

# PulseChat: An investigation into shared heart rate information in the workplace

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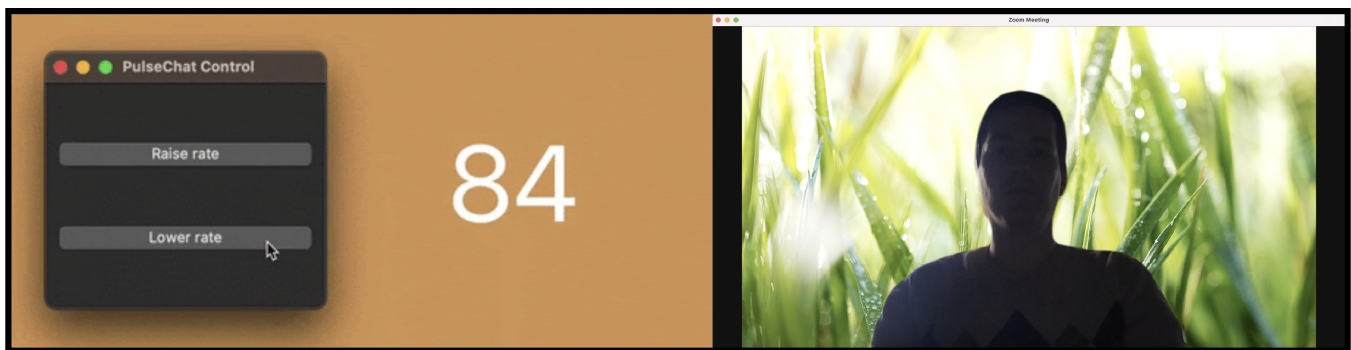


Figure 1: The PulseChat System (left) Teleconferencing Information Loss Example (right)

## ABSTRACT

The idea that digital interactions can use new techniques to surpass their physical counterparts has long been present in HCI research [3]. In the age of COVID-19 this idea has perhaps never been more relevant. With an increasing amount of communication being conducted remotely, there is a real opportunity for users to adopt new tools that would not be possible or acceptable in a world that primarily engages in face-to-face interactions. Along these lines, we present PulseChat, a prototype heart rate monitoring system that broadcasts a user's pulse to other users in a video conference. We explore the degree to which this technology may decrease levels of confrontation in remote work environments and how willing the average user may be to adopt such a system. Through an informal study, we find that sharing pulse rates does not lead to significantly different interactions, but it can negatively impact perception of the monitored subject if their heart rate fluctuates. Additionally, we report results that suggest universal reticence to use technology

along these lines. Finally, we discuss next steps for future research that may make this concept more effective and palatable.

## CCS CONCEPTS

• **Human-centered computing** → Empirical studies in HCI.

## KEYWORDS

biofeedback, biosignal communication, heart rate, video conferencing

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## 1 INTRODUCTION

With the sudden post-pandemic development of ubiquitous teleconferencing in the workplace on our minds, we began our project with the goal of combating the interpersonal information loss found in teleconferencing. Specifically, we wanted to recover lost emotional cues between teleconferencing participants. In an attempt to pinpoint a measurable and specific emotional cue to recover, we formulated the question: Will users be less confrontational if they have access to others' heart rates in a workplace environment? With our question, we assume that users may miss body language cues such as rigid posture, hand wringing, or foot/leg movements

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that could imply anxiety, and we replace those cues with a new one, heart rate. We believe that heart rate has a direct correlation to perceived anxiety (i.e. users will associate a high heart rate with high anxiety and a low heart rate with low anxiety). Results from our post interview survey reinforce this belief. To test our hypothesis, we propose to communicate a user's heart rate via a color and number system displayed over a window and to try to understand whether or not the ability to perceive a stranger's heart rate leads a person to engage in less confrontational lines of communication over teleconference. We are also interested in the general effects that a heart rate display will have on user's perceptions of each other, and we tailored our post-interview survey to garner such information.

## 2 RELATED WORK

Our work builds on two areas of research: biofeedback and biosignals in communication.

### 2.1 Biofeedback

Similar to EmotionCheck [1] we use heart rate to understand if and how access to biofeedback can affect conversations. While EmotionCheck explored the possibilities posed by an individual having access to their own biofeedback, PulseChat is interested in what happens when an individual has access to someone else's heart rate. In this way, it bears elements in common with CandidInteraction [2], in which a device wearer's actions are broadcast to other people. PulseChat builds on the work performed by both of these systems and attempts to ascertain the conversational ramifications of virtual interactions that are supplemented by biofeedback.

### 2.2 Biosignals in Communication

Literature review reveals a system with similarities to PulseChat, but in a gaming context - All The Feels [6]. Our project aims to focus on biometric displays being used for two-way social interaction rather than self-regulation or one-way communication while streaming gameplay. We also build on recent works by Fannie Liu and her colleagues as they have been working on biosignals in communication with their 2017 paper Emotionally Expressive Heart Rate Texting [4] and 2021 paper Significant Otter [5] in which users choose to share their heart rates at specific moments with specific people. Our system shares the goal of analyzing the results of heart rate sharing on human interaction with these two papers, but where they look for information about private channels of communication, we look for information about more general and less personal channels of communication.

## 3 PULSECHAT SYSTEM

PulseChat is a device that measures a person's pulse and displays the user's heart beats per minute with a color coded system. The pulse data is then sent to a server implemented in Go and hosted on Amazon Web Services. The server then forwards the data to a web front-end implemented using React. The front-end consists of a number representing the heart rate being displayed at the center of the page with a colored background. If the heart rate is close to the person's resting heart rate, then the screen background displays a green color. When the person's heart-rate rises beyond

normal range, the background color displays a yellowish orange color (Figure 1, middle).

While we did not implement live heart-rate measurements, it would not be difficult to implement a smartwatch app that sends data to our servers, which is then displayed on the front end. To imitate a working prototype of PulseChat for the study, the Go server randomly generates a number within a defined range. This number range is controlled by another interface implemented in Go (Figure 1, left), thus allowing us to imitate the rise and fall of a real heart-rate during an interview.

## 4 USER STUDY: EVALUATING EFFECTIVENESS OF PULSECHAT

We performed a Wizard of Oz style study, which we enhanced after a pilot study, using our working prototype to see if the system had an effect on the user's actions and impression of the person whose heart rate is being displayed. Our study also had an additional goal to get a general idea of how the system is perceived.

### 4.1 User Study Participants

Our study involved twelve participants, 7 of whom were female and 5 of whom were male. The ages of the participants ranged from 21 to 65, with a median age of 25. We recruited from the author's social circle, but during the study we made sure that the study facilitator and the actor were unknown to the participants in order to avoid confounding variables.

### 4.2 User Study Procedure

Each participant was asked to interview another participant (the other participant was actually a confederate). The scenario the participants were given was as follows, "You work for a large company and your boss has tasked you with putting together a team of employees from other parts of the company to work on a very important project. You will be interviewing potential team members and deciding whether or not you would like them to join your team." The participants then went on to ask the confederate 20 questions, which received canned responses from the confederate. Video was turned off to reduce bias. The questions were structured so that every other question was an introductory question and then there were two possible follow up questions that the participants had to choose from. Each of the pairs of follow up questions included one more confrontational question and one less confrontational question (the perceived level of confrontation of the question pairs was verified with a survey). After the interviews, the participants were walked through a post-interview survey by the interview facilitator in order to ensure understanding of all questions and to receive real-time feedback on their perceptions of the interviewee and (when applicable) the PulseChat system.

The participants were split into 3 groups of 4 people. One group acted as the control group, and conducted the interview without knowing the existence of PulseChat. The second group was shown the PulseChat front-end with the heart rate hovering around 60 beats per minute. The third group was shown the PulseChat front-end with the heart-rate varying in level. For each participant in

**Table 1: Bi-variate Analysis of Question Selection**

Question Type	Elevated	Non-Elevated	No HR
Confrontational	12	24	20
Non-confrontational	12	32	20

this group, 6 out of 10 questions were designated as elevated heart rate and 4 were designated as non-elevated (resting) heart rate. Questions were divided into five contiguous pairs, each of which was randomly assigned a designation. This was done to imitate real heart rates, which would not be able to change quickly enough to switch on each question.

### 4.3 User Study Results

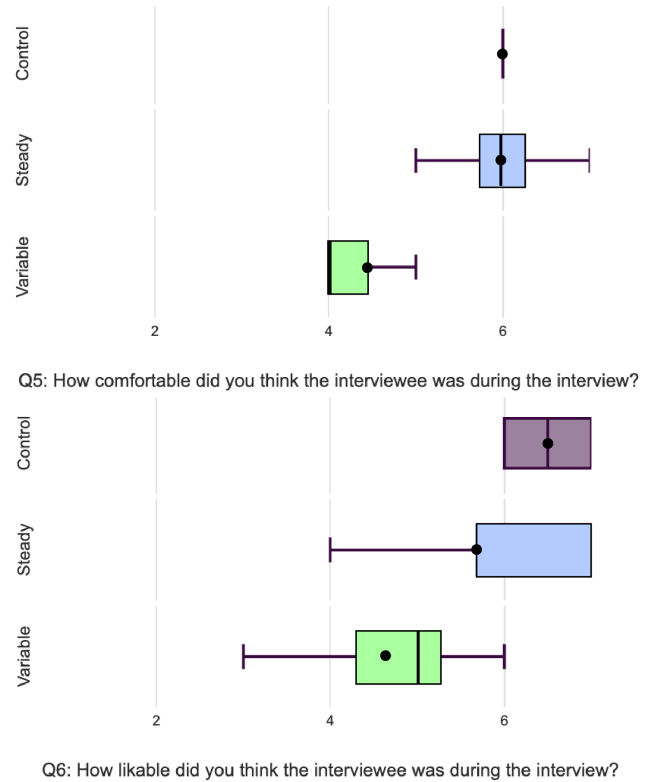
**4.3.1 Quantitative.** The post-interview survey was made up of 9 questions utilizing a Likert scale from 1-7, where 1 is the least effect and 7 is the strongest effect for any given question. There were also several multiple choice questions with areas for free typing to justify responses.

*PulseChat Influence:* There was no significant difference between the variable (Q9; score=3.00, SD=1.63) and non-elevated (Q9; score=4.00, SD=1.41) groups with regard to their interaction with the system - both groups mainly saw the influence of PulseChat to be neutral. Furthermore, not a single participant from the experimental groups (control group was not asked this) thought that having people display their live pulse information during regular work video conferences would reduce workplace hostility (Q12; Yes=0, No=4, Maybe=3, Unsure=1).

*Follow-up Question Selection:* There was no quantitative data to support that the system affected follow-up question selection. Bi-variate analysis (Chi-squared = 0.61, df = 2, p-value = 0.74) revealed that there was no relationship between the status of the displayed pulse (none, non-elevated, variable) and what type of follow up question was asked (confrontational or non-confrontational). Furthermore, there was great intragroup variability when participants were asked if the system influenced their follow-up question selection in both variable (Q8; score=3.25, SD=1.5) and non-elevated (Q8; score=3.5, SD=2.38) groups, but the intergroup scores were similar.

*Views of the Interviewee (Confederate):* As depicted in Figure 2, the questionnaire results for Q5 and Q6 indicate that the variable group saw the confederate as less comfortable (Q5; score=4.25, SD=0.5) compared to the non-elevated group (Q5; score=6.00, SD=0.82) and the control group (Q5; score=6.00, SD=0.00). The variable group also viewed the confederate as less likable (Q6; score=4.75, SD=1.26) compared to the non-elevated (Q6; score=6.25, SD=1.50) and control groups (Q6; score=6.50, SD=0.58).

**4.3.2 Qualitative.** We analyzed our qualitative results (participant quotes) via qualitative coding. All authors collectively clustered data into common themes, debating among themselves until there was mutual agreement on the themes.

**Figure 2: Boxplot by heart rate condition of Q5 and Q6.**

#### Theme 1: PulseChat influenced interview decisions

Although the quantitative analysis showed that the system had no statistical effect on the participants' question selection, this is not the case for the qualitative findings. One of the four participants, P6, in the variable group chose friendlier questions when the pulse was high because they thought it "would calm [the confederate] down". Also, P6 noticed that the heart rate was elevated for most of the time so they "tried to choose the gentler question". Two of the four participants in the non-elevated group tried to influence the heart rate as well, but not in the same manner. P11 was simply "curious to see if [they] could get the [heart rate] to move" and noticed that there was a "friendlier question" and a "stress-inducing question" so they varied their selection based on the type of question. P7 varied their approach, but said that "sometimes [they were] trying to ask questions that [they] think would raise [the confederate's] pulse". These comments suggest that the system conveyed actionable information to the participants, but what they did with that information varied greatly.

#### Theme 2: On allowing others to know about comfort and frustration (appropriate use cases)

Participants were asked to discuss different scenarios and implications for using PulseChat. It is interesting to note that a few participants pointed out that nervousness and fluctuating heart rate does not indicate the actual competence and likability of the interviewee, which contradicted our quantitative findings. P2 was

willing to share their pulse information if they were “comfortable with the subject matter [of the interview]” and if the information was “of use to the interviewer”. P2 also added that sharing their pulse information reduced their ability to “cover up” feelings of being “frustrated with another employee,” but the knowledge that other employees are not aroused can show that they are “calm while they are talking to you,” which “could be a positive thing”. This finding suggests that the system reduces worker’s agency in what emotions are conveyed during the video conference, but it can also demonstrate comfort level in a productive manner.

### Theme 3: PulseChat can be used for personal development

We asked participants to discuss situations that they thought PulseChat could be helpful and got varying responses. One theme that we noticed was the idea that PulseChat could be helpful if used for professional development. P2 said that “it would help [them] prepare more for interviews” to practice having a “slow heart rate”, similar to how they practice their body language. P5 said that they were against regular sharing of their heart rate, but “if it has to do with growth and development of a team or a job, then [they are] okay with it”. P11 brought up the idea that the pulse may have fluctuations due to normal bodily functions instead of acting as a direct indicator for emotion, which is certainly something to consider when users interpret the heart rate information. Additionally, four out of 12 participants also said there is no situation that they would want their pulse information shared while video conferencing.

## 5 DISCUSSION

The results did not align with what our team expected. Initially, we suspected that participants who saw the changing heart rate would empathize with the confederate, ask them gentler questions, and be more charitable with how they viewed them afterwards. Our results contradicted this, despite some participants stating that changing heart rates does not imply that the other person is less competent or likable.

Our findings have a few implications for future usage of heart rate information in a workplace context. First, people were unlikely to be comfortable with sharing heart rate data in a workplace setting. Secondly, heart rate data may not be very useful in a workplace setting due to people needing to appear competent by pretending to be calm even in high stress situations. Furthermore, it is not always clear how people should respond to seeing someone having a high heart rate. These reasons make implementation of heart rate sharing systems in a workplace setting unlikely in its current form.

## 6 LIMITATIONS AND FUTURE WORK

While the results contain valuable information, there were not a large number of statistically significant differences between conditions. Our work is not without limitations, and we see several potential future improvements. We suspect that performing the study with a greater number of participants could reveal trends that were not apparent with only four people per condition. Additionally, while the interview script provided to participants worked well, it could be significantly improved by several more rounds of survey-driven changes. Current concerns include that one of the

two follow-ups may simply work better with the context of the confederate’s scripted answer. More preliminary studies could identify and solve these issues. In the changing condition, we chose to randomize which questions had a high heart rate between participants. We did this randomization in order to combat the aforementioned concerns about the script and the possibility of some follow-ups being more attractive than others, but found that it made analysis difficult. In the future after improving the script, we will standardize which questions are associated with high and low rates in the changing condition. Finally, we believe that an additional condition with a constant high pulse rate would contextualize our results more.

## 7 CONCLUSION

Our goal was to explore new forms of communication to help users better understand each other while teleconferencing. To that end, we created PulseChat, a system that allows users to see a heart rate display, and we conducted a study to understand how having access to user heart rates could affect behavior, specifically levels of confrontation, in a workplace teleconferencing environment. We found no significant difference in confrontation levels between our study conditions. Nevertheless, our post-interview survey revealed that people who saw a varying heart rate had a lower opinion of their interviewee. This tied in to qualitative feedback that participants were nearly universally opposed to sharing their heart rate in a work setting. Based on our feedback, we suspect that the amount of trust users would require to share their heart rate publicly in the workplace is too high to implement this system currently.

## 8 ACKNOWLEDGMENTS

We would like to specially thank the following individual for their consultation of our study design as well as providing insight into biosignal communication.

Fannie Liu

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## A RESEARCH METHODS

### A.1 Participant's Interview Script

#### 1. Tell me about the last time you had a customer, client, or even friend get angry with you. What happened?

- What could you have done to prevent the situation in the first place?
- Did you feel like you learned something from the situation that you could use in other situations?

#### 2. What qualities do you look for in a teammate?

- Can you tell me about a time where you embodied any of those qualities?
- In what ways do you feel that you fall short of those qualities?

#### 3. What kind of work environment do you like best?

- Can you tell me about a time where you meshed really well with a team?
- Say our team didn't match your ideal environment, how would you respond to the mismatch between your desires and reality?

#### 4. What do you do if you disagree with someone at work?

- Have you ever been unable to work things out in a disagreement with a coworker?
- Do you feel like working through disagreements can bring a team closer together?

#### 5. What would you say your weaknesses are?

- What would you say your strengths are?
- Do you feel that those weaknesses would hinder your success here?

#### 6. What is your dream job?

- What motivates you most about that interest?
- Do you think those interests will make you a strong member of this team?

#### 7. How do you handle stress?

- What is your favorite thing to do in your free time?
- This team may require a lot of time and effort. Have you dealt with anything in your life that you feel will prepare you for this experience?

#### 8. How do you handle a challenge? Give an example.

- What could you have improved about your response to the challenge?
- What do you think you learned from your challenge?

#### 9. Have you personally encountered any moral dilemmas to date? Of what nature?

- How would you take what you learned from your experience and apply it in a workplace environment?
- Where do you think that you failed in your response to your moral dilemma?

#### 10. Tell me about a time when you've had to deal with conflict.

- Tell me about a time when you have had to deal with the consequences of your own mistake.
- How would you handle a disagreement with a manager that you do not get along with?

## A.2 PulseChat Questions Survey

4/16/2021

PulseChat Questions

### PulseChat Questions

Hello and thanks for helping us (a team of Columbia CS students) with our project! We would really appreciate it if you could read these 10 pairs of questions and select the option that you think is *\*more confrontational\** between the 2 options of each pair.

When reading these questions you should imagine that you are asking a follow-up question in a job interview.

Thanks again!

-PulseChat Team

Contact: [jla2206@columbia.edu](mailto:jla2206@columbia.edu)

1. Tell me about the last time you had a customer, client, or even friend get angry with you. What happened?

*Mark only one oval.*

☐ Did you feel like you learned something from the situation that you could use in other situations?

☐ What could you have done to prevent the situation in the first place?

2. What qualities do you look for in a teammate?

*Mark only one oval.*

☐ Can you tell me about a time where you embodied any of those qualities?

☐ In what ways do you feel that you fall short of those qualities?

4/16/2021

PulseChat Questions

3. What kind of work environment do you like best?

*Mark only one oval.*

- ☐ Can you tell me about a time where you meshed really well with a team?
- ☐ Say our team didn't match your ideal environment, how would you respond to the mismatch between your desires and reality?

4. What do you do if you disagree with someone at work?

*Mark only one oval.*

- ☐ Do you feel like working through disagreements can bring a team closer together?
- ☐ Have you ever been unable to work things out in a disagreement with a co-worker?

5. What would you say your weaknesses are?

*Mark only one oval.*

- ☐ What would you say your strengths are?
- ☐ Do you feel that those weaknesses would hinder your success here?

6. What is your dream job?

*Mark only one oval.*

- ☐ What motivates you most about that interest?
- ☐ Do you think those interests will make you a strong member of this team?

4/16/2021

PulseChat Questions

7. How do you handle stress?

*Mark only one oval.*

- ☐ What is your favorite thing to do in your free time?
- ☐ This team may require a lot of time and effort. Have you dealt with anything in your life that you feel will prepare you for this experience?

8. How do you handle a challenge? Give an example.

*Mark only one oval.*

- ☐ What do you think you learned from your challenge?
- ☐ What could you have improved about your response to the challenge?

9. Have you personally encountered any moral dilemmas to date? Of what nature?

*Mark only one oval.*

- ☐ How would you take what you learned from your experience and apply it in a work place environment?
- ☐ Where do you think that you failed in your response to your moral dilemma?

10. Tell me about a time when you've had to deal with conflict.

*Mark only one oval.*

- ☐ Tell me about a time when you have had to deal with the consequences of your own mistake.
- ☐ How would you handle a disagreement with a manager that you do not get along with?

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## A.3 Post-Interview Survey

4/16/2021

PulseChat Post-Interview Survey

# PulseChat Post-Interview Survey

Thank you for being a study participant! Please answer the following questions:

### Demographics

1. Name (Type from zoom, don't ask)

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2. What is your age range?

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3. What is your gender?

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4. How experienced are you in interviewing people for jobs?

*Mark only one oval.*

1      2      3      4      5      6      7

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Very Inexperienced   ☐   ☐   ☐   ☐   ☐   ☐   ☐   Very Experienced

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### Interviewee Impression

4/16/2021

PulseChat Post-Interview Survey

5. How likely are you to recommend the interviewee to join your team?

*Mark only one oval.*

	1	2	3	4	5	6	7	
Very Unlikely	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very likely

6. How competent did you think the interviewee was during the interview?

*Mark only one oval.*

	1	2	3	4	5	6	7	
Not competent at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very competent

7. Overall, how difficult did you think the interview you gave was for the interviewee?

*Mark only one oval.*

	1	2	3	4	5	6	7	
Not difficult at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very difficult

8. How comfortable did you think the interviewee was during the interview?

*Mark only one oval.*

	1	2	3	4	5	6	7	
Very Uncomfortable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very Comfortable

4/16/2021

PulseChat Post-Interview Survey

9. How likable did you think the interviewee was during the interview?

Mark only one oval.

	1	2	3	4	5	6	7	
Very Unlikable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very Likable

### PulseChat Impression

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10. How much did you pay attention to the pulse rate display?

Mark only one oval.

	1	2	3	4	5	6	7	
Paid no attention at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Paid very close attention

11. How much influence did the pulse rate information have on which follow-up question you chose to ask?

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very much

12. How useful do you think seeing the pulse information of the interviewee was?

Mark only one oval.

	1	2	3	4	5	6	7	
Not useful	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Very useful

4/16/2021

PulseChat Post-Interview Survey

13. Which of the situations below would you want your live-pulse information shared while video conferencing? (select all that apply)

*Check all that apply.*

- ☐ Regular workplace activities  
☐ Job interview or an admissions interview  
☐ While giving an important presentation at school or work  
☐ During social functions  
☐ Never

Other: ☐ \_\_\_\_\_

14. Could you elaborate on why you chose those options?

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15. Do you think having everybody display their live pulse information during regular work video conferences would reduce workplace hostility?

*Mark only one oval.*

- ☐ Yes  
☐ No  
☐ Maybe  
☐ Unsure

4/16/2021

PulseChat Post-Interview Survey

16. Could you elaborate why you chose that option?

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17. Please give any details that you'd like to share about what informed your decisions during the interview.

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## A.4 Facilitator Script

### INTRODUCTION

1. Hi, I'm [NAME] and I'm a student at Columbia University. This study is for a student project on Human Computer Interaction. Thank you for helping us with our study today! The study you're going to take part in will involve interviewing a job applicant. He is another participant in the study. He does not know what interview questions will be asked, but he does know that the questions will be in the style of a job interview.
2. There is no need for video in this study. So please everyone's camera will be off.

### EXPLANATION OF PULSECHAT [ONLY IF DOING HEARTRATE]

3. We have attached a heart rate monitor to the other participant. You are free to use the information or not.
4. We have created a website to receive heart rate data from the other participant. It is at <http://brian.ma/PulseChat>
5. [Do not proceed until participant confirms that they can see heart rate]
6. Please Make sure half of the screen is the interview script and the other half is the heart rate monitor.
7. This screen will change colour based on the heartrate of your interviewee.
8. Heart rates can vary based on many factors, including nervousness, anxiety, or stress
9. When your interviewee's heart rate is within normal range, the colour of the screen will be green.
10. When interviewee's heart rate is above normal range, the colour of the screen will be a yellowish orange colour.

### INTERVIEW TASK

11. Your task is to conduct the interview by choosing from a set list of dialogue options. The choice is up to you. Side comments are okay but please try to stay on script.
12. So the scenario you are in is as follows:  
You work for a large company and your boss has tasked you with putting together a team of employees from other parts of the company to work on a very important project. You will be interviewing potential team members and deciding whether or not you would like them to join your team.
13. Please look over the Interview questions and follow up questions.
14. You will first ask the question in the large font. Then, once the interviewee has answered, please ask ONE follow up question from the two choices provided.
15. Do you have any clarifying questions regarding how you will conduct the interview?

### RICO ENTERS

16. Ok, I will ask the other participant to enter the zoom room now [Rico enters room]
17. Rico, do you have your heartrate monitor ready? [Rico answers yes]



18. Are both of you ok with us recording the interview? We will only use the recording for our own review and it will be deleted afterward. [Rico answers yes] [start recording if participant also says yes]

#### STUDY BEGINS

1. You may now begin interviewing Rico

#### STUDY ENDS

1. OK thank you all so much!
2. Rico you may now go back to your previous zoom session where you were briefed. We will do your interview there.
3. [Rico leaves room]

#### DO POST STUDY SURVEY

1. We will now conduct a post study survey
2. <https://forms.gle/GjBrndfThJ8hM6F86>

#### DEBRIEF

1. Thank you so much! That is the end of the survey.
2. Now to debrief:
3. [IF SHOWN PULSECHAT] This study was actually about how PulseChat -- the heart-rate monitor you saw -- affects the level of confrontation during a job interview.
4. [IF NOT SHOWN PULSECHAT] This study was actually about how a device we built that monitors heart-rates affects how confrontational people are during job interviews. You were part of the control group, so you were not shown the device. Would you like to see it? [Give link if participant would like to see PulseChat]
5. Rico was actually part of the study, he was not actually another participant, but another facilitator. He also knew beforehand what questions would be asked.
6. The heart rate you saw on the website is not actually real. It is being controlled by another person.
7. I hope you enjoyed participating in the study, do you have any other questions for us?