of Assessment Experiment - 1

A different meeting audio clip was played each time. 10 of the clips were low quality, and the remaining 10 were high quality. The order of low-quality and high-quality clips was randomized. The time taken for the experiment was one hour in total.

During the listening in step 2, the participants did not take any notes and were told to just listen to the clip. They were also instructed to avoid moving their head and arms as much as possible during the experiment, and that their facial expressions could be natural. The participants were asked to be sure not to close their eyes. The details of the task were displayed to participants on PC screens during the experiment, and only the summarization part was performed by writing on paper with the right hand (to which no measurement instruments were attached).

For the questionnaire in step 4, participants answered the four questions below on a PC screen using a VAS (visual analog scale*) ranging from 0: Not at all applicable to 1: Very applicable.

VAS (Visual Analog Scale)

1. I feel tired
2. I understood the content
3. The content was difficult
4. It was hard to make out what was being said

A scale that enables respondents to freely indicate their self-assessment on a non-incremental line, and it is thought of as a scale that allows minute differences and changes to be measured.

Stress Indicator Measurement

In this experiment, we measured the following three biological stress indicators in order to assess the stress caused by differences in meeting audio quality. The device we used was the BIOPAC SYSTEMS MP160 system, and the analysis software we used was AcqKnowledge. (Figure 6.)

1 Pulse (Heart rate)

In general, increases in blood pressure due to increased cardiac activity, such as increased cardiac output and heart rate, are commonly seen in cases of stress involving activity where participants must be actively involved, such as calculation tasks. Conversely, stress in situations where participants are passive, such as exposure to noise or cold water, generally results in an increase in blood pressure due to increased constriction of blood vessels, such as a decrease in cardiac output and heart rate.

We recorded electrocardiograms using BIOPAC's ECG100C amplifier for electrocardiograms.

2 Corrugator supercillii muscle activity (frown between eyebrows)

It is known that the stress response due to unpleasant emotions can be assessed by measuring the minute activity of the muscle between the eyebrows.

We recorded electromyograms using BIOPAC's ECG100C amplifier for electromyograms.

3 Electrodermal activity (hand sweat)

It is known that the psychogenic sweating seen in palms, fingers, and other locations caused by increased tension and other such arousal levels indicates increased electrodermal activity, and this is an indicator that can be used to assess stress as the sympathetic nervous tone and so-called excitement.

Recorded using BIOPAC Electrodermal Activity Amplifier EDA100C.

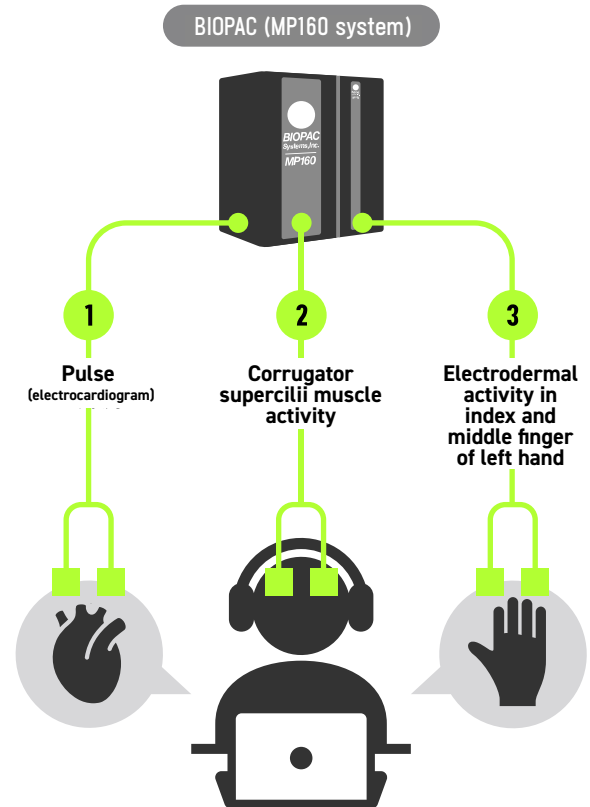


Figure 6. Overview of Assessment Experiment -2



EXPERIMENT RESULTS 1: SUBJECTIVE ASSESSMENT

POOR AUDIO QUALITY MADE THE CONTENT SEEM MORE DIFFICULT, AND INCREASED STRESS ON THE LISTENER

The subjective assessment results from the questionnaire showed that participants felt more stressed in the low audio quality condition than in the high audio quality condition.

First, focusing on the two central results in Figure 7, we see that in the low audio quality condition (gray), compared to the high audio quality condition (green), the participants not only **(1) did not understand the content, but also judged the content to be more difficult.**

In addition, focusing on the rightmost and leftmost results, it was found that although (1) it was clearly more difficult to hear in the low quality (gray) condition than in the high quality (green) condition, **(2) the degree of fatigue, which is positioned as one indicator of subjective stress, did not differ significantly from the high-quality conference audio.**

The poor audio quality of the meeting not only makes it difficult to fully hear the audio and understand the content, but also makes the content seem more difficult, which in turn puts a greater burden on the people participating in the meeting.

The "p" in the graph annotation indicates the probability that the results of the low and high audio quality conditions are statistically the same. In general, if this value is smaller than 0.05, the probability that the results are the same is considered to be extremely low (statistically significant difference between the conditions).

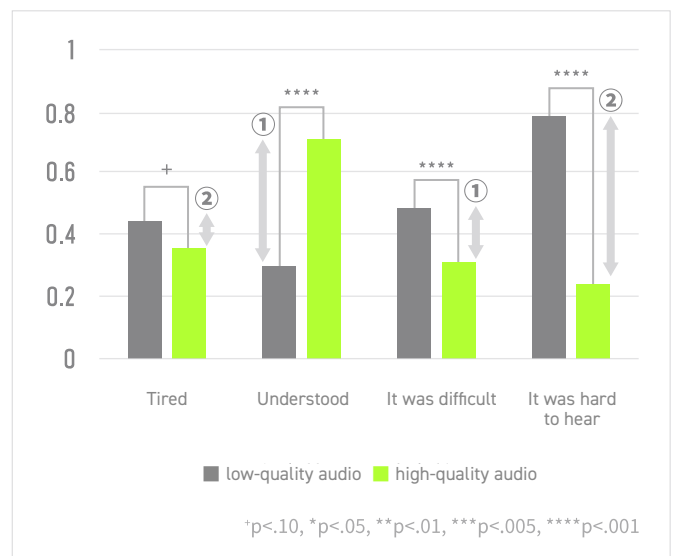


Figure 7. Results of Subjective Assessment

- 1 Poor conference audio quality makes the content seem more difficult to understand.
- 2 There were no significant differences in the degree of fatigue perceived by the participants in this experiment.



EXPERIMENT RESULTS 2: PULSE (HEART RATE)

POOR AUDIO QUALITY INCREASES THE LOAD ON COGNITIVE FUNCTIONS AND INHIBITS POST-HEARING RESPONSE BEHAVIOR

The heart rate measurements provided a more detailed picture of the type of stress caused by low quality conference audio.

Figure 8 shows the time series of each meeting audio (1.5 to 2 minutes) divided into 4 sections, RRI (RR Interval: the interval between two adjacent R waves in the ECG) in each section (§) and the difference from the RRI at rest (average for all participants) is shown. Look at Figure 8, noting that as the heart rate falls, the RRI value rises, and conversely, as the heart rate rises, the RRI value falls.

As mentioned earlier, the heart rate is known to increase with stress involving active activities, such as computational tasks, and conversely the heart rate decrease with stress involving passive activities, such as enduring cold water. If listening to the conference audio is stressful in this case, it is considered to be a passive stress of focusing more on the audio, since no action is specifically required. This more concentrated state (higher load on cognitive function) will be evaluated as a lower heart rate and higher RRI.

In the leftmost §1 of Figure 8, the RRI was markedly elevated only for the low-quality conference audio (gray), indicating that **(1) a stress response associated with increased load on cognitive functions occurred at the beginning of the listening session.**

Such an elevated RRI response is known to involve activity of the vagus nervous system and can be viewed as the body's attempt to brake and respond to stimuli (stress) that have a high load on cognitive functions.

It can also be seen that the RRI values in both the low and high audio quality conditions show a gradual downward trend as the section progresses. This can be taken as the body preparing for the active activity of writing down the summary content after listening.

With respect to this body preparation, in the rightmost §4 of Figure 8, for example, the low tone quality condition (gray) showed a smaller decrease in RRP, i.e., a smaller degree of heart rate increase, than the high tone quality condition (green), indicating that **(2) the body's preparation for the summary transcription was delayed.**

These results indicate that poor audio quality in meetings causes stress on cognitive functions, which induces stress in the participants' attempts to understand the audio, and that this stress also interferes with their ability to organize the content and prepare for the question-and-answer session.

In an actual meeting situation, **reactions to what others say are very important, such as agreeing with what they say and sometimes trying to persuade others, but the poor audio quality of the meeting may have reduced these reactions as well.**

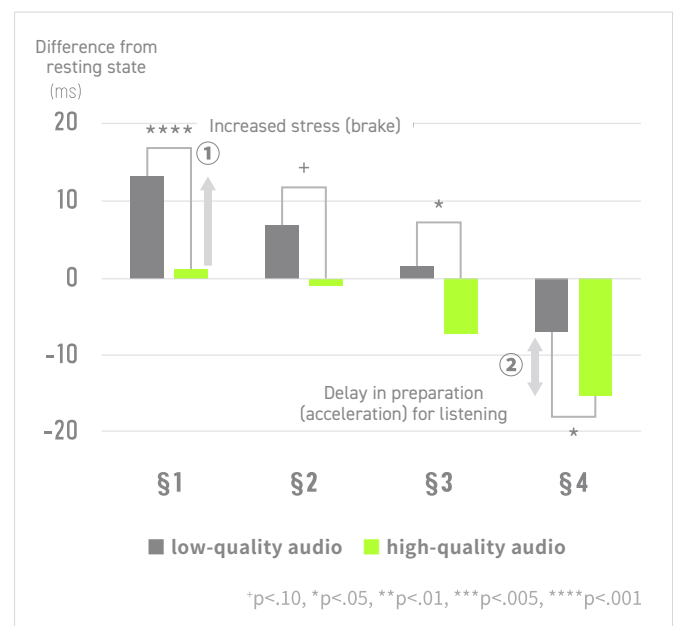


Figure 8. Difference in heart rate from resting heart rate

1 Poor conference audio quality causes stress due to the increased load on cognitive functions.

2 Poor conference audio quality also inhibits responses to what others say.

EXPERIMENT RESULTS 3: CORRUGATOR SUPERCILII MUSCLE ACTIVITY

STRESS DUE TO POOR AUDIO QUALITY ACCUMULATES

Measurements of wrinkled brow muscle activity, which moves during the so-called "furling of the brow," revealed temporal changes in stress caused by low-quality conference audio.

Figure 9 shows that, as with the heart rate, each conference audio was divided into sections over time. It shows the percent change in corrugator supercilii muscle activity in each time course section with respect to the resting corrugator supercilii muscle activity (average for all participants).

The rightmost §4 of the graph shows a significant increase in the rate of change in the low audio quality condition (gray) compared to the high audio quality condition (green), indicating that **(1) the stress response with the largest unpleasant emotion occurred at the end of the listening phase.**

Stress associated with cognitive load, as confirmed by heart rate measurements, was more pronounced at the beginning of the listening session, whereas **stress responses with unpleasant emotions**, as seen by corrugator supercilii muscle activity, were seen toward the end of the listening session. This suggests that although the participants were focused on listening at the beginning of the listening session, it gradually became apparent that they were unable to listen (or perform the writing task), and their **emotional stress about this increased.**

The rate of change in corrugator supercilii muscle activity in the low audio quality condition (gray) increased as the section progressed, indicating that (2) poor conference audio quality gradually increases stress with unpleasant emotions.

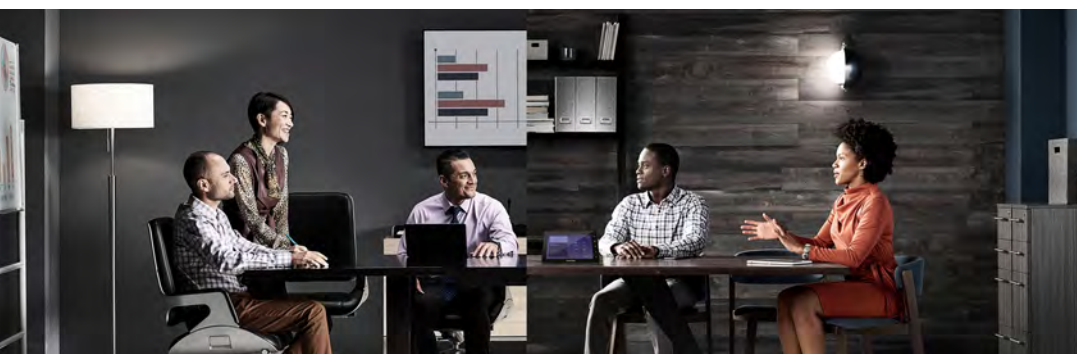
Although this meeting audio clip was shorter than the actual meeting, lasting 1.5 to 2 minutes, these differences still suggest that **the effects of stress may be more severe** if the poor audio quality continues further or is chronically occurring.



Figure 9. Change in corrugator supercilii muscle activity from Resting State

1 Poor conference audio quality causes stress with unpleasant emotions.

2 Stress with unpleasant emotions accumulates throughout the meeting and can be severe.



EXPERIMENT RESULTS 4: ELECTRODERMAL ACTIVITY

STRESS DUE TO POOR AUDIO QUALITY IS NOT CAUSED BY AROUSAL OR TENSION, BUT BY LOAD ON COGNITIVE FUNCTION

Measurements of electrodermal activity, which measures mental perspiration of the palms and fingers, suggest support for the type of stress revealed by the heart rate measurements.

As mentioned above, electrodermal activity reflects psychogenic sweating seen in the palms and fingers due to increased arousal levels, such as tension, and is known to increase with sympathetic nervous tone or so-called excitement.

Figure 10 shows the values of electrodermal activity in each section of the conference audio, divided by time course, as well as heart rate and corrugator supercilii muscle activity, averaged across all experimental participants. Transient activity was observed in §1 at the beginning of the listening task in both the low (gray) and high (green) audio quality conditions, indicating that the meeting audio listening task involves some degree of tension and arousal. However, unlike heart rate and corrugator supercilii muscle activity, there were no significant differences in audio quality in either section.

This indicates that **(1) poor conference audio quality does not cause increased tension or excitement.** This is consistent with what heart rate measurements have revealed: that stress due to poor meeting audio quality is caused by an increased load on cognitive function. **Arousal, tension, and excitement can be physically and mentally taxing when overexcited, but in actual meetings, they are needed in moderation for activities such as understanding the content, responding to what is said, and making judgments.**

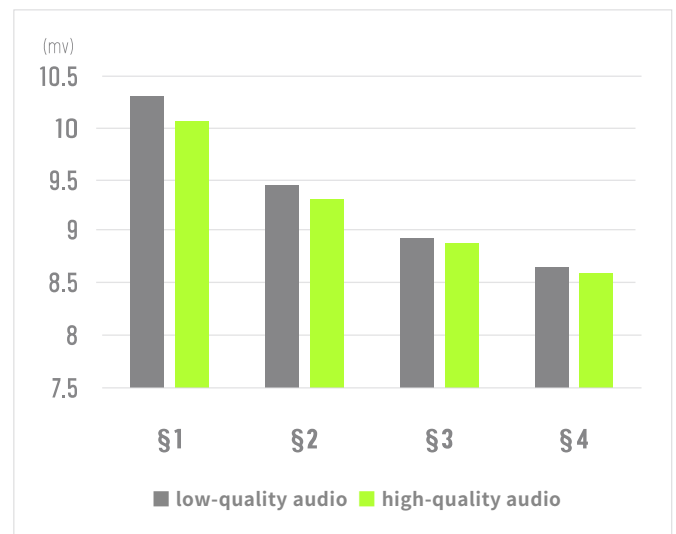


Figure 10. Transition in electrodermal activity

Stress due to poor conference audio quality is not due to arousal, excitement, or tension, but rather to load on cognitive functions.





MEETINGS WITH POOR AUDIO QUALITY CAN CAUSE ACCUMULATING STRESS AND HAVE A NEGATIVE IMPACT ON WORK

KENTA KIMURA

National Institute of Advanced Industrial Science and Technology (AIST) Human Information Interaction Research Division Psychosomatic Function and Modeling Research Group Research Group Leader

This experiment focused on the audio quality of online meetings and examined the effects of changing the audio quality on people's stress. In general, studies of audio quality and stress often focus on how obvious noise, such as white noise, produces stress. In this context, the focus on the audio quality of online conferencing, which is becoming a standard conferencing method, especially since the COVID-19 pandemic, is very interesting from both an academic and real-world application perspective.

The results of the experiment conducted showed that when **the audio quality of online conferences is low, stress accumulates among conference participants**. The key point is that deterioration in audio quality creates stress on cognitive functions. In general, there is an upper limit to the amount of information that can be processed in human cognitive activities (paying attention, understanding, judging, etc.). Therefore, attention to the information that needs to be processed and allocation of sufficient cognitive resources are necessary to properly process the information and take appropriate actions in the surrounding environment. This concept is called allocation of cognitive resource.

Conversely, when cognitive resources must be allocated to inappropriate information, appropriate behavior is inhibited. Therefore, with poor conference audio quality and stress on cognitive functions, **excessive cognitive resources are devoted to processing audio information, which leaves fewer cognitive resources available for other, higher-priority information**.

In a real-life situation, this leads to the concentration on listening to the conference audio, **which inhibits the cognitive activities that are most necessary in a meeting, such as understanding, reviewing, and judging the content of the meeting**. Needless to say, such a condition **would be considered a hindrance to various operations**.

It is also important to note that the results of this experiment were observed not only in survey responses, but also in heart rate and other physiological activities. This indicates that online meetings with poor audio quality may also act as a physiological stressor for people.

It is widely known that the accumulation of physiological stress has a detrimental effect on mental and physical conditions. Of course, we do not know the actual influence of the deteriorating meeting audio quality on the psychosomatic state, since the present experiment was conducted under the experimental situation of listening to a 2-minute audio recording.

However, one can imagine that poor conference audio quality in an online meeting during work, where there is no room for missed listening, would be **a stronger stress than in the experimental situation**. Furthermore, if this situation is repeated on a daily basis, it is quite possible that it will affect the mental and physical state of the meeting participants. Accordingly, the results of this experiment suggest that **online meetings with poor audio quality may accumulate not only in terms of work efficiency but also in terms of mental and physical stress**.

The results obtained from this experiment will serve as fundamental research results to promote attention to audio quality in online conferencing and to explore more efficient ways of conducting online conferences, which are now established as a standard method of conferencing.

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SUMMARY

IMPROVING THE QUALITY OF ONLINE MEETINGS IS THE FIRST STEP IN DEVELOPING MANAGEMENT INFRASTRUCTURE FOR NEW WAYS OF WORKING

Through the experiments conducted in this study, it became clear that poor audio quality in meetings, even if it is only for two minutes, increases the load on cognitive functions and induces stress.

We also found that this stress inhibited preparation for actions such as responding after listening, asking questions, and writing down the content. Furthermore, we found that not only stress due to load on cognitive functions, but also **stress with unpleasant emotions accumulated throughout the meeting.**

Some participants commented that the poor-quality conference audio they heard in this experiment was similar to the web conference audio they heard when several people gathered around a single computer to participate in a meeting in their actual workplace due to the lack of audio equipment for conferences. The recording environment that we experimentally set as a low sound quality condition may not necessarily match your work environment (online conference environment), but in reality, a combination of various factors such as the influence of environmental noise and network problems not covered in this study may have resulted in the same sound quality in the conference.

If the audio quality is such, even if only temporarily, it may be causing stress to the meeting participants as indicated in this case.

In an actual online conference situation, even if the sound quality is poor, it may be possible to understand the content by referring to the conference materials. If that is the situation, then problems due to the sound quality of online meetings may not come up much in internal surveys. Or, after the meeting, they may not have the motivation to report again to the IT or general affairs department responsible for the company's facilities to request improvements. However, as the results of this experiment show, participants may have accumulated stress at the stage of listening to poor-quality conference audio.

When such a bio-stress reaction occurs, even if **the person did not consciously feel it, there may be unconscious stress building up.** In turn, this may lead to a negative impression of the meeting itself. Negative impressions may lead to lower work engagement and productivity among participating employees and could negatively impact sales results and performance if the participants are clients.

Ensuring good meeting quality is not only a business infrastructure improvement to **reduce stress among meeting participants**, but **also an important management infrastructure improvement for new ways of working**, in terms of **ensuring employee engagement** and improving efficiency and productivity in all corporate activities.

Even after the COVID-19 pandemic has ended, online conferencing will be here to stay. In conjunction with the concurrent reform of work styles, communication environments, including meetings and conferences, have become a diverse mixture. These include connecting multiple people gathered in a conference room to a home or outside office, or connecting multiple locations, including satellite offices, to an individual. This trend is expected to continue.

In this current situation and outlook, the first thing that needs to be addressed to reduce stress in online meetings as much as possible is to solve the problem of **being unable to hear what is being said by those participating from the conference room. This problem is seen in many hybrid environments,** such as that described above.

In other words, the problem is often with **the equipment in the office conference room,** rather than with the teleworkers, who are wearing earphones with microphones and are therefore able to hear themselves relatively well.

Between 2020 and early 2021, approximately 50% of corporate facilities managers said they would increase their investment in conferencing systems (Shure's research report, "Issues and Needs in the Field, Based on Awareness Surveys"), but in 2022, both this percentage and the amount of investment are trending upward, according to the many consultations Shure undertakes for clients.

Most of the requests Shure receives regarding audio equipment (microphones, speakers, etc.) for online conferencing are either about installing new equipment from scratch in an empty conference room, or about using inexpensive, easy-to-use integrated equipment that was eventually inadequate for the size of the space and does not capture what is being said. In such cases, the fixed equipment that meets the communication needs of the organization has to be installed in each meeting room again.

In some cases where there are problems with participants' behaviors in online meetings and discussions or poor communication, we should not only attribute them to individual staff members and their responsibilities, but also consider whether there **may be a potential equipment cause of participants being unable to hear in the first place.** And if this becomes apparent, seek advice. In the first instance, we recommend consulting with the system integrator or other partner company responsible for installing and maintaining the in-house equipment.

While everyone shares the awareness that facilitating communication is fundamental to business continuity and corporate operations, **in an age where staff are dispersed and connected online,** there is also a need to assess what is really happening on the ground and quickly invest in appropriate environmental improvements.

REFERENCE

MAKE CONNECTIONS FEEL EFFORTLESS

<https://effortless.shure.com/>

SHURE CONFERENCE & MEETINGS

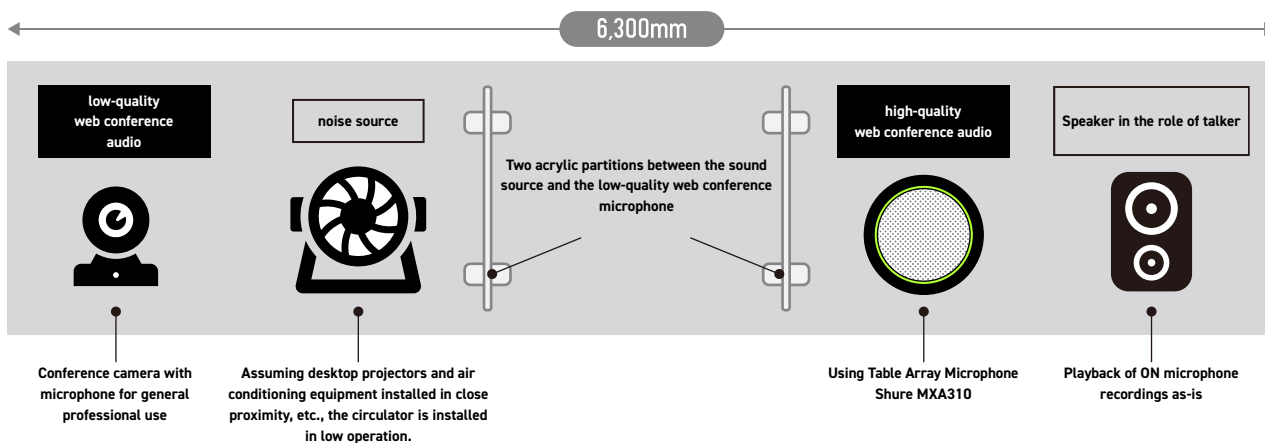
<https://www.shure.com/en-US/conferencing-meetings>

APPENDIX

Appendix 1 Environment for recording voice data

Recording
Method

- Using symposium panel discussion sound files from the Japanese government's Internet TV recorded with appropriate microphone set up.
- As a simulation of speech, the above is played back on reference speakers commonly used in recording studios.
- High-quality web conference audio and low-quality web conference audio recorded with the following settings were simultaneously recorded on two tracks and each was exported to an uncompressed audio file.



Appendix 2 Details of the actual voice data used

ID	TOPIC/THEME	START TIME	END TIME	LENGTH
1	Playback of ON microphone recordings as-is	2:05:47	2:07:46	1:59
2	External influences on community revitalization	2:17:43	2:19:37	1:54
3	If we were to take a step toward improving the community	2:46:57	2:48:40	1:43
4	Preparing for a major disaster under the COVID-19	1:59:02	2:00:42	1:40
5	What is Needed for Flood Prevention in Tokyo	2:06:16	2:08:04	1:48
6	Importance of Local Communities in Times of Disaster	2:09:30	2:11:23	1:53
7	Necessary measures for the penetration of national land resilience	2:13:09	2:14:55	1:47
8	Impressions and Prospects of the 5G Demonstration Experiment	1:53:17	1:55:01	1:44
9	Message to Students	2:23:09	2:25:00	1:51
10	Basic data is important for policy	1:50:06	1:51:51	1:45

ID	TOPIC/THEME	START TIME	END TIME	LENGTH
11	Changing Perceptions of Enlightenment	2:01:43	2:03:17	1:34
12	Nurture a spirit of protection of the marine environment	1:52:48	1:54:41	1:53
13	Cooperation of citizens that the recycling industry would like to obtain	2:10:18	2:11:15	1:37
14	What is important in women's success	1:58:09	1:59:56	1:47
15	What Matters in Human Rights Due Diligence in Japan	2:14:41	2:16:23	1:42
16	Challenges for Japanese Companies in Human Rights Due Diligence	2:17:43	2:19:22	1:39
17	Human Rights Due Diligence in Supermarkets	2:19:42	2:21:42	2:00
18	Operator Initiatives on 6G	2:10:41	2:12:26	1:45
19	Features of the region that make the idea a reality	2:40:43	2:42:13	1:30
20	Local Blue Ocean Initiative Policy	2:17:15	2:19:10	1:55