Are you there? : Presence in collaborative distance work

Bauters, Merja; Pejoska, Jana; Dural, Eva; Saarikivi, Katri Annukka; Wikström, Valtteri ...

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ARE YOU THERE? PRESENCE IN COLLABORATIVE DISTANCE WORK

Merja Bauters
School of Technologies
University of Tallinn
Estonia;
History and Art Studies
University of Helsinki, Helsinki
Finland

Jana Pejoska
Faculty of Educational Sciences
University of Helsinki, Helsinki
Finland

Eva Durall
NTERACT Research Group
University of Oulu
Finland

Katri Saarikivi
Faculty of Educational Sciences
University of Helsinki, Helsinki
Finland

Valtteri Wikström
Faculty of Educational Sciences
University of Helsinki, Helsinki
Finland

Mari Falcon
Faculty of Educational Sciences
University of Helsinki, Helsinki
Finland

Silja Martikainen
Faculty of Educational Sciences, University of Helsinki, Helsinki,
Finland

Abstract: *Already before the pandemic, digitally mediated collaborative work and communication were perceived as challenging. We investigate the attitudes towards emerging technologies and for transforming practises in workplaces. The focus lies on understanding the readiness for appropriating emotional tracking on presence and support for collaboration. The research-based design framework allowed to combine the various perspectives of the transdisciplinary team. Methods included participatory design, design thinking, contextual inquiry and prototype testing for enhancing presence while working with shared objects in video conferencing to explore the appropriation of tools. The findings revealed four indications: 1) awareness of interlocutors' presence during synchronous communication is crucial. 2) Emotion and behaviour tracking raises concerns about privacy and personal control over what is displayed to others, and technology could be simpler non-distracting the work at hand. 3) The prototype was found to enhance the feeling of presence without disturbing work at hand, and 4) appropriation requires a step-by-step approach.*

Keywords: *Research-based design, tracking, presence, computer-mediated communication, collaboration at work, distance work.*

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INTRODUCTION

Communication and collaboration through digital technologies are necessary aspects of almost all types of work. Not surprisingly, communication through digital technologies is still perceived to be unsatisfactory. For instance, it takes too much effort to make sense if the others are attentive and present, especially when the participants do not know each other well enough. Remote communication hinders collaborative work as participation in the work is not displayed evenly to all. (Hannola, Richter, Richter, & Stocker, 2018). The solutions thus far have not adequately solved the challenge of presence in a way that maintains concentration on the work.

Prominent perspectives into the subject can be grouped into a technology-dominant angle studying features which enable or support, for instance, participants' feeling of other participants' presence and practice, and an experience-dominant angle investigating requirements of how to support collaboration and communication during work. Various research areas, for instance, Human-Computer Interaction (HCI), Computer-Mediated Communication (CMC), Computer Supported Cooperative Work (CSCW), and cognitive neuroscience, have explored the challenges associated with digital communication and collaboration tools.

In this article, we approach the issues of presence, awareness, and support for collaboration from a transdisciplinary perspective. Our team consists of design researchers with expertise in co-design and design thinking, technology-enhanced work and learning research, and researchers in the field of cognitive neuroscience. Thus, the framework we use is broad, and it includes the fields of HCI, CMC, CSCW and cognitive neuroscience. CSCW has discussed various aspects of collaboration, from Grudin's (1994) group work and social dynamics to Stahl's (2016) recent studies on intersubjectivity and group cognition. CMC, similarly, has been digging into issues on digital, remote, and synchronous communication from Boon and Holmes (1991) discussing the dynamics of interpersonal trust to Biocca, Harms, & Burgoon (2003) on theory and measurement of social presence. HCI began with awareness features (Gutwin & Greenberg, 1998) and advanced into complex presence measures (Froese, Iizuka, & Ikegami, 2014), borrowing ideas from cognitive neuroscience. We also have first-hand experience designing some of the first awareness features into computer-supported learning and working in various international projects (e.g., Netpro[1]). However, digital tools have improved, and research on how presence is observed and experienced, including topics such as the relationship between inter-brain synchronisation (Balters, Mayseless, Hawthorne, & Reiss, 2021), has increased recently. We complement the new neuroscientific findings by looking back and including research-based design studies to understand the current needs and attitudes in workplaces. It seems that we are in a paradigm shift on what learning and working means. This disruptive transformation is partially initiated by digitalisation – using emerging tools such as algorithmic systems that are proposed to be implemented in all parts of life. The pandemic has been accelerating this tendency (Trenerry al., 2021).

Our objectives for the research were to understand if there is a change in the hindrances of collaboration and communication in remote work due to the forceful introduction of emerged technologies and digitalisation. The workplace sectors were based on the Business Finland project HUMEX Quantifying Human Experience for Increased Intelligence Within

Work Teams and in the Customer Interface. Most sectors can be categorised as knowledge work, e.g., legal, insurance, development, design and marketing companies/customer services, and the construction sector at the decision-making level.

We used research-based design methods to investigate the current workplace hindrances and benefits of emerging technologies. The research-based design allows us to combine the different disciplines and real context on workplaces providing a thicker description of the current change, attitudes towards the new technologies and potential transformation of work cultures.

Our research is based on the hypothesis H1: *there is a need to use algorithmic systems on generating emotional and behavioural data for tools that enhance, support and scaffold the digitally mediated collaborative work*

During the research process, it became clear we had to narrow our hypothesis into (H2): *Simplify the tools used for collaboration in the work setting*

a) the feedback of the presence of other interlocutors must be as simplified as possible so that it can be perceived at a glance or with peripheral vision and

b) the workers must feel that they are in control of what is presented to the other interlocutors.

Next, we go through the previous research on the framework of HCI, CMC, CSCW and contrast these with current findings on cognitive neuroscience. We start with older research to build the background of what is known and could be used for new approaches. After which, we describe the methods, data collection and analysis. From there, we move to the findings and results.

BACKGROUND ON COMMUNICATION AND COLLABORATION THROUGH DIGITAL TECHNOLOGIES

This section discusses research that has allowed us to tackle new difficulties of appropriating new tools and practises for digitally mediated communication and collaboration.

The crucial features of digitally mediated communication are visibility of interlocutors' actions to guide interactions and seeing that others are present and available for communication, which affects communicative behaviours and accountability. Previous research has focused on improving turn-taking (Anderson, Beard, & Walther, 2010), enhancing situation-, work-, social- and self-awareness (Dourish & Bellotti, 1992; Gross, 2013) and identifying relevant non-verbal communication cues (Cameron & Webster, 2005; Kruger, Epley, Parker, & Ng, 2005) or on evoking affective interdependencies (Salminen et al., 2018). Part of the awareness is to understand that *I* and *others* are receptive to communication (Gutwin & Greenberg, 1998). Quan-Haase, Cothrel, and Wellman (2005) investigated online communication, and they explained the underlying needs for successful, digitally mediated communication and collaboration. The four needs are a) The interlocutors' task interdependencies, their history of collaboration and informal socialising support the success of communication during collaborative work; b) Visibility results in awareness when the interlocutors know each other or share experiences; c) Increasing social cues works well when the interlocutors are acquainted with each other and have established trust; and d) The roles the interlocutors possess make a difference: lower-status employees feel a need to answer timely, and higher status employees expect responses within a short time.

Recently, the focus has been on future technologies in HCI. Mueller, Maes, and Grudin (2019) referred to as Human-Computer Integration (HInt). The HInt is divided into three classes on their ability to provoke different types of awareness in humans: on-, off- and in-body. Off-body is technology situated in the environment around the body and is not physically attached to the body. The on-body is technology existing on the surface of the body (such as wearables or hand-held devices), and the in-body is a technology that exists internally within the body (such as ingestible devices) (Mueller, Maes, & Grudin, 2019). These technologies are seen to provide to their "wearers" various benefits; for instance, off-body provides the familiar sensor information for checking the weather, location, and speed. These are often used in recreational and work practises alike. The on-body technology may be most known by health applications such as monitoring sleep patterns, heart rate and blood sugar levels. Lastly, in-body technology is often unthought-of but well-known since it includes pacemakers, hearing aids, eyesight improvements, and new technology such as memory aids and stress management. All of these known so far aim to help, support and make life easier by knowing oneself and one's behaviour, namely one's habits. However, the arousal information is not often used for enhancing empathy or collaboration or for interpersonal communication, but monitoring stress levels, for being calm, strong, social and smart, for instance, with mental health smartphone apps (Bakker, Kazantzis, Rickwood, & Rickard, 2016; Peake, Kerr, & Sullivan, 2018).

Although many communication tools provide rich media such as emojis, audio and video notes, and video conference features, people still need to adapt their communication and work styles to the possibilities and limitations of what the current technology supports (Koskinen, Zimmerman, Binder, Redstrom, & Wensveen, 2013; Zhao, Lampe, & Ellison, 2016). As a result, achieving successful collaboration in workplace settings requires participants' attention and effort to overcome technological limitations. According to well-known works of Trigg and Bødker (1994) and Schmidt and Bannon (1992), achieving better tools requires that the tools evolve with use, meaning the tools support appropriation, customisation and tailoring culture as well as provide affordances for adaptation. In this article, the interest lies in determining how attitudes towards computer-mediated interactions have changed for synchronous communication and collaboration in a work context and whether this knowledge can be used to co-design tools that evolve along with the use. It is relevant to ascertain how automated tracking of interlocutors' behaviours and emotions can impact workers' perceived use of computer-mediated communication tools. For instance, Dourish (2003) has aptly stated that tools change practises, and modified practises change what is expected from the tools, meaning that the tools and systems should evolve with use while being situated in the intersection of technical design and social practice. Therefore, the mismatch between the flexible, mutable and evolving practises contrary to the predefined, rigid, resistant tools creates a gap between the practises and technological possibilities, called the 'socio-technical gap'(Ackerman, 2000; Törpel, Pipek, & Rittenbruch, 2003). Wulf et al., (2015) underline that appropriation is a complex process, it takes long, and the practises undergo changes during the process. The complexity of the appropriation process is due to the many different societal levels where the newly designed artefacts connect to the known, and unknown social practises. Social practises are not abstract but embodied and routinised, which means the practises are intertwined with the environment and form habits (Wulf et al., 2015). Ramstead, Veissière, and Kirmayer (2016) described how normative practises built on

the immersive participation of the agent in a social context are seen to regulate joint attention and shared intentionality. Knowing the habits of action and context will aid in supporting appropriation because it allows us to design tools and scaffolding for changing the habits (Fiore & Wiltshire, 2016).

Due to the differences between what technology can do and how people act and develop practises, it is essential to investigate how people anticipate the future, what they expect from technology and what they feel that they are willing to appropriate to transform existing digitally mediated collaborative practises at work.

Considering the advances in emotion tracking technologies and the positive impact that these technologies are expected to bring, in this study, we explore the way potential users feel about emotion tracking tools in workplace contexts and what is expected from these technologies. One of these technologies to consider is the ones measuring arousal. Arousal tracking is in focus because it is increasingly integrated into the tools offered to workers. Arousal refers to a physiological state that denotes energy and activation, associated with being awake, alert and ready to respond. In the dimensional models of emotions, high levels of arousal are related to emotions such as surprise, while emotions such as sadness are associated with low arousal levels (Bhattacharjee et al., 2018).

Sensor-based technologies monitor arousal by collecting data on the changes in heart rate, blood pressure or skin conductance to estimate the level of alertness of a person's physiological states (Gravina, Parastoo, Ghasemzadeh, & Fortino, 2017). These are increasingly used in natural situations, for instance, to measure heart rate variability changes using T-shirt integrated sensors and visualisations of heartbeat (Wikström et al., 2021).

From previous research, one of the focus areas that we listed as potential is awareness, also called presence. The terms awareness and presence are sometimes used interchangeably. Awareness is divided into actions about the others involved, context, and content. Other areas emphasise the feelings or emotions, showing empathy, agreement, understanding and support for habit-forming or changing practises. The above areas can be tackled with various technologies, e.g., sensors and algorithmic systems, that have different intrusion aspects that previous and current technologies use. The novel technologies are thought to support work, and work practises (for instance, knowledge work and understanding the feelings of co-workers or clients). As the work sectors available for the research have various aims and practises, our first task was to narrow the scope by understanding the current situation and the envisioned future.

We present a case study that follows the research-based design approach to identify the main challenges that digitally mediated interactions have on synchronous communication and collaboration in work contexts. The following section will describe the process, methods, and analysis we used.

RESEARCH-BASED DESIGN: CONTEXTUAL INQUIRY, PROTOTYPING, DATA AND ANALYSIS

The study has three parts: part A contextual inquiry and getting acquainted with the previous studies for creating the design hypothesis (see Figure 1, empirical-study part); and part B, where prototypes are designed and implemented for testing the hypothesis (fig.1, prototyping). We have also outlined a beginning of the future study part C – appropriation,

where the actual use at workplaces is studied longitudinally. All three parts have many iterations of data collection and analysis.

H1: Initial research hypothesis was that *there is a need to use algorithmic systems on generating emotional and behavioural data for tools that enhance, support and scaffold the digitally mediated collaborative work.* Algorithmic systems can provide recommendations, suggestions and sometimes interpretations based on various data collections.

H2: *After part A, we had to simplify our hypothesis to be: Simplify the tools used for collaboration in the work setting*

H2 was divided into two parts:

a) the feedback of the presence of other interlocutors must be as simplified as possible so that it can be perceived at a glance or with peripheral vision and

b) the workers must feel that they are in control of what is presented to the other interlocutors.

Study part A explores whether and how tracking interlocutors' physiological affective and arousal states could improve computer-mediated collaboration and communication and what types of attitudes people have towards the new technologies. During part B, we developed potential prototypes with the participants based on the findings. At the beginning of part C, the design prototypes were tested with the participants from the companies. Drawing on the prototype testing, we propose the design implications that promote design decisions and chosen methods.

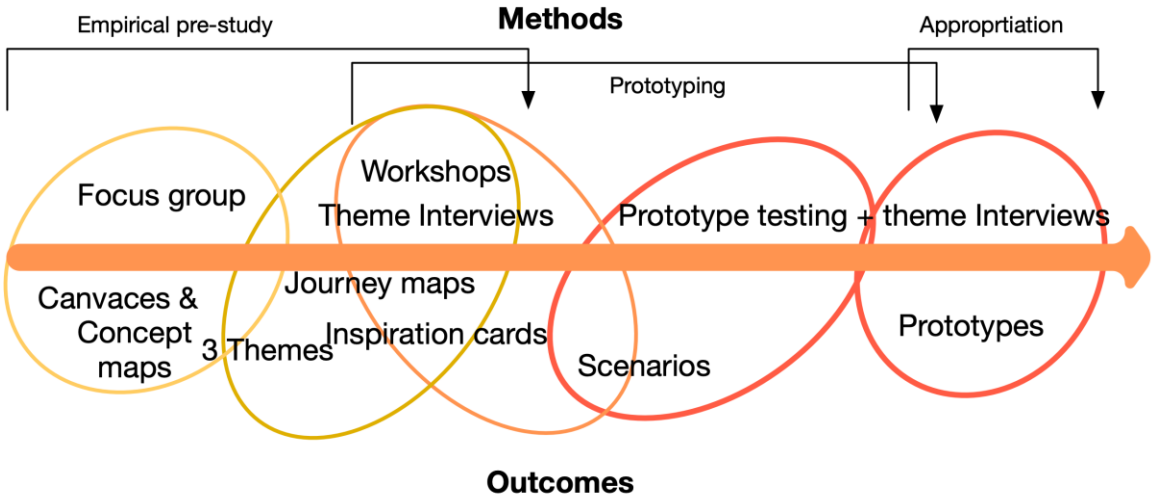

Figure 1. The figure presents the whole process of the design from contextual inquiry (part A), design, prototyping (part B) and a short study on appropriation, (part C) the methods used and the related outcomes.

We followed the constructive design approach (Koskinen et al. 2013) based on prototyping, frequent iterations, and encouragement for developing the prototypes (Mackay, 2000). The prototypes were developed iteratively involving representatives in all stages of the design process (Mattelmäki, 2006) for ensuring that digitally mediated communication and collaboration systems meet the participants' needs and researchers' aims. In particular, we adopted research-based design, which is influenced by co-design (Sanders, 2003) and the

user-centred design tradition (Stewart & Shamdasani, 2014). It is critical to involve artefacts called probes during the design process (Pirinen, 2016). Facilitators provide probes in focus groups and workshops to the participants, thus allowing them to express their expectations of digitally mediated collaboration challenges with tangible objects. Using artefacts early in the design process allows participants to try out and suggest potential usage practises. This practice enables us to detect the direction in which tools might need to evolve during actual usage. The process supports using empirically grounded conceptualisations (Wulf et al., 2015).

We selected the participants to represent different economic sectors such as software development, construction, marketing, insurance and advertising, and digital legal services. The companies' role was to provide a research context. The companies were future-oriented, executing knowledge work and using various digital tools. The selection of the companies' participants aimed to gather as wide as possible representative worker base covering various tasks from service, design, management, and execution. The selection was inspired by including extreme participants following the design thinking methodology. We sent messages or discussed with the company representatives to acquire the best variation between workers in each company). In total, we had 30 participants (16 female and 14 males, see Table 1).

Table 1. All participants in the contextual inquiry, prototyping and appropriation.

Sector	Female/male	Novice–expert
Design/marketing	7 females/ 3 males	full range
Development	3 females /5 males	full range
Insurance/customer service	4 females/ 4 males	full range
Legal services	1 female/ 1 male	leader/ expert
Construction	1 female/1 male	middle management / novice
Total	30	

Part A) Contextual and Empirical Research

During the design process of part: A) contextual and empirical research, we used various methods and techniques for prompting conversations about digitally mediated work challenges and attitudes towards emotional tracking in the work context. We carefully chose all the methods and techniques to provide in-depth and thick description knowledge from the field. As mentioned, the process was cyclic with data collection and analysis. The chosen techniques were observations, focus groups, workshops, and theme interviews to ensure that attitudes and practises could be made tangible.

In this phase, we facilitated two focus group sessions, four workshops, two interviews and background benchmarking were used to collect data. The data included video data, notes and design artefacts (see Table 2, and for the whole process, Figure 1). We investigated the attitudes towards emotion tracking, how the participants see it could enhance their work, current practises and what is not working at work when it comes to digitally mediated collaboration and communication. The focus groups and workshops were formed from different sectors. The focus groups allowed us to find overlaps in the work and attitudes. These were the guiding themes that directed the design of workshops and interviews.

The outputs of focus groups were then validated in workshops using inspiration cards and journey maps. The cards provoked discussion on tools in use, collaboration in distance

work, customer service challenges, communication issues, practises that work and do no work. We designed six cards in total (see Figure 3 for examples). Journey maps were on 1) Community building through instant messaging; 2) Showing engagement (presence) in an online focus group using video-conferencing (audio, no video); 3) Supporting shared understanding among groups using online video-conferencing (audio, no video construction field work[2] (see Figure 3 for example). These kinds of reused outcomes are called tangible outcomes and provide better iteration of the research process and design). In this part A, the participants came from insurance and legal service/company, development, design, marketing, and construction. Female and male division overall in part A. was 13 males and 14 females. The count does not add to 30 (see Table 1, where all participants of part A B C are counted) nor to the beyond 30 in Table 2 as some participants took part in more than one focus group or workshop. The number of participants is not enough to make broad generalisations but indicative suggestions for similar types of knowledge and service types of works. Through the methods and outputs, we answer to the

H1, *there is a need to use algorithmic systems on generated emotional and behavioural tools to enhance, support and scaffold the digitally mediated collaborative work.*

Table 2. Table 2 presents the methods, participants, data collection and analysis methods during the contextual inquiry (part A). The participant number does not add to 30 because some participants attended more than once to provide continuation.

Method	Participants	Length	Data collection	Techniques & materials used	Analysis methods
Focus groups (2)	Design/marketing (2), development (1) & construction (2) & insurance (1); legal company (1) people (7 on each workshop)	2 h	Notes, video & audio recording, outcomes of the activities	Synchronising practises (synchronous hand clapping), sketching and games	Qualitative analysis using design thinking techniques, such as canvases, templates and journey maps, to organise the data & artefacts. Spatial and physical organisation jointly by researchers belong to design thinking analysis methods
Workshops (4)	Design/marketing (1-2), development (1) & insurance (0-1); legal company (1) people (3-4 per each focus group)	2 h	Notes & video recording	Inspiration cards & scenarios	
Interviews (2)	Development (1) & insurance (1) company	1 h each	Notes & recording	Theme interviews	

Part B) Prototyping and Part C) Appropriating

Part B) prototyping and part C) appropriating included two different types of prototype testing. The setting of the prototype testing included two separate rooms where the workers were working on a joint document (shared artefact). Communication occurred through Skype or a similar audio/video conferencing tool. A randomly selected worker and student

participated in the first two prototype testing prototypes. Both were well-acquainted with video conferences and collaboration with co-workers/learners mediated by digital tools. One researcher was in one room in the first two prototype testing, and the worker/student was in another room. The participants could not see or hear each other directly. The document, or scenario, was described to the participant. The scenario described presented the challenges with a Skype discussion and collaborative work – named: Facilitating a focus group using video-conferencing (see Appendix 1). Overall, we had three scenarios to choose from (Facilitating a focus group using video-conferencing, Group discussion using audio-conference and Community building using instant messaging). Participants told which was closest to them). Both rooms and the screens of the researcher and the worker were video-recorded. One of the researchers observed the worker, taking notes and helping if the prototype failed to function correctly. These prototype testing aimed to determine whether The Nodders prototype functioned as anticipated and how the participants felt about it.

The first two prototype testing lasted an hour, and data was collected by observations, interviews and audio recording. These were transcribed and analysed by three researchers. The second two prototype testing were executed with real workers executing actual tasks. The workers came from digital legal services and marketing companies. The selection was based on the availability of a real collaborative online task. These lasted for one hour and a half. The workers were connected through their internal tool in different rooms and were working with an actual work document. The legal services workers were used to work on a joint document from distance offices. The collaborative tool for the shared document was the company's internal tool; however, in this setting, only half of the screen — the part where The Nodders was displayed — could be recorded because the document under discussion was classified. The second prototype testing with the marketing company followed the same setting, except the location was in the marketing company building. In both prototype testing, theme interviews, which were recorded, and during which notes were taken, were conducted afterwards. The themes of the interviews were the same as those of the first prototype testing.

The interviews were semi-structured, themed interviews. The themes were: the workers' feelings when using the Nodders, positive and negative feedback related to the concept of the prototype and its feasibility in real work and concerns and hopes of technology and improvements for the prototype. Three researchers analysed the data by comparing the lists of relevant comments from participants, videos, and notes. Important notes were highlighted and discussed to answer the hypothesis and considered for future development. The results cannot be generalised broadly but can indicate design directions for a similar collaborative work setting. The hypotheses were: a) the feedback of the presence of other interlocutors must be as simplified as possible so that it can be perceived at a glance or with peripheral vision, and b) the workers must feel that they are in control of what is presented to the other interlocutors.

The Analysis Methods of the Part A) Contextual and Empirical Research

The researchers from two universities analysed part A) contextual and empirical research in a design thinking manner using different canvases, templates and three journey maps (Biocca et al., 2003) to arrange the data in various ways and study them from multiple perspectives. We transcribed the focus groups, workshops, videos, theme interview audios and observation notes.

These were then sorted out into topics emerging from the data. The classification of relevant topics took three iterations. The researchers focused on physical and spatial arrangements of data to categorise them bottom-up. Spatial manner is supported in design thinking, providing tangible visual outcomes (for instance, the earlier mentioned topic descriptions canvases, inspiration cards, journey maps, scenarios) that can be reused to validate the outcomes with the participants in iterative manners. It is also one of the main ideas of research-based design (Mattelmäki, 2006). Such outcomes and work processes cannot be acquired when using digital tools such as Atlas.ti. Three researchers executed the primary analysis. The preliminary analysis of the process outputs was shared with four researchers from the project's partner universities to validate the analysis and provide a broader perspective. The process' outcomes of the focus groups led to canvases of classification and concept maps. These were summarised by the emerged themes (see Figure 2 a, b and c). Based on the previous outcomes, journey maps and inspiration cards were created for discussion with the participants. From the focus groups, workshops, and interviews, we had over 150 post-it notes. The data was analysed again by bottom-up note comparison between the researchers and categorised by emerging theme activities, context and tools. These provided the basis for scenarios to be used in prototype design. See the research team's outcomes blog[3].

The concept of validity has been defined in various ways (Onwuegbuzie & Johnson, 2006). We followed the description of Teddlie and Tashakkori (2003), who see validity in qualitative research as inference transferability and inference quality. Inference quality is the identification of four evaluation criteria (a) within-design consistency, i.e., consistency of the design of the study and from which the inference emerged; (b) conceptual consistency is the degree to which the inferences are consistent with each other and with the known state of knowledge and theory; (c) interpretive agreement is the consistency of interpretations across people and (d) interpretations of the results and rival explanations are ruled out.

The Analysis Methods of Part B) Prototyping

The qualitative and thematic analysis of the part B prototyping was executed by comparing three researchers' notes and interpretations of the video recordings. For the analysis, we used triangulation in different researchers and data collection. The researchers transcribed the video recordings and digitalised the handwritten notes. After which, they listed the comments on the data. The prototype testing data were discussed, and similarities in the data were grouped in a similar spatial manner as in part A).

Business Finland supported the HUMEX project (Quantifying Human Experience for Increased Intelligence Within Work Teams and in the Customer Interface). The AALTO university's Ethical Review Board approved the study protocol. All participants signed written informed consent.

Section 4 describes the outcomes of the contextual inquiry and explains the choices made regarding the prototype to be designed with the participants. The findings indicated the need to narrow our hypothesis and simplify the prototype ideas.

FINDINGS FROM THE CONTEXTUAL INQUIRY (PART A)

After analysing the data from the focus groups (topics in focus groups: Facilitating a focus group using video-conferencing; Group collaboration using audio-conference; audio conference and Community building using Instant Messaging) where all the participants (insurance and legal service/company, development, design and marketing and construction sectors) were involved, the research team created a summary in the form of three themes – the topic description canvases. The themes recapitulate the most critical findings from focus groups' data (Fig.1). This outcome was a result of three (3) iterations. As a summary, the analysis revealed that people's awareness of interlocutors' presence during synchronous communication is a crucial need for successful collaboration, trust-building and shared understanding. These are difficult to establish in digitally mediated communications. Another finding was that the attitudes towards tracking arousal and the proposed interpretations of the state of the participants varied considerably. The arousal tracking was confusing to all except one participant. This one participant had executed festival micro-expression mapping from facial recognition of the crowd to the festival organisers. The others understood the arousal tracking to be data from facial recognition systems, owned or gathered by outside party sensory data. All of the above use algorithmic systems; thus, the hesitancy can be related to data use and accuracy of algorithmic systems and privacy.

The three canvases of the main themes are presented in Figure 2. We will summarise each one of them. We have not separated the outcomes by the workplace sector the participants represent because there was not that much variation between sectors; instead, variation occurred between individuals. Most participants were cautious of the new and emerging technologies. For us research designers, it was interesting to find out if the participants brought something new into the scene. Thus, we first summarise the participants' views, present some quotations from them and then provide a summary of already known challenges.

The bottom-up themes formulated to consist of a) presence – being able to feel the presence of others, b) trust – being able to build trust with others and c) shared understanding – knowing when shared understanding has been achieved. Below we summarise the findings using the above three themes from the focus groups. As mentioned, we focused on the H1 – topics of the attitudes towards emotion tracking, how the participants see it could be used to enhance their work, current practises and what is not working at work regarding digitally mediated collaboration and communication. The descriptions of the themes start with a summary of outcomes and quotations from the participants, relation to previous research (literature) to see if the participants came up with something not discussed before and what this means for future tools, and what we need to consider.

Presence

Summary

The participants explained presence[4] as feeling the presence of the other interlocutor. This feeling may come holistically, or it can be sensed by one dominant sensory channel. Presence is essential in itself and as it enables knowing whether the other interlocutor is engaged in active listening. These formulations were used by the participants of the contextual inquiry (Figure 2 left side).

In this case, the tracking was understood as the system's default action, and attentiveness was presented based on the automatically tracked data. The participants wished to have control over what would be displayed for other interlocutors to see. Another concern was the system's amount of interpretation based on the data. For instance, it was mentioned that the system might interpret that one is not attentive and not present incorrectly due to personal differences that vary concerning the average of the measurements that are used by the system. The audio was mentioned as a way to understand presence.

Participants mentioning the audio/voice-related issues:

"Audio communications tend to be more "clinical" as people tend to make their comments and dialogue in a more condensed way. The conversation can be more straight, built is less rich than in F2F."

"Tone of voice, I have the image I do get the emotional involvement level view voice as well."

" But in big conversation it is the official voice. Lecture mode the one is group. Reporting situations are also that kind of non-emotional voice situations. "

"It is something common that in these contexts someone takes over, since these tools do not enable normal signs to show that you disagree, agree or so on, so giving this type of feedback is challenging. Voice is still is the only way to express yourself, even when there is video."

Other interesting statements from the participants related to tracking o expressions and control:

"In festivals analysis object and people - video-analysis for instance, XYZ festival, what people feel, micro-expressions - analysis of emotions and visible expressions for festival organisers."

"Feedback through other channels than video or audio – especially in the case of big presentations, would benefit from using other ways of sensing since this would allow keep eye contact."

"If the data tracked consists in a voluntary expression of people's mood, it is OK" Obtaining/giving feedback that is voluntary (like thumbs up, sending question marks…) – if it not verbal, e.g. thumbs up, down, nodding and so forth would feel comfortable.

"It's important to know beforehand if one is being tracked. Tracking could be beneficial as it re-inforce personal connection (presence?), help concentrating, performing active listening."

"Might be automated but I have the control and then I could do something, decide how the convey those signs."

"More control on how these data are conveyed"... "I prefer tracking at group level. "

"We want to have a good level of empathy in communications with customers– it it relates to the attitude of the person who is attending you, it is important that you feel that the other person really wants to understand your case "

There were few suggestions, but one caught our eye, which was about how to code the overall atmosphere: **"***Colour coding if I am losing people overall feeling of the group."*

Previous Research

In the context of this design research, the concept idea of presence (related to awareness, see Biocca et al. 2003) consists of supporting different types of feedback, which allows for knowing the extent to which people taking part are present in a conversation or joint work mediated by digital tools. The array of tools that could provide this type of feedback changes according to the context, the conversation purpose and the type of presence that is being performed (Rogers & Lea, 2005).

Presence has also been connected to empathy, or the ability to understand the feelings of the other and the possibility to be present (Iacoboni et al., 2005). Recently, empathy has been defined as a skill that can be learned, even if it is still composed of different aspects, such as 1) experience sharing: vicariously sharing targets' internal states, 2) mentalising: explicitly considering (and perhaps understanding) targets' states and their sources, and 3) prosocial concern: expressing motivation to improve targets' experiences (for example, by reducing their suffering) (Zaki & Ochsner, 2012). Empathy can be viewed as part of the more frequently used definition of social presence (Sivunen & Nordbäck, 2015). Sivunen and Nordbäck (2015) defined empathy as composed of three aspects: a) co-presence, such as feeling inclusion or isolation and mutual awareness; b) psychological involvement, referring to mutual attention, empathy and shared understanding; and c) behavioural engagement, referring to behavioural interaction and dependent action. In this regard, social presence can be viewed as a group/team-level construct and observed in interactions between interlocutors.

Recently Grassini and Laumann (2020) executed a systematic literature review and brought up that only Lee (2004) has managed to provide some consistency into the concept of presence. Presence can be separated into three distinct domains: physical, social, and self. Physical refers to the experience of the physical environment and the objects within the environment, social directs to the experience of other entities with social value within the environment, and self-experience describes the experiences the user has of him/herself.

Meaning for Design

From the current research (Grassini & Laumann, 2020), it seems like the participants had reasonable suspicion since, so far, it is not possible to measure the feeling of presence accurately. The effects that the context has on the discussion, the role one has in the discussion, and the subject matter determine the amount of attention required to follow attentively. However, the participants also mentioned that if the data on presence would be acquired from the group activity where the information is anonymous, it might be acceptable (Quan-Haase et al., 2005; Sivunen & Nordbäck, 2015 on favouring group/team-level constructs). Thus, we may say that it can be accepted if it is general tracking and no persons can be detected. The suggestions and recommendations can be controlled by the users (participants). Being in control seems a valuable design feature as it is also often required by the algorithmic systems – having the human in the loop (Leslie & Briggs, 2021).

Shared Understanding

Summary

For the participants, shared understanding[5] meant arriving at and knowing when there is an agreed understanding of a topic of discussion. The concept aims to provide tools for sharing and receiving information that will help detect whether people have a shared understanding of the topic under study (Fig. 2 middle). It was difficult for participants to determine what the system could track to help them understand that there is shared understanding. The participants requested cues for positive feelings and agreement, which they saw as supporting the building of the shared understanding. These feelings were more comfortable to digest than what the system displays about participants' feelings. Positive emotions are more natural to accept as the system's interpretation of what to present to other interlocutors, even without controlling what is displayed — some points made by the participants.

"Getting feedback about how well people are following/understanding could help adapt the speech (slow down or modifying the explanation)."

"Human touch" in their communications. It relates to the attitude of the person who is attending you; it is important that you feel that the other person really wants to understand your case."

"We want to have a good level of empathy in communications with customers– it it relates to the attitude of the person who is attending you, it is important that you feel that the other person really wants to understand your case"

"We want to have a good level of empathy in communications with customers– it it relates to the attitude of the person who is attending you, it is important that you feel that the other person really wants to understand your case"

Human touch" in their communications. It relates to the attitude of the person who is attending you, it is important that you feel that the other person really wants to understand your case"

"Virtual object that you are touching together - shared something."

"The more people get involved is through virtual objects, something you share with others. "An example of drawing - if members start drawing with me, this is a sign they are really interested and are willing to "buy" services/product. Therefore, making participation physical through a shared object contributes to increasing involvement."

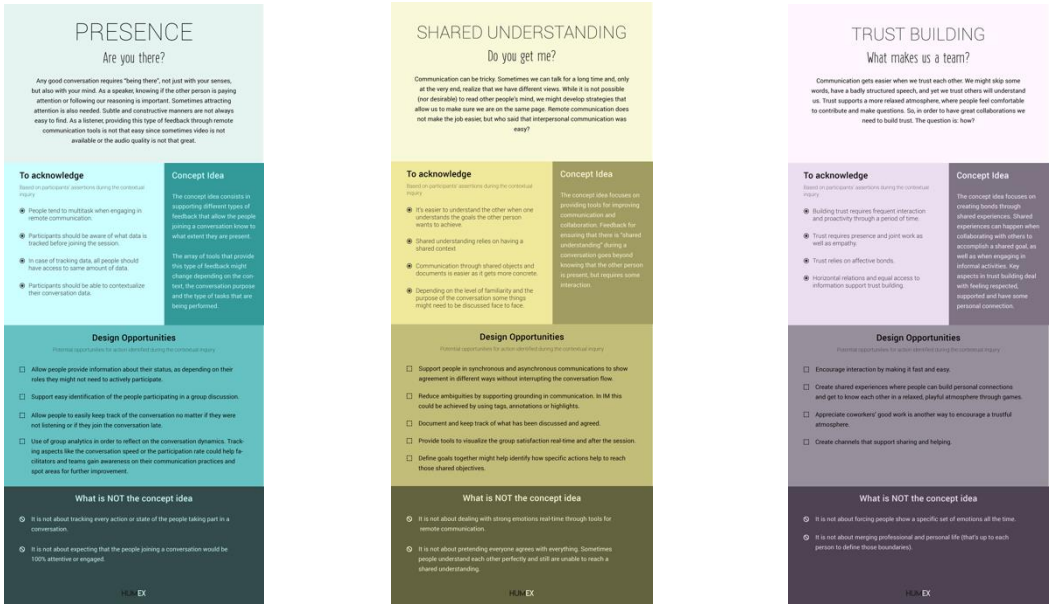

Figure 2. The themes as we presented them to participants for validation if we grasped their meaning well enough.

Previous Research

Shared understanding is a quintessential feature for successful joint and collaborative work practises, especially in the transition from dialogical practises to collaborative practises executed through shared artefacts (Paavola & Miettinen, 2019; Stahl, 2016). Most of the investigated work tasks were precisely these activities during which the participants were collaboratively and systematically developing shared, concrete artefacts together towards a common aim (see Appendix 1 on the scenarios drafted later in the process). A common ground ensures negotiation related to the shared artefacts (Clark & Brennan, 1991). In the work settings described by the participants, indexical signs were used to indicate tangible objects. These signs referred to actual occurrences and experiences familiar to those communicating to convey a meaning shared through similar experiences. The interlocutors share similar experiences through the common ground and correct and reshape the common ground during the conversation (Arrighi & Ferrario, 2008). Recently common ground supporting shared understanding has been researched within the scope of music interpretations (Schober & Neta, 2016). It means that the participants of the event augment the base for forming a shared understanding. The joint base of, e.g., experiences has also been referred to as ‘anchored discussion’ (Van der Pol, 2007). From the perspective of technologies, these should provide supporting affordances and cues for fluent and organised joint work with shared artefacts and practises (Bayer, Campbell, & Ling, 2015). The workshops’ participants’ thoughts were aligned with previous research exploring challenges for shared understanding, such as interpersonal differences, the absence of shared history and context (Hinds & Mortensen, 2005) and a lack of information related to the team members and tool ecosystems used (Bayer et al., 2015).

Meaning for Design

The participants generally mentioned sharing objects or doing things together as necessary. Thus, allowing collaboration focussed collaboration might support shared understanding. The other worries that arose were following the others, understanding if they are on the same page, or engaged, possibilities to show empathy. For design, it would mean enhanced means to collaborate without attention distracters. We could imagine that using other senses to detect the other participants' eagerness and ability to follow might provide some solutions.

Trust

Summary

According to the workshop participants, trust[6] relates to feeling comfortable and safe and is associated with a relaxed atmosphere where it is possible to fail or express oneself poorly, such as forgetting words or using incorrect terms and incomplete sentences. We heard ideas such as: *"Critical to have is trust – there is no trust the system conveying in the right manner."*

"Like when seeing people's faces - problem in video-conf tools like skype is that people's face icons are too small and it's difficult to get that information) – depending on trust level, useful to get participants' feedback (from 1 to 10) about how was their day – make the conversation more human and give useful feedback about the state (mood, involvement) of the person "

"Trust is also built by the company culture or let's say the company culture has strong effect on how trust is built. It is not so much about horizontal or vertical company structure. The company needs to assists, acceptance agreement, raw data doesn't help – needs to be aggregated."

"*Trust is not built by the coffee mate app (nor by giving "hugs") but by actions. "*

The concept emphasises creating bonds through shared experiences (Figure 2 right side). For two companies (marketing and design & development – fusion company), the aim was to build and maintain a more profound work culture of respect, appreciation and trust with a homely atmosphere. The participants expressed the need to maintain the homely feeling even when the companies grow by promoting interactions, such as organising meetings between different offices from different countries.

For example, a heartbeat without a system interpreting what the heartbeat means was more acceptable than when the system would present an interpretation of what an increase in a heartbeat might mean (below as one of the prototypes developed further and see Wikström et al., 2021).

Previous Research

A key aspect of trust-building relies on the feeling that one is respected and supported (Boon & Holmes, 1991). Personal connections might help develop trust, but they are not sufficient

(Preece, 2004). Kuo and Yu (2009) divided trust into three categories. The first is calculus-based trust in distant teamwork. Calculus-based trust emerges based on a member's assessment of the outcomes and costs of maintaining a group relationship. When a team continues to work productively, calculus-based trust transforms into knowledge-based trust (knowledge of others' competencies allowing the members to make predictions on each other's behaviours). Ultimately, identity-based trust emerges. It is grounded in the members' mutual identity and the willingness to support each other (Lewicki, McAllister, & Bies, 1998; Rousseau, Sitkin, Burt, & Camerer, 1998). Identity-based trust develops after the teams have worked together effectively for extended periods or at the end of the project. Järvenpää, Shaw, and Staples (2004) and McKnight Choudhury and Kacmar (2002) found that identity-based trust is dependent on the members' shared values and norms of obligations, and it allows members to support others.

Meaning for Design

For the current investigation, identity-based trust is attractive because the companies involved were attempting to build and maintain a particular work culture. The considerations on the trustfulness of technological actions come close to how the participants defined their suspicions as there is some risk of mistakes technology may make. However, although the participants had these concerns, they were optimistic that the new technologies would help people be more empathic and supportive towards each other in the future.

To answer the H1, *there is a need to use algorithmic systems on generated emotional and behavioural tools to enhance, support and scaffold the digitally mediated collaborative work*; we can answer yes. There is a need to use algorithms but not necessarily for suggesting, recommending or providing interpretations of emotions or behaviours. Subtle ways of positive emotions (such as agreement, following, empathy, and understanding of the topic under discussion) were seen to bring positive outcomes. In addition, voluntary feedback presentation – the need to control what is presented and how was another topic of discussion. Tentatively, we could summarise that small attempts towards new technologies were supported, and despite the concerns, there was optimism about the future.

Journey Maps, Inspiration Cards and Next Steps

After reviewing these three themes in the light of previous research and discussing them with the workshop participants, the journey maps were developed. The journey maps helped obtain a better understanding of the interactions between the actors, tools and the ecosystem where the communications and collaborations occurred. The themes and the journey maps: Community building with instant messaging, Showing engagement (presence) in an online focus group using video-conferencing (audio, no video), Supporting shared understanding among the group using online video-conferencing (audio) (see Figure 3 right for an example) provided relevant insights that informed the creation of scenarios: Facilitating a focus group using video-conferencing, Group discussion using audio-conference and Community building using instant messaging (see Appendix 1) and inspiration cards (see Figure 3 left).

Figure 3. Inspiration cards that encouraged people to think about the challenges related to digitally mediated communication and collaboration (left) and journey maps describing the process of actions are physical, spatial and tangible intermediate research output.

The scenarios presented different experiences with digital tools connected to community building using instant messaging, group discussions using audio-conferencing and facilitating a focus group using video-conferencing with shared artefacts. The researcher presented the scenario at the beginning of the workshop to introduce the theme and provide a concrete example similar to the participants' experiences with CMC and collaboration in the workplace regarding the challenges associated with specific tools. The feedback collected from the interviews and workshops using the inspiration cards and scenarios elucidated that the notion of presence was felt to be the most central aspect of the study. The workshops and interviews underlined again the difficulty of showing negative emotions or the care that these should be expressed constructively:

"Negative feelings can be expressed alone in virtual situations and you can still" look" professional."

"Constructive fear, frustration, anger, personal antipathy - sometimes yes good to show, If there is trust, it works, but in the customer meeting - sometimes I even reflect."

"Presenting individual feelings … No. 70% frustrated - but as group level you get the feelings"

"Shared a thing all of the group feels it - atmosphere."

"Constructive way to express is needed, group level, maybe from tone of voice and posture, positive things spread, a negative spiral can be spread by one person."

"Anonymous positive feedback to colleagues creates the bonus system."

2Perhaps this would not be a good idea if everyone gets same emotional info, possibility to fake, plus loss of control because one ends following the system instructions."

The participants mentioned that when feelings and emotions, such as agreement and disagreement, are presented in a manner that simulates a face-to-face situation as closely as possible, it is ineffective. These simulated situations require too much concentration in a digitally mediated context to be fruitful. Therefore, for efficiency during work tasks, it is essential to perceive agreement and attention easily.

"Technical quality seemless quality"

"Challenge in remote communications: the more people join the communication, the more info (audio, audiovisual) is coming in and that's difficult to handle from the technical point of view."

"This type of video conferencing without the video doesn't add anything and it is just like a phone call. On top of that chat is used for common discussion or notes. In a collaborative session like this someone is sharing their screen (who is leading the meeting) and the rest look at that, not faces. Its is easier to see, show screen then explain verbally. "
"In F2F it's easier to find out that the other person is lost, and thus he can adjust (move to a plan B), whereas in remote communication systems noticing is not that easy that the other person is lost."
"Nodding is helpful in conversations, but it is not; it is used if it has to be done on purpose (both considered emoticons in 'skype' are useful, but somehow they are not that used or might be awkward to use if there is not much confidence."
"Communication over a shared object happens almost all the time– it keeps the communication focused."

In addition, the display should be straightforward, so it does not disturb actual work. These outcomes directed us to redefine the hypothesis into a narrower scope, and we had to dismantle complex tools ideas for this study to allow appropriation (Dourish, 2003).

Based on the journey maps and scenarios, various prototypes were created. In the HUMEX project's seminar, we presented prototypes created by students. There were two prototypes on voice, communication on shared work support – Nodders and customer service. Twelve participants (unanimously) selected the heartbeat customer service and the Nodders to be continued (see the finalised presentation of the prototypes in Appendix 2). The rest of the prototypes were completed as far as the student teams needed for their grade. The seminar allowed participants to try out the prototypes to understand them better. The student developers and designers were present to answer questions. The heartbeat visualisation for customer service development can be read from Wikström et al. (2021). Both selected prototypes allowed a step-to-step development towards different usage of technologies.

The Nodders prototype explores the challenges associated with the notion of presence. It aims to improve collaboration by providing non-verbal feedback regarding head gestures as an addition to the audio or video communication channel. During the design process, another factor was considered – a tool should evolve over time and with use (Arias, Eden, Fischer, & Gorman 2000; Wulf et al. 2015). The Nodders prototype is meant to be used in an audio or video conference.

Currently, the prototype consists of sensors attached to a headband, which reacts to the nodding7 of the wearer (see Figure 4a and b). The action is rendered close to real-time and is displayed as an animated nodding or shaking of the smiley on a computer screen visible to the participants on the conference call. The prototype design is minimal and uncomplicated to provide the interlocutors with feedback that is easy to process and perceived with peripheral attention (Carroll, Rosson, Farooq, & Xiao, 2009). The literature does not often mention this, but simplicity in collaborative technologies is vital for success. For instance, Nardi and Miller (1991) conducted a study that showed that effortless technologies designed as collaboration tools have proven to be most effective in encouraging collaborative work. These technologies succeed because they allow a smoother evolvement with the use (Arias et al., 2000). The decision to reduce possible sensor-based features was difficult because many ideas related to tracking arousal that could have been designed and developed were abandoned. We dropped

out the idea of gaze following (see Pöysä-Tarhonen, Awwal, Häkkinen, & Otieno, 2020) and facial or micro-expression detection (Zhao & Li, 2019) because of the need for more technology to be added into the participants' use. In addition, to avoid such data collection from the participants, they could not control. The Nodders use algorithms to learn the nodding of the person wearing the sensor. Because people nod in different manners, some nod heavily and others lightly, but the participants still control the nodding. Thus, the use of the algorithmic system is minimal, and it is not providing suggestions or recommendations. We could say that it tries to interpret the nodding of a person.

To date, four prototype testing with workers were performed to attain iterative and frequent feedback that informs further development cycles. The first two prototype tests were carried out with simulated tasks. The second two with actual tasks shared artefacts and workers from two companies that participated in the previous focus groups. Next, the findings are described.

THE NODDERS PROTOTYPE TESTING AND DATA COLLECTION

Analysis of the prototype testing

During the first observations, it was difficult to recognise when the workers and the students noticed the smiley. The first impression was that they ignored it; however, during the interviews, the workers and the student mentioned that they were glancing at the smiley when it nodded. They also expressed that they saw the smiley in their peripheral vision because the movement was detectable as the smiley was otherwise still (Figure 4). For instance, participants stated: *"Usually, concentration on another's presence takes effort. This takes it away from the joint work at hand. Now, I just saw it from the corner of my eye, or I saw it for a moment. That was enough because it only nods or doesn't. I do not need to concentrate on the expression."*

Similar comments were expressed after the prototype testing with workers from companies. In addition, when observing the second testing, it was easier to notice when the workers reacted to the smiley. The ability to observe better could be due to the researchers learning to pay attention to particular reactions (e.g., small head movements and pauses7) after the first two prototype tests.

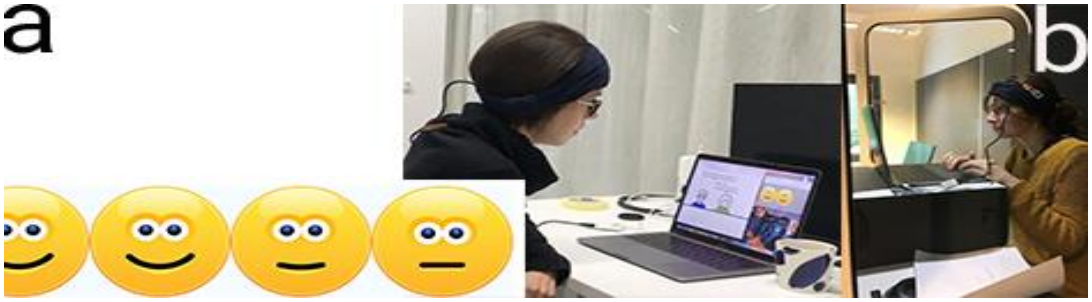

Figure 4. Left side (a): The different stages of smileys on different participants (4 on this side of the image) – the two smileys on the left are in the nodding process, the second from right is neutral, and the far right is in the process of shaking the head. In the video, you can see the state of the neutral and nodding and a development phase sensor testing[8]. On the right side (b), the current sensor in the headband for detecting nodding. On the screen, you can see two smiles, two taking part in the conversation.

The workers and the student mentioned that the Nodders would improve their work and study. They explained that even though the video is available in the conferencing tool, they do not use it because interpreting cues from faces in a small video takes concentration away from the joint work. For instance, the following was expressed: *"Too detailed display would be horrible. I do not want to see myself in that much detail. A smiley is better—more neutral; video is too up front."*

In addition, technological obstacles are still frequent. For instance, wireless connections are insufficient, and the video is not displayed well. The workers and the student stated that the delay in a video is more disturbing than it is in the smiley. The participants also mentioned they saw the smiley at a glance. For example*: "There should not be too many cues or too much noise. The smiley was fast and easy to see."*

The slight delay was irrelevant because they had received the feedback that the interlocutor was attentive, while during a video, one must concentrate on seeing it well. Thus, one must shift continuously back and forth from the shared artefact to the video. The smiley was perceived to be simple enough not to take too much screen real estate, which is essential when the work at hand requires most of the screen space. One participant stated: *"I liked it because it is simple, fast to see and fits into the screen space without taking space from work, it reduces the technologies I use, or so I feel."*

Furthermore, the participants pointed out that they did not feel intimidated because the system tracked their head nodding. It was felt to be the action that they wanted to express. With the smiley, attention was made visible, but physiological measures were not exposed to interpretation, which might happen with emotional tracking. The most interesting of the statements was*: "Seeing the smiley move made me nod more, and it reminded to give feedback to the co- worker that yes, I am hereco-workerning."*

All stated that they might not need the shaking of the smiley's head to indicate that the interlocutor disagrees. The shaking smiley was viewed as unnecessary and confusing. If there is a disagreement, they most likely should discuss the issue. For instance, a participant mentioned: *"Positive emotions are good to see. Negative ones are not. One has to prepare to express the negatives correctly and constructively. Otherwise, it may escalate and become out of hand."*

Most (5/6) also stated that if there were many participants, the smileys would need a different colour or something visual to distinguish the workers from each other. Another issue that needs to be resolved is the attachment of the sensor to the headset. Currently, it is attached to a headband due to the state of the prototype (Figure 3 b). The workers and students suggested that the sensors could be integrated into a headset, which they use when communicating using digital tools; moreover, they also stated that the headband was not an issue: *"The headband did not bother me. I am so used to headsets, which I use daily at work, that I did not notice the headband after a few seconds."*

This study provided an indication of confirming both of the hypotheses: a) The smiley is simple enough to be perceived at a glance with peripheral vision. The shaking of the smiley's head will be eliminated so that it is even more straightforward and allows a design for distinguishing between many workers. b) Being in control of what occurs was also confirmed. The smiley promoted control in providing feedback to other interlocutors better than a typical Skype audio call. Another indication of a successful design direction and potential appropriation is that the companies wished to continue the prototype development.

DISCUSSION

Implications of Designing Tools for Supporting Presence in CMC and CSCW at Work

Based on the contextual inquiry findings and the prototype testing results, we describe some practical implications for the design of digital communication and collaboration tools that track data regarding the interlocutors' emotional states to increase the feeling of presence. Issues related to the attitudes of tracking arousal and potential for appropriation at work. This topic was pressing among the forerunners already before the COVID-19 pandemic, and now it is a central issue, especially in knowledge work. In addition, the number of devices that track physiological data has increased, and many are in some use already (Peake et al., 2018; Wikström et al., 2017; Gravina et al., 2017). Furthermore, the need to solve the still existing problems related to the presence, shared understanding and trust with these kinds of tools has been presented as part of the digitalisation process (Garro-Abarca, Palos-Sanchez, & Aguayo-Camacho, 2021).

Our hypothesis: *there is a need to use algorithmic systems on generating emotional and behavioural data for tools that enhance, support and scaffold the digitally mediated collaborative work,* was explored through readiness to accept new technologies, attitudes towards physiological data tracking and aspects of successful remote work. We found some surprising results and well-established essential factors for digitally mediated collaboration and communication at work.

Attitudes on tracking physiological states

First, people's readiness to accept the tracking of their physiological states, such as arousal levels, depends on myriads of factors connected to age, culture, work position, values and attitudes, and their familiarity with tracking technologies. Design implications derived from these observations deal with the anonymity and privacy level that the tools enable. For instance, people might feel comfortable with group activity tracking provided the information is kept anonymous but feel uncomfortable if the tracking takes place at the individual level. Additional implications involve providing clear information and obtaining consent. It means that the appropriation has started, but it is not well supported, as stated by Ingusci et al. (2021) on job crafting, which is well in line with the previous studies on appropriation (Ramstead et al., 2016).

Attitudes on readiness to apply

Second, people dislike being unable to control the data that the system monitors of their physiological states. In other words, people want to control the physiological data that tools display in visualisations to others and the machine interpretation of these data as it might affect the relationship with their counterparts (Noble and Roberts, 2016). Furthermore, there was a clear difference between negative and positive feelings. Negative feelings were felt to be private and should only be presented to others by the participant and not by the system. In

contrast, positive feelings can be presented to others as long as the participant is aware that this occurs. It supports maintaining cohesion (Garro-Abarca et al., 2021).

Direction of design for successful CMC and collaboration at work

Third, in the design direction, the research participants confirmed the importance of knowing that the interlocutors are present and engaged in active listening as being essential. It became apparent on the described current practises and the suggested scenarios that we used with the participants. Such scenarios were the digital tools connected to community building using instant messaging, group discussions using audio-conferencing and facilitating a focus group using video-conferencing with shared artefacts. Interestingly, being present did not mean that the interlocutors needed to be continuously monitored during the conversation, which was further tried out with The Nodders. In other words, a feeling of continuous presence is not necessary, but perceiving a useful presence is. In addition to presence, trust and shared understanding were mentioned, as Ingusci et al. (2021) also stress.

The Nodders prototype

The second hypothesis for enhancing presence with sensor-based tools that track voluntary physiological acts was tested. The hypothesis was that *a) the feedback of the presence of other interlocutors must be as simplified as possible so that it can be perceived at a glance or with peripheral vision, and b) the workers must feel that they are in control of what is presented to the other interlocutors.* During the participatory workshops and prototype testing, it was possible to conclude that tools for tracking presence can be distracting and, therefore, counterproductive if it increases cognitive overload (Ingusci et al., 2021). In this regard, it is vital to identify ways to provide feedback regarding a useful presence using peripheral attention. It also means there might be a reason to reduce technology and not add more. Sivunen and Nordbäck (2015) found a similar tendency in the virtual work environment research. The avatars played a minor role in creating a social presence during virtual team meetings in their study. The team members did not control the avatars. Controlling the avatars was too time-consuming concerning the focus on the subject and the aim of the meeting itself. In research on simulation fidelity at work training context, Hontvedt and Øvergård (2019) found that when in training, if the learning collaboration objectives are problem-solving strategies, mental models and feelings (psychological fidelity) and coordination and collaborative patterns within a team (interactional fidelity), high technical fidelity was not required but fidelity in reaching closely same feeling or collaborative patterns, often by reducing technology, e.g. by role-playing was required.

In this research study, the smiley was sufficient; it maintained concentration on the actual joint work, which was modified through the shared artefact. In addition, the animated emoji promoted the participants to nod more than usual during the work to maintain the attentiveness of the other empathy (Sivunen& Nordbäck, 2015; Zaki & Ochsner, 2012). Remarkably, one of the essential issues is a simplification. However, it is not about abandoning technology but pointing to the essential features of technology that support the correct issues at work and not offering all possible features available or keeping the ones that are hindering or unnecessary for the work (Garro-Abarca et al., 2021).

CONCLUSIONS

The research-based design has been prominently used in design research of tools for enhancing communication and collaboration (Bauters, Purma, & Leinonen, 2014; Pejoska, Bauters, Purma, & Leinonen, 2016). It has benefits such as the emphasis on hypotheses, theory-rich designs and allowing time for reflection on designs. It also supports the continuous critical revision of the research hypothesis. In the context of this research, some of the early hypotheses were related to the potential technologies to track interlocutors' physiological affective and arousal states, such as emotions. The expectation was that visualising data related to interlocutors' emotions enriches communication by increasing the feeling of presence, shared understanding and trust. The hypothesis (H1) was modified after the contextual inquiry to be more specific and to consider the participants' attitudes towards tracking emotions, which were positive in general but critical regarding what is displayed and how it is displayed to whom. Namely, a) tools must respect the interlocutors' control over them in addition that b) presenting negative emotions should always be under the complete control of the worker.

The Nodders prototype testing hypotheses were: a) The nodding smiley is simple enough to be perceived at a glance with the peripheral vision and b) Being in control of what is interpreted and displayed by the system. Both hypotheses were confirmed in the prototype testing. However, since this study was qualitative and we had six participants in the prototype testing, the results cannot be generalised. However, they can provide a base for further testing, especially in other collaborative work settings than the current setting. The Nodders prototype testing participants provided a significant advantage as they were willing to try out during actual work tasks in natural work environments. One of the prototypes testings' important insights is related to the current use, but insights also arose related to the next steps for the tools to evolve with the users. The hesitance of transforming practises requires step by step appropriation or well organised bottom-up support for the workers to accept a new form of work culture. These prototype testing furnished the research with a glimpse of possible appropriation of The Nodders into work use and how it might change the work practises, which we could not have had in case we had only simulated games in a laboratory setting or with student participants (Järvenpää et al., 2004; Kiesler, Siegel, & McGuire 1984). The Nodders was the first step in the appropriation.

The most crucial feature of enhanced presence is that it does not disturb concentration on the joint work. It means that much effort has to be invested in adapting to the current tools to focus on the main things – the actual work at hand. Thus, when designing new tools with emergent technologies, building the new tools on top of the old ones should be avoided, as this adds excess noise into digitally mediated collaboration at work. In our understanding, it means that bottom-up support is needed for scaffolding the appropriation of new tools and, if possible, reducing the old tools. Since the emerging technologies allow so many different types of collaboration that their actual value may be lost when mixed with the old tools, the best approach might be to start from scratch. However, the more significant the change is in working practises, and culture, the more robust support is needed (Ingusci et al., 2021). It was visible through the reluctance of the workers to try out with the dismantled prototypes of recognising emotions from live audio, deep learning on concepts used during discussions,

using face recognition to detect emotions in video conference collaboration had to be discarded from further prototyping.

The design-based research allowed the integrating of previous and current research from different disciplines. This broad and longitudinal view showed that the same challenges that were new in the 90s on digitally mediated work still exist. The themes of presence, trust, and shared understanding persist. We suggest that more interdisciplinary research is needed and thinking outside the box to solve these challenges. In addition, there is a global need to design beyond user-centric research. For instance, Feenberg (2010) pleads for reflections on the ethical aspects related to the responsibility of designers when developing tools. The limits of user-centred approaches are questioned as they might not be sufficient for dealing with complex and fast-changing systems (Törpel et al., 2003). Designers must consider the broader system in which the design takes place and consider the impact on the work culture and environment (Bauters, 2017).

Future Research Needs

The appropriation of The Nodders should be investigated because it provides a view on appropriating new concepts, practises and tools into the work context. It was also mentioned by the enterprises taking part in the Nodders prototype testing that they will continue the development. Thus, there is a context for further research. Future research might focus on, for instance, whether nodding might be replaced with eye tracking for measuring the presence or with some other physiological manner which is not found to be invasive, and if the attitude what is invasive will change and how (see also Pöysä-Tarhonen, Awwal, Häkkinen, & Otieno, 2020).

Currently, the pandemic is teaching many issues to us and directing us towards future research on the balance that could be found between face to face and digitally mediated communication and collaboration at work.

The Limitations of the Research

The study's limitations consist of focusing on a specific group of participants. The workers were selected from the companies which are forerunners in technology use, have resilience towards change, and are executing asynchronous and synchronous distance work. These workers are early adopters, well-aware of emerging technologies, and willing to transform their work practices. In addition, the number of participants is not large enough for generalisation. However, the contextual inquiry and prototyping length were long (18 months), so sustained research was possible with the same participants. Having the same participants in the study is a merit but also limits the variations or statistical analysis of the data. The highly interdisciplinary research team and framework can be seen as problematic because concepts, methodologies and analysis methods are hard to fit together, not to mention to follow by others or replicate it. The qualitative research-based design might have been difficult to digest. Since this research tradition tends to be descriptive, and case studies are emphasised, providing flesh to the research but reducing the ability to provide hard facts that can be used directly in other contexts. In our view, the topic we covered was missing this descriptive view and the different insight provided in it.

IMPLICATIONS FOR RESEARCH, APPLICATION, OR POLICY

The benefits of this research can be seen in the problematising the current user- and human-centric design methods, which cannot consider the longitudinal, nor the whole implications of the tools introduced to the tool ecosystems or as a part of the technology, society and environment ecosystems. We suggest increasingly interdisciplinary with a global perspective going beyond user-centric research to solve these challenges. For instance, future design and research need reflections on the ethical aspects that the tools can create and implications these tools have on habit changes (societal changes) and environmental biodiversity. Designers, researchers, citizens, participants must consider the broader system in which the design takes place and consider the impact on the work culture and environment (Bauters, 2017). We propose pondering using the system-centric view, deriving from Latour's (1999) actor-network theory.

On a more pragmatic scale, this research provides guidelines and ideas on reducing technology for better attention and concentration on the actual tasks at hand in collaborative work situations.

ENDNOTES [NOT FOOTNOTES]

1. https://cordis.europa.eu/project/id/9727020
2. The construction field work case is not described here in more detail, because their need was different. Related to communication and shared understanding but on understand various languages and especially construction slang in the different languages used.
3. https://processingevidence.tumblr.com/.
4. Theme presence: https://66.media.tumblr.com/d0113b5bf8434b167164ed141464e22c/tumblr_p7hvkc16FG1xpkdiro3_1280.png
5. Theme shared understanding: https://66.media.tumblr.com/f16759c0edc9d22575172451b33aa289/tumblr_p7hvkc16FG1xpkdiro2_1280.png
6. Theme trust: https://66.media.tumblr.com/da30d0de8a1e4e2f7f88164d14975597/tumblr_p7hvkc16FG1xpkdiro1_1280.png
7. We are aware that nodding is not a sign of agreement in all cultures, but for the first prototype and in our culture, it was enough to try out with the idea of detecting head gestures for agreement in distance collaboration at work.
8. Link to the video on the sensor in a headband: https://processingevidence.tumblr.com/post/172855322678/first-look-of-the-nodding-prototype-a-device-that

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All correspondence should be addressed to
Merja Bauters
Digital Transformation and Lifelong Learning Research Group, School of Technologies, University of Tallinn, Tallinn, Estonia
Department of Education, Faculty of Educational Sciences, University of Helsinki, Helsinki, Finland
merjabauters@tu.ee

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Appendix 1
Scenarios

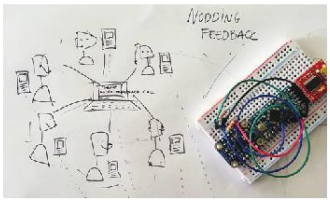
Appendix 2
Card on prototypes

The Nodders

Are you there? Supporting presence in computer-mediated communication at work

Context

When comparing communication through digital technologies versus face-to-face interaction, digital communication is still perceived as more challenging. This creates some challenges for successful communication and collaboration in workplace settings. In particular, people's lack of feeling other interlocutors' presence during synchronous communications is an important challenge for successful collaboration, trust building and shared understanding.



Concept

The Nodders provides feedback about head gestures, like agreement, during audio calls and visualizes the information through animated emoticons. The prototype is meant to be used with a headset when taking part in a video conference.

Scenario of Use

Jaakko works as service designer at Easylife. As part of his work, he uses audio calls to communicate with clients. He has difficulty to make sure his clients follow all the aspects discussed in the conversation. In order improve communication, he uses The Nodders. The feedback provided by The Nodders helps him see if his clients agree with the ideas he explains them. This contributes to make the conversation smoother since he doesn't need to ask for confirmation continuously.

Contact Information

Merja Bauters (coordinator)
merja.bauters@aalto.fi

Joaquin Aldunate
Eva Durall
Jana Pejoska

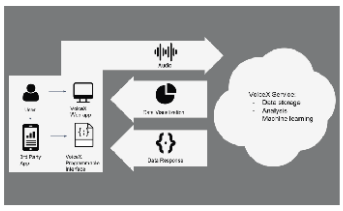
HUMEX Aalto University School of Arts, Design and Architecture

VoiceX

Improve your speechcraft.

Context

Time is often wasted when speaking, whether in meetings or presentations, because speakers aren't well prepared, don'tt know what to say, have to think a lot before finding the right words etc. This is frustrating to participants and may prove costly to companies. Our goal is to improve the performance of presenters and meeting attendees by enabling them to speak more fluently and efficiently.



Concept

Our web application recognizes user-defined filling words from an uploaded or recorded audio file and provides statistics on how often the words were used. The statistics include comparisons to previous audio entries and shows the user's improvement over time.

Scenario of Use

A company has a lot of inefficient meetings. Participants don't prepare well enough and waste time talking about non-relevant things. Sometimes there are fights about turns and people tend to have problems communicating their points in a clear way. The company decides to start using VoiceX to improve the efficiency of their meetings and minimize the time wasted in them.

Contact Information

Merja Bauters (coordinator)
merja.bauters@aalto.fi

Sophia Lentz
Guillaume Wetsch
Lennord Bijl
Julius Niiniranta
Miikka Lehto

VoiceX

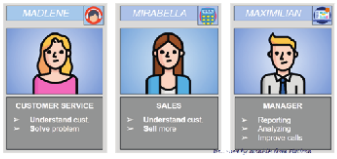
HUMEX Aalto University School of Arts, Design and Architecture

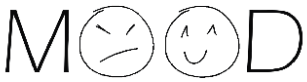
Mood

Recognizing emotions from live audio: An assistant to customer service and sales

Context

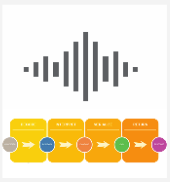
Every company, B2C or B2B, does sales. The de-facto interface to this since the 20th century is a telephone. Most companies also have their customer support over a telephone. In both cases, employees of the company interact with customers, and misjudgments of emotions can end up costly. An employee may be inexperienced, unfocused, or succumbing to tunnel vision after tens of calls that day, which endangers either case.





Concept

We present a software tool, to assist an employee in sales or customer support. Our software taps in on customer's live audio, and relays recognized emotions to the employee, additionally giving recommendations for appropriate reactions.



Scenario of Use

Imaginary employee Madlene works in customer support of an insurance company, dealing with reclamations. Every day when accidents occur, the victims of said accidents, customers, face various emotions depending on their circumstances.
A father whose child is in a hospital after a car accident they had, may be feeling distressed, expressing it as sadness or fear. If Madlene was to act overtly carefree (maybe after a joyful coffee break), the customer might think he is being neglected. (After all, his child is in a hospital, even though Madlene is not aware of this.) This may end in a retention, if she doesn't notice the sadness from his speech.
Meanwhile a customer, whose car broke down mid-trip, could be frustrated of the situation to the point of anger. As opposed to the previous case of car accident, here a carefree calming attitude may be very welcome, reminding him how good it is he has an insurance!

Contact Information

Minna Wahlroos
Minna.Wahlroos@metropolia.fi

Sandra Prestel
Sandra.Prestel@metropolia.fi

Simon Kunz
Simon.Kunz@metropolia.fi

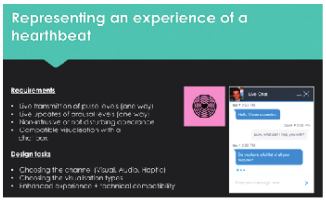
HUMEX Aalto University School of Arts, Design and Architecture

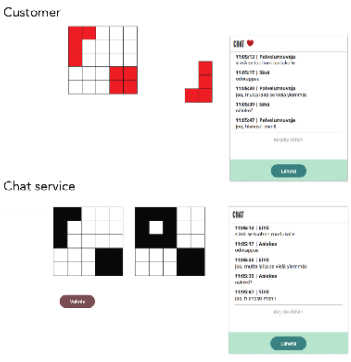
Chat with Heart

An instant messaging task for two players, simulating an expert advisor and client customer service situation, with a heart

Context

Customer service over online chat is often preferred to phone or email and increasingly used in many of Humex partner companies, sometimes together with chat bots. If is especially active in this area, and we wanted to investigate a controllable task to improve collaboration over instant messaging. The goal is to have a task with measurable outcomes, which can be used to support qualitative data in prototype development.



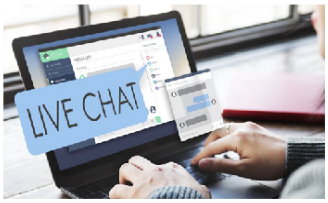


Concept

In this prototype we are testing an abstract matrix reasoning task designed for the online chat environment, and experimenting with how to improve the chat experience by visualizing the advisors heart beat to the customer. Additionally, video data is collected to improve the heart beat prototype by moving towards camera based heart rate detection. The experiments are carried out by actual If employees in a pop up lab at If HQ, and real If customers who are participating from home.

Scenario of Use

Pekka's son Pikku-Pekka has dented Pekka's car, and he is unsure about whether his insurance will cover it. He is frustrated, and his first reaction is to vent out on the customer service employee Siiri who is trying their best to help him. Pekka starts off impolitely and bluntly demanding an easy resolution, but soon he realizes that he is causing Siiri to become agitated, since her heart is beating faster. This makes Pekka relate to Siiri more, and he changes to a more cooperative tone.



Contact Information

Valtteri Wikström
valtteri.wikstrom@helsinki.fi

Jana Pejoska

HUMEX Aalto University School of Arts, Design and Architecture