A User Study on Awareness Signals for Social Communication

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Abstract

Very often today people are depending on distant social communication to maintain contact with their working groups or families. This distant communication happens often very abruptly without any awareness signal in advance. This paper presents a Wizard-of-Oz user study based on awareness signals, specifically illumination and sound effects, which were triggered by an experimenter before the communication started. Participants had to test a distant vs. a close light vs. a sound effect vs. combination of light-sound vs. absence of any signals. Although the distant light was in the periphery of the focused attention of the users, it was generally better accepted, though less perceptible than the close light. Promising results towards "peripheral awareness" show that the existence of triggered awareness signals in the unobtrusive periphery transmit a communication message fluently to the users.

Index Terms: awareness, human-computer interaction, interaction design, social communication.

1. Introduction

Nowadays synchronous (e.g., telephone, video-conference systems) and asynchronous (e.g., email, social networks) means help us communicate with our distantly separated peers. However, this distant communication is not as productive and effective as face-to-face communication and it often happens abruptly and obtrusively. At workplace when teams are co-located, spontaneous communication occurs very often at a daily basis: people meet at the coffee corner or have lunch together. However, nowadays due to globalization, the teams are often distributed over branch offices located in different cities and countries.

Let us imagine that at the foyer of a company there is an ambient display and we are currently passing by. In a branch office in another city a colleague does the same. It would have been nice if both colleagues would be aware of each other and have some social communication. Before a video communication software pops up, what kind of signals would users expect as an output from the display? It could be, for instance, a pulsing background light, a soundscape with increasing volume as we come closer or even an avatar, which welcomes us and introduces to the display's functionalities. As an input, there could be an in-air hand gesture, voice, but also raw sensor data, such as spatial distance, etc. Some of these modalities are more implicit, some more explicit; the transition from implicit to explicit communication should be transparent, but fluent. In our opinion, awareness signals before the beginning of communication would make the transition from the actual activity state to the communication state more fluent and in addition, would preserve privacy.

Our research is on facilitating spontaneous and informal communication in spatially distributed working groups by exploiting smart environments and ambient intelligence. In the project SOCIAL (Van de Ven et al. [1]) we focus on this research goal through the following three key steps:

1. Detection of situations with the potential for spontaneous informal communication;
2. Representation of these situations appropriately to distant users;
3. Enabling them to engage in communication spanning multiple spatial locations.

The above steps include the perception of the current potential communication situations, the transparent and privacy-preserving detection of instances of situations, representation of formalized behavioural cues in distributed setting, and last but not least, human-computer interaction (HCI) methods. The detection step includes representation and reasoning about the situational context. This requires a formal language to describe specific situations of interest, available knowledge, e.g., abstracted perceptions of situation context, and the behavior of the system. [1] applied methods from the field of qualitative spatio-temporal representation and reasoning (QSTR).

In this paper we focus particularly on the HCI methods for social communication and their requirements, such as implicit/ implied communication, intuitiveness, and unobtrusiveness. A pilot study is a first step towards exploring which signals are more appropriate for designing an awareness-communication system which fills these requirements. The paper is structured as follows: in Section 2 we present some related work of this interdisciplinary field and in Section 3 we discuss the user study, including the set-up (3.1), hypotheses and experimental methods (3.2) as well as its results (3.3). We have a short summary and discussion in Section 4 concluding the paper with a few future prospects in Section 5.

2. Related Work

As our research is interdisciplinary covering, among others, Sociological Studies, Ambient Intelligence, and Awareness Systems, here we present only a few related work of these fields to set the scene where the article belongs to. Kiesler and

Cummings [2] reviewed the term of *proximity* in work groups since the 60s and concluded that for distributed work groups, the use of communication technology is likely to be most successful when work groups are cohesive, i.e. they have already forged close relationships, so that the existing feelings of alliance or commitment sustain motivation. More recently and in the domain of Internet of Things (IoT), Atzori et al. [3] claim that in analogy with the human evolution from *homo sapiens* to *homo agens*, we may talk of an evolution path from a *res sapiens* (smart object) to a *res agens* (an acting object) and even to a *res socialis* (social object). The *res sapiens* communicates with the external world by relying on web protocols and communication paradigms by the current Internet of Services, while the *res socialis* refers to an object that is part of and acts in a social community of objects and devices.

Awareness systems, as a subfield of Ambient Intelligence, can be broadly defined as "systems intended to help people construct and maintain awareness of each other's activities, context or status, even when the participants are not co-located" (Markopoulos et al. [4]: v). There have been many systems in the past, the so-called *media spaces* connecting separate places, such as *Portholes* (Dourish & Bly [5]) and *Telemurals* (Karahalios et al. [6]). Moreover, the *Hello.Wall* and *Personal Aura* artefacts by Streitz et al. [7] emitted awareness information between distributed team members. *Hello.Wall* was an ambient display that emitted awareness information via different light patterns. Personal Aura (PA) enabled persons to indicate their "professional role" and "availability" to remote team members. PA consists of a reader module and an ID stick containing a unique identity and optional personal information.

Our research work, similarly as for [5], [6] and [7], can be categorized under "workspace awareness" systems. Gutwin & Greenberg [8] defined workspace awareness as "the collection of up-to-the-moment knowledge a person uses to capture another's interaction with the workspace". In 2001 Gutwin & Greenberg [9] created a workspace awareness framework with three aspects of: i) component elements (answer Wh questions), ii) mechanisms to maintain it (gather perceptual information), and iii) its uses in collaboration.

As far as auditory awareness signals are concerned, work goes back to middles 80s, when Sumikawa [10] provided guidelines for the integration of audio cues into computer user interfaces. In late 90s the Audio Aura system (Mynatt et al. [11]) provided serendipitous information tied to physical locations and delivered via portable wireless headphones. The PANDAA system (Sun et al. [12]) was a zero-configuration spatial localization system for networked devices based on ambient sound sensing. Ambient sounds, such as human speech, music, foot-steps, finger snaps, hand claps, or coughs and sneezes, were used to autonomously resolve the spatial relative arrangement of devices in a ubiquitous home environments using trigonometric bounds and successive approximation.

More recently Kainulainen et al. [13] presented guidelines regarding six common auditory techniques: speech, auditory icons, earcons, music, soundscapes, and sonifications and designed a general structure of an audio awareness architecture following the agent-evaluator-manger principle.

Within the project SOCIAL, Sartison [14] conducted an online survey and interviews with 23 participants to set the requirements for designing a stationary prototype which exchanges unobtrusive audio messages with the users as awareness signals. Participants had to evaluate a speech message vs. an auditory icon (sound of a coffee machine) vs. an earcon vs. a soundscape (cafeteria environment). The speech message was ranked as the most informative, but also the most obtrusive one. The auditory icon occupied the second place with regards to its perception, following very closely the speech message. Based on these user requirements, [14] developed a stationary prototype which automatically sends audio messages to users (mobile) based on their spatial location and their calendar availability. She also developed an mobile application to set up custom settings and the assignment of audio signals to a specific person.

As for visual signals, we particularly focus on illumination. Müller et al. [15] presented six examples of ambient light information displays, which address humans' perception abilities to gain cues from the periphery instead of attracting the user's visual focus. Our future system distinguishes from [15] as it will not be an information display system, but it will explore peripheral awareness through visual cues. Ehrhardt [16] designed a social communication vase with bubbling and colour-changing water based on the status of the social communication between remote people: orange colour when the situation for communication is detected, green colour to give the consent for communication, and red to decline it. The prototypes [14] and [16] used Raspberry Pi and Arduino respectively.

For the evaluation of our awareness system, we considered some of the heuristics of Mankoff et al. [17]: i) peripherality of display, ii) match between design of ambient display and environments, iii) easy transition to more in-depth information, iv) visibility of state, and vi) aesthetic and pleasing design.

3. User Study

In this section we discuss the study's set up (3.1), our hypotheses along with the post-study questionnaire (3.2), as well as the most significant results (3.3).

3.1. Set up

The user study took place in April-May 2015 at a lab at the University of Oldenburg. The goal of the study is to get initial results about the perception and overall acceptance of close/peripheral as well as visual/auditory awareness signals. 17 subjects (11 female, 6 male, mean age=25) participated in the study. Apart from one participant who has never used video communication software before, most of them were computer-savvy (but not computer science students). Each experiment lasted about 45 minutes and had two parts: i) a WoZ experiment and ii) filling in a user experience post-study questionnaire. As for the former part, the participants were asked to sit at a desk and watch a music video on a PC monitor at low volume; they were offered to have coffee and sweets during the video watching. With this setting we aimed at simulating a working environment, though not tied with a hardly concentrating job task, but rather a coffee break. They were informed that various signals, like light and sound, would appear in the room, without the experimenter pointing or verbally explaining the signal's exact output source. Should the participant notice a signal, (s)he should wait 5 secs and then call the experimenter on *Skype*; the addresser-addressee process and the communication mean *per se* was not the focus in this study. The experimenter was at a surveillance room and triggered the light and sound remotely. There were five experimental conditions tested:

i) Close light (lamp was next to the PC);

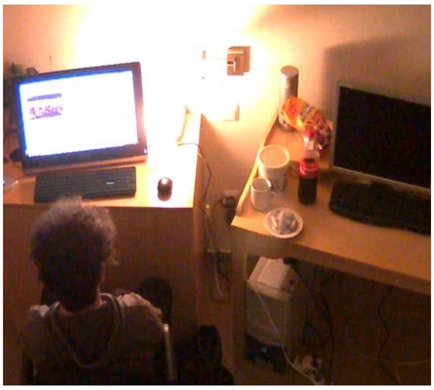
ii) Distant light (lamp was on a chair on the participant's left side);

iii) Sound (output of a wall-mounted speaker);

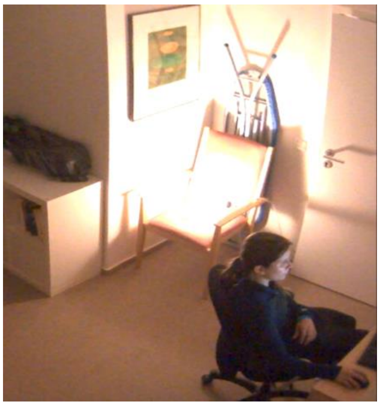
iv) Combination of sound and light;

v) Absence of signals.

The lamp used in the first, second, and fourth condition is a small lamp, ca. 30 cm high and it was illuminated white; there was not any pulsing light or other light patterns used. The investigator turned the lamp on and off with a time interval of 5 secs. The distant lamp was about 90º at the left side of the participant. This means that the actual signal perceived by the participant was a change in ambient illumination and their own shadow cast over the work area. The close light was in direct line of sight of the participant. For these reasons, we consider the distant light as a peripheral signal and the second as not peripheral signal. The lamp selected for the fourth condition was also random; for half of the participants it was the close lamp triggered and for the other half the distant one. The sound was output from a wall-mounted speaker, also about 90º at the right side of the participant, thus a peripheral audio signal. Pictures 1 and 2 show the setting of the experiment and precisely the close (Pic. 1) vs. distant lamp (Pic. 2).



Picture 1. Close light as awareness signal



Picture 2. Distant light as awareness signal

3.2. Hypotheses

In usability testing, questionnaires or subjective evaluations are used to learn from the users what a usable system is. To system designers, subjective evaluations may provide more informative data of system functionality than objective performance measures, since they focus on the user's first-hand experience. In our study we selected two subjective evaluation measures: a closed-ended questionnaire and a think-aloud protocol at the end of each experiment. In this sub-section we present our hypotheses with regards to spatial position of the awareness signal, overall user acceptance as well as the transition from awareness to communication. After each hypothesis, the questions of the questionnaire selected to test those hypotheses are presented.

Hypothesis 1 (Spatial position): *The spatial position of the signal's source influences its perception. A signal close to the user is easier and faster receipted than a distant one.*

The questions in the questionnaire that test this hypothesis are:

Q1	Does the spatial position of the lamp influence its perception?
Q2	How easily perceptible was the signal?

Hypothesis 2 (User acceptance): *The signal source that is close to the communication medium is better accepted by the users than the distant one.*

Sub-hypothesis 2a (Effectiveness): *The combination of two or more awareness signals is more effective than a single signal.*

The questions to test hypothesis 2 and 2a are:

Q3	Which of the following signals do you prefer?
Q4	How did you like the design/form of the signal?
Q5	Evaluate the idea of using light, sound, and the combination of light and sound as awareness signals.

Hypothesis 3 (Transition): *Peripheral signals provide a more fluent transition to communication than close signals.* The relevant questions to test this hypothesis are:

Q6	How gradual was the transition from the task to communication?
Q7	How much did the signal distract you from your task?

In statistical terms, we have three *discrete dependent variable* and four *discrete independent variables*; each independent variable has five *levels* on Likert scale (1-5)/ordinal variables. For Hyp.1, we tested 4 independent variables (absence of signals was excluded). We had a *within-subject* design, i.e. each user performs under each different condition. In order the design not to suffer from transfer of learning effects, we randomized the order of the conditions for each participant.

Discrete dependent variables	Perception, user acceptance, transition
Discrete independent variables	Close vs. distant light vs. sound vs. combination of sound and light vs. absence of signals.

3.3. Results

The results of our study are presented in the order of the hypotheses presented above.

Hypothesis 1 (Spatial position): In a dichotomous yes/no question (Q1), 88,24% of the participants stated that the spatial position of the lamp influences its perception. A significant percentage of 11,76% did not share this opinion, showing that awareness signals in the periphery does not seem to affect its perception negatively based on the user's experience. Diagram 1A presents the options along the Likert scale.

As far as the perception of signals is concerned (Q2), the close light was evaluated as the most easily perceptible signal with 94,12% (scale 5-strongest perception) followed by the distant light with 64,71% (scale 4). Comparing the close light with the sound in particular, on one hand, the close light raised the strongest awareness of most participants (MD=5, σ=0,24, Var=0,06). The sound, on the other hand, showed a much higher standard deviation and variance (MD=4, σ=0,9, Var=0,81). Based on the think-aloud protocol, a participant said that he perceived the light much faster than the sound, while another one mentioned that the sound has to be repeated to be more perceptible. Diagram 1B depicts in a boxplot the min, max, Q1, Q3 and MD values of the five signals.

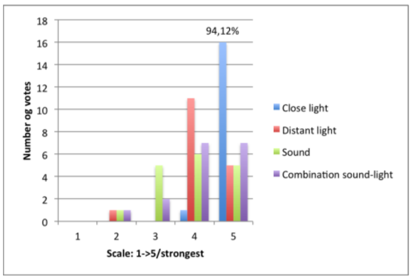


Diagram 1A. Perception of various signals based on their spatial position

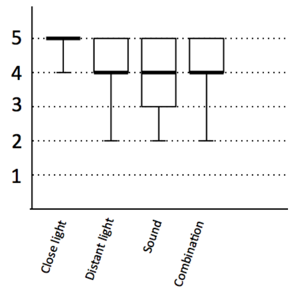


Diagram 1B. Boxplot about the perception

Hypothesis 2 (User acceptance) and sub-hypothesis 2a (Effectiveness): As for the overall preference of signals (Q3), Diagram 2A shows that most participants (64,71%) selected the situation-dependent option and not the combination of the signals (29,41%)[1]. The former means that either light or sound is selected as a signal based on a specific situation, e.g. in a loud environment, light is more appropriate, whereas in a very bright environment, sound is rather appropriate. Moreover, the situation-dependent option makes the system accessible for people with disabilities; a participant was a Sign Language Interpreter and mentioned that for the deaf, light signals lit up on every door when there is a knock on the entry door. Remarkably, light was ranked second with a big gap from sound (difference of 52,94%). º

With regards to aesthetic design of the signals (Q4), the distant light was ranked higher (MD=5), whereas the sound was less accepted (MD=2). This might be due to the kind of the selected sound effect (whispering "Psst..psst" sound); from the think-aloud protocol we deduce that participants would rather prefer a sound similar to an alert tone, a bell sound, or typical mobile phone tones that most people are familiar with. As the user acceptance is subjective and very much dependent on the selection of the study's triggered signals, we also report some statements from the participants (Table 1).

Table 1. *Statements from the think-aloud protocol about light, sound, and the combination*

The light is more user-friendly and discreet than the sound; you can easily blend it out in order to watch the video. The sound is always the same. You get frightened by the close light.
The close light was too penetrative.
If the close light was brighter, I would prefer that.
If you are concentrated, you don't perceive the distant light strongly.
The sound hacks me off, as it should happen often in order to be perceived.
You can mistake the awareness sound with another sound.
One signal is actually sufficient, as the combination leads to stimulus satiation.

As far as the evaluation of the idea of using light, sound, and the combination as awareness signals is concerned (Q5), participants were asked to compare their familiarity, interest and necessity (questionnaire's pre-defined answers). As expected, the sound was most familiar due to auditory signals known from mobile phones. The awareness with light was ranked equally interesting and necessary with the combination.

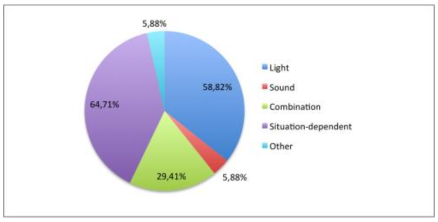


Diagram 2A. General preference of signals

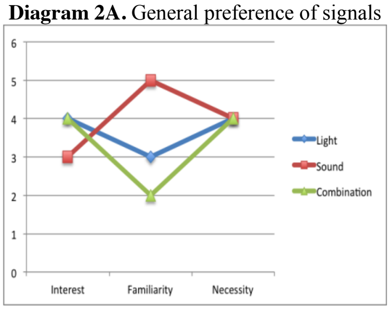


Diagram 2B. Evaluation of the idea of using awareness signals

[1] The sum of the votes is over 100%, as this question allowed multiple answers.

Hyp. 3 (Transition): Diagram 3A shows the transition with the absence of signals being ranked as the most abrupt (47,06%-scale 1), whereas through the distant light as the most fluent (52,94%-scale 5) transition. Regarding the results of the distraction from the actual activity, the distant light seemed to distract less (Var=1,28, σ=1,13) than the close light (Var=2,62, σ=1,62). The fact that the distant light distracted less justifies the fact that the distant light seemed to provide a more fluent transition to communication, as evaluated by the users. As the Diagram 3B boxplot shows about the transition from awareness to communication through the different options, the MD was the same for close and distant light and sound (MD=4), while it was lower for the combination (MD=3) and very low for the absence of signals (MD=1).

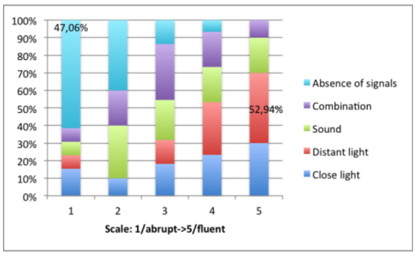


Diagram 3A. Transition from awareness to communication

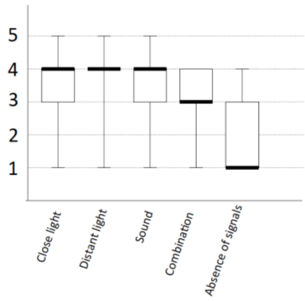


Diagram 3B. Boxplot about the transition

In addition to the results based on the hypotheses, we did a video annotation in order to test the viewing position of the participants when the peripheral light was triggered.
We deduce that 76,47% of the participants did not turn their head (focus) to look at the peripheral light. The remaining 23,53% looked at the peripheral light and did that even repeatedly after they noticed the signal. One out of 17 participants did not notice the distant lamp *per se*, although he realised that there was an ambient light. Moreover, one of the participants who looked at the distant lamp did that only after he called the investigator on *Skype*; that shows that awareness was raised before. Last but not least, only one of 17 participants looked at the wall-mounted speaker, when the sound was triggered.

4. Discussion

Non-verbal or implicit communication is very important in our frequent communication with our spatially distributed co-workers. This kind of communication includes the perception of the currently performed activity, behaviour or the presence of other people.
In this paper we presented our pilot user study regarding awareness signals for social communication. We evaluated their perception, user acceptance, and transition to communication. The system to be designed is a workspace awareness system in which visual and/or auditory signals will notify the co-workers in spatially distant settings that at that moment there is an opportunity for communication. The results showed that in general, light was higher accepted than sound and definitely better than the combination of two signals. Although the close signal was more perceptible than the distant one, the peripheral signal was more highly accepted by the users regarding aesthetics, unobtrusivess, and provision of a fluent transition to communication. These results along with the fact that the majority of the participants did not turn their viewing direction to the distant light show that raising peripheral awareness is not only feasible, but also effective, privacy preserving, and more closely tied with implicit communication which is a crucial requirement for our system.

5. Future Prospects

Awareness systems should be able to capture the presence of other people or their performed activity. The future system should be unobtrusive, scalable, and customizable to the user's needs. For these and other reasons, the future interface should be multimodal in order to give the user the opportunity to intuitively choose the interaction mode and easily use this mode. So far in practice, there is unfortunately no technical support system for implicit communication between spatially separated people.
In the future, we would like to explore further possibilities of multimodal signals for awareness and communication systems. This is possible by interpreting social signals through the recognition of behavioral cues (Vinciarelli et al. [18]), such as facial expressions, head movement, body gestures, voice detection, and speech recognition. Last but not least, as far as the representation design of our future system is concerned and with the actual developments of the Internet-of-Things (IoT), the ambient display might be replaced with any smart object that is available in a pervasive (working) environment: coffee mug, desk, chair, whiteboard, flower pot, etc. For instance, Wallbaum et al. [19] developed an artificial social plant which enables users to keep track of a loved person throughout the day by unobtrusively visualizing the partner's current state of mind via different colors of the blossom.

6. Acknowledgements

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