Julia Seitz (2022): Designing User-Adaptive Video Meeting Systems . In: Proceedings of the 20th European Conference on Computer-Supported Cooperative Work: The International Venue on Practice-centred Computing on the Design of Cooperation Technologies - Doctoral Colloquium, Reports of the European Society for Socially Embedded Technologies (ISSN 2510-2591), DOI: 10.48340/ecscw2022_dc03

Designing User-Adaptive Video Meeting Systems

Julia Seitz
Karlsruhe Institute of Technology
julia.seitz@kit.edu

Abstract. Video meetings are omnipresent in our daily life. Besides their widely acknowledged advantages, negative impacts in the form of the "ZOOM fatigue" phenomenon became increasingly observable. This feeling of exhaustion according to current knowledge is caused by a myriad of antecedents, where inappropriate or extensive use is recognized as a major driver for ZOOM fatigue. Currently proposed countermeasures are mostly related to changing user behavior and require action from the user. To shift the action from the user to the system, in my PhD project, I aim to design a user-adaptive video meeting system that automatically adapts based on the recognition of user's current state with biosignals. Thereby, I plan to contribute with descriptive and prescriptive knowledge on user-adaptive video meeting systems.

Motivation

Due to the ongoing pandemic and the related shift towards remote work, the amount of time spent in video meetings increased drastically and video meeting systems have become a key element in our daily work (Chew and Azizi, 2022). Experiences with this strong use of video meeting systems show that users experience a phenomena referred to as ZOOM fatigue (Bailenson, 2021; Fosslien and Duffy, 2020). ZOOM fatigue, the *"somatic and cognitive exhaustion that is* *caused by the intensive and/or inappropriate use of videoconferencing tools"* (Riedl, 2021, p.5), thereby relates to symptoms such as headache, tiredness, or discomfort (Riedl, 2021). It leads to decreased well-being (e.g., digital burnout, incorrect edacious behavior, appearance dissatisfaction) and productivity (e.g., poor participation, engagement, task performance) (Bailenson, 2021; Fauville et al., 2021; Pikoos et al., 2021; Kuhn, 2022; Rogelberg, 2020; Yilmaz et al., 2020; Shockley et al., 2021; Sharma et al., 2021). In previous research, related concepts researched in the CSCW field are for instance exhaustion, low energy, technostress, social media or mental fatigue (Bullock et al., 2022; Riedl, 2021; Fauville et al., 2021). Literature suggests that it can be caused by a myriad of antecedents, which are either user-specific (personal characteristics, emotions, endured cognitive load), organization-specific (role in meeting, degree of interactivity, group belongingness), or technology-specific (nonverbal overload due to sending and receiving cues, constant self-view, decreased distance to screen) ((Bailenson, 2021; Bennett et al., 2021; Fauville et al., 2021; Kushner, 2021; Nesher Shoshan and Wehrt, 2021; Shockley et al., 2021), see Döring et al. (2022) for a review). To tackle ZOOM fatigue, diverse countermeasures are proposed in research and practice, such as biobreaks, reduced amount of meetings, or reduced stimuli on the screen (Bennett et al., 2021; Peper et al., 2021; Toney et al., 2021). However, these countermeasures are mainly related to the adaptation of behavior and must be initiated by the users themselves.

An interesting alternative to reducing ZOOM fatigue is to design the system itself intelligent. This system-centric adaptation can be realized by recognizing corresponding user states via biosignals, which according to first evidences, is also possible for ZOOM fatigue (Patel, 2021). Following the principles of physio-adaptive systems (Fairclough, 2009), this information about the user can be used to cover the advantages of individuation by responding proactively and implicitly (Aarts, 2004; Hancock et al., 2005). Physio-adaptive systems rely on the biocybernetic loop and build upon the collection of biosignals, which are then analyzed to recognize the current state (Pope et al., 1995). Afterward, the system adapts based on the recognized state (Allanson and Fairclough, 2004; Riedl and Léger, 2016) and positively impacts well-being and performance (Gilleade et al., 2005; Rani et al., 2005; Pope and Palsson, 2001). I thus want to research and leverage existing knowledge on ZOOM fatigue and its predicted antecedents, as well as insights on the possibility to measure ZOOM fatigue and its antecedents by biosignals, to explore the design of adaptive video meeting systems that aim to reduce the user's fatigue through intelligent adaptations.

Research Questions

To achieve my research goal, I identified existing research gaps which lead to my research questions (RQ). I articulate my overall RQ as the following: *How to design user-adaptive video meeting systems that combat selected antecedents and* *ultimately* ZOOM *fatigue based on biosignals?* Therefore, my overall PhD project is organized in the two major streams of recognition and adaptation:

1. Recognition Stream: In this stream I focus on recognizing user states via biosignals, especially eye-tracking and electrocardiogram (ECG) signals. To the best of my knowledge, no systematic overview on existing publicly available datasets exists that measure cognitive load, an antecedent to fatigue, or fatigue itself based on biosignals as a basis for training classifiers using machine learning. I aim to first create such an overview and subsequently train classifiers using biosignals captured in the available datasets. In case available data does not cover my requirements, it may be required to collect a new dataset. Afterward, I aim to evaluate the trained classifiers in the context of video meetings to explore their applicability and performance. This can be summarized in the following RQ:

   Can a classifier for cognitive load and ultimately ZOOM *fatigue be successfully trained using biosignals in virtual meeting context?*

2. Adaptation Stream: Here I want to understand the current state-of-the-art on adaptations in video meeting systems. As to the best of my knowledge no overview on the adaptability of these systems exists, I plan to close this gap by creating a literature review including a conceptual framework. Subsequently, I plan to contribute with a dedicated design proposal for a user-adaptive video meeting system that aims to decrease ZOOM fatigue and selected antecedents such as cognitive load. As a starting point, I observe and afterwards aim to decrease the suggested impact of the self-view feature provided by contemporary video meeting tools on cognitive load and distraction as antecedents to fatigue based on selected biosignals and afterwards pursue with other features (Bailenson, 2021; Horn and Behrend, 2017). This can be summarized in the following RQ:

   Which features of video meeting systems can be designed adaptive? How to design adaptive video meeting systems to reduce ZOOM *fatigue and selected antecedents?*

Methodology

To answer these RQ, I will leverage design science research (DSR) (Vaishnavi and Kuechler, 2004). DSR aims to deliver design knowledge and follows a cyclic approach to deliver an artifact which solves a real-world problem. Following Vaishnavi and Kuechler (2004), each cycle consists of five phases: problem awareness, suggestion, development, evaluation and conclusion. To achieve problem awareness, I gain insights from existing literature, by following the methodology of a systematic literature review, and an observation study of gaze patterns and user states while being confronted with different forms of self-view. Additionally, with regards to the recognition stream, I will collect and explore existing biosignal datasets and corresponding classifiers. In the suggestion and development phase, I plan to leverage biosignals and classifiers trained according to the machine learning lifecycle as the foundation for the planned adaptation. Subsequently, I will conduct experimental studies in the evaluation phase to analyze whether the adaptation is perceived timely, accurate and intuitive without unwanted consequences (Fairclough and Gilleade, 2012). Subsequent cycles include additional adaptation features.

Findings

To motivate my topic from a user's perspective, I already conducted a systematic review on collaboration technology's impact on affective and cognitive states, which identified that using biosignals are an underrepresented modality and adaptive or intervening features mostly focus on joint attention or emotion support.

In the recognition stream, I conducted a systematic review and identified 34 publicly available biosignal datasets and their classifiers for identifying cognitive load, an antecedent leading to fatigue, which I rated based on comparison criteria for reference datasets. Based on these findings, I develop a machine learning model leveraging ECG data to classify cognitive load.

In the adaptation stream, I explored potential features to focus on when designing user-adaptive video meeting systems. Specifically, I identified the self-view feature as my focus for a first DSR cycle due to its impact on ZOOM fatigue (Bailenson, 2021). In the problem awareness phase, I leveraged insights from literature and data. Thus, besides reviewing existing studies on the impact of self-view and underlying psychological theories in the online and offline world (i.e., self-presentation, self-awareness, attention-restoration theory) (Duval and Wicklund, 1972; Kaplan, 1995; Kuhn, 2022; Vohs et al., 2005), I used data from a field study of a colleague involving virtual meetings conducted in triads to gain initial insights on differences in gaze patterns regarding the self-view. Differences in the share of fixation duration per area of interest (i.e., content, pictures of others and own self-view) were visible depending on the role in the meeting (presenter/listener/conversation participant) and between the both groups which performed different tasks. Within the groups, between person differences varying between 0.8 to 13 percent of total fixation duration during listening on the self-view were observable. This suggests that offline mirror gaze patterns and related differences in self-view traits might be applicable to the online domain as well (Barnier and Collison, 2019; Potthoff and Schienle, 2021).

Next Steps

As I am still in an early stage of my PhD project, my next step is to focus my research direction with regards to recognition of ZOOM fatigue and selected antecedents and adaptation features of video meeting systems. To answer my outlined RQ, I take the following steps: As the sample size in my observation presented in the findings was fairly small and only one specific setting was observed, I am currently designing an experimental observation study to further investigate the gaze patterns on the self-view feature. I plan to run this study with a larger sample size (approx. 30 participants) and additional control variables (e.g., self-esteem) to strengthen my previous insights. Also, I plan to evaluate the trained classifier to ensure its applicability in the video meeting context. I will combine this evaluation with my experimental observation study on the user's self-view as I aim to simultaneously record ECG data and cognitive load in the conducted sessions. Afterward, the subjective state information can be compared with the prediction of the classifier. This is done to decide whether classifier and gaze patterns are capable of recognizing the user state sufficiently to ensure a well-designed adaptation logic or whether other mechanisms (e.g., differentiation based on task/meeting characteristics) need to be used instead. Based on this, I will, subsequently, proceed in the next step of the DSR cycle addressing the design of the adaptation feature, which will be evaluated afterwards. The user interface design of the adaptation and a combination of both will be explored in an additional cycle. In parallel, I plan to work on the systematic review of adaptability in video meeting systems.

Expected Contributions

In this research project, I expect to make several contributions. First, I would like to contribute by providing a systematic review of video meeting system features to better understand the system's adaptation possibilities. Second, in the recognition stream, I contribute with a state-of-the-art overview on existing publicly available datasets and classifiers for antecedents of ZOOM fatigue. Furthermore, I aim to contribute with a biosignal-based classifier for antecedents and ZOOM fatigue. Besides, I aim to contribute with the results of an experimental study on gaze patterns on the self-view during video meetings, based on the presented observation, and thereby use objective instead of subjective measurement methods in the literature stream on ZOOM fatigue. Fourth, I plan to use these results for designing biosignal-based adaptations of video-meeting systems. The goal is to continuously measure user states while collaborating and dynamically adapt features such as the self-view option. Thereby, I aim to contribute with prescriptive knowledge for user-adaptive video meeting systems.

Overall, the expected results should help to decrease ZOOM fatigue during video meetings by adapting the system to the users' needs. Thereby I aim to contribute to more human-centered digital work environments able to reduce zoom fatigue in a post-pandemic world.

Acknowledgement

Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – GRK2739/1 – Project Nr. 447089431 – Research Training Group: KD²School – Designing Adaptive Systems for Economic Decisions.

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