



AN AUGMENTED INFOCOMMUNICATION MODEL FOR UNIFIED COMMUNICATIONS IN SITUATIONAL CONTEXTS OF COLLABORATION

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ABSTRACT

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| Aim/Purpose | In this work, the authors propose an augmented model for human-centered Unified Communications & Collaboration (UC&C) product design and evaluation, which is supported by previous theoretical work. |
| Background | Although the goal of implementing UC&C in an organization is to promote and mediate group dynamics, increasing overall productivity and collaboration; it does not seem to provide a solution for effective communication. It is clear that there is still a lack of consideration for human communication processes in the development of such products. |
| Methodology | This paper is sustained by existing research to propose and test the application of an augmented model capable of supporting the design, development and evaluation of UC&C services that can be driven by the human communication process. To test the application of the augmented model in UC&C service development, a proof-of-concept mobile prototype was elaborated upon and evaluated, making use of User Experience (UX) and user-centred methods and techniques. A total of nine testing sessions were carried out in an organizational communication setup and recorded with eye tracking technology. |

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| Contribution | The authors argue that UC&C services should look at the user's (human) natural processes to improve effective infocommunication and thus enhance collaboration. Authors believe this augmented version of the model will pave the way improving the research and development of useful and practical infocommunication products, capable of truly serving users' needs. |
| Findings | On evaluation of the prototype, qualitative data analysis uncovered structural problems in the proposed prototype which hindered the augmented model's elements and subsequently, the user experience. Five out of eighteen identified interaction issues are highlighted in this paper to demonstrate the proposed augmented model's validity, applied in UC&C services evaluation. |
| Recommendations for Practitioners | Considering and respecting the user's natural communication processes, practitioners should be able to propose and develop innovative solutions that truly enable and empower effective organizational collaboration. UC&C functionalities should be designed, taking the augmented model's proposed elements and their pertinence in representing the human interpersonal communication phenomena into consideration, namely: Social Presence; Immediacy of Communication; Concurrency and Synchronicity. |
| Recommendations for Researchers | This paper intends to demonstrate that the adoption and use of UTAUT technology characteristics, in conjunction with Synchronicity proposition, can be considered as a reference for human-centric design and the evaluation of UC&C systems. |
| Impact on Society | To highlight the need to develop further research on this important topic of human collaboration mediated by technology inside organizations. |
| Future Research | This research focused its attention on communication functionalities. However, collaboration can potentially be affected by other services that may be included in a UC&C system, such as scheduling, meetings or task management. Future research could consider employing this augmented model to evaluate such systems or proof-of-concept prototypes. |
| Keywords | human-computer interaction, organizational communication and collaboration, human-centred design, interpersonal communication, empirical study |

INTRODUCTION

This paper is sustained by existing research to propose an augmented model capable of supporting the design, development and evaluation of Unified Communications & Collaboration (UC&C) services, that can be driven by natural human communication processes to truly serve users' needs in organizational communication contexts.

In order to achieve this, it is important to establish functionalities that enable frictionless communications and user's cognitive load optimization. Such functionalities should be designed considering elements that represent human interpersonal communications and captured in the model in question.

Furthermore, the application of the model's elements is exemplified in the proposal of a new UC&C service, by prototyping user experience evaluation and its follow-up analysis. The methodology streamlines the prototype into functionalities and their relationship to the model's elements. As part of its evaluation, a list of interaction issues has been composed and clustered according to the proposed elements from user experiences (UX) concerns and methods. It is possible to visualize which model's elements collected the most issues and through severity rating calculation, it is possible to see which elements have been more affected, thus jeopardising user's experience. It is expected that

through this hands-on model application, problems and flaws can be amended and the model can be further expanded in the future.

BACKGROUND

As technology advances at such breakneck speed, more and more digital products are developed and become available on the market. In the sphere of communication, it seems that for every interaction situation or modality there is a specific app. Not just on a personal communications level, but also organizationally. Quoting Fuze (2017) it has become a “productivity threat in the form of application sprawl”, so for every interaction situation, both employers and employees have to select the best medium to convey their message. Productivity is in jeopardy with failed communications and work interruptions which lead to lost time and misunderstandings in team collaboration. Moreover, workers are overloaded, having to interrupt work to resume a conversation, remember the best medium to reach the desired colleague and/or external business partner (Evans, 2004; Riemer & Wulf, 2010). Though virtual interaction has become commonplace (Silic & Back, 2016), juggling between distinct media for communication has long been associated with interaction overload and communication deficiency by Ljungberg and Sørensen (1998). As an organizational worker, it may be necessary to be accessible during working hours, but the way and moment in which communication is received might not be really appropriate or desirable.

Unified Communications (UC), also referred to as a Unified Communication Service (UCS), and/or Unified Communication & Collaboration (UC&C), uses the additional element of the purpose for Collaboration, which seems to be a promising approach to this problem. This paper refers to UC as UC&C because it integrates the human interaction situations on which our investigation focuses, namely the activity of collaboration.

Riemer and Taing (2009, p. 326) state that UC&C was created as an attempt to “integrate traditional and novel communication media (speech, text, video) and devices (phone, computer) with presence information and further collaboration features”. It integrates several communication media (telephony, instant messaging, e-mail, videoconference, and telepresence) into one application. Inherently, with this solution a user does not need to juggle between apps, so it seems a favourable resolution *vs* the application sprawl mentioned above. From a productivity point of view, UC&C allows us to continue doing multiple tasks or even to communicate at the same time, as pointed out by Fluker and Murray (2017). The release of the first UC&C solution signalled the convergence of information technology and telecommunications (Stark, 2015) and driven by the problems of distributed collaboration in work contexts, triggered an interest of relevant IT companies such as Microsoft, Cisco, Siemens and IBM, who released their own UC&C products (Riemer & Taing, 2009; Stark, 2015).

However the goal of implementing UC&C in an organization is to promote and mediate group dynamics, aspiring to increase overall productivity (Fluker & Murray, 2017; Stark, 2015), collaboration and user experience (Lei & Ranganathan, 2004); therefore in this sense, it does not provide a solution for interaction overload, or for communication deficiency either. Users are still interrupted by undesirable media and these services still lack a contextualization of the interaction history, which also contributes to a greater cognitive effort. Scholtz et al. (2016) also point out that poor usability, or perceiving something as easy to use, has systematically led to misconceptions regarding its usefulness and has been a source of failures and inefficiencies, generating user frustration or even resistance.

“One future challenge in areas such as mobile, ubiquitous, and multimodal-multisensor interfaces is for human-centered design to adequately model human communication and activity patterns more broadly, as well as usage contexts.” (Oviatt, 2006, p. 2)

The proposed model intends to convey users’ perspectives and real needs during the design, specification and development of UC&C services, hopefully suppressing the identified difficulties of interaction overload, communication deficiency, and lack of contextualization and overall increase of cognitive effort and user frustrations.

LITERATURE REVIEW

The literature review aims to introduce the key research that led to the proposed model presented in the following section. Significant studies on UTAUT and UC&C adoption, human communications processes and human-centred design are introduced in the following sections, granting a better understanding of the model's foundations.

THE UTAUT MODEL

The work of Brown et al. (2010) on the adoption and use of collaboration technology, based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003), is one of the core references of the applied research reported in this paper. In their work, the authors highlight the intrinsic characteristics to be considered for collaborative technologies that drive intention to use.

Venkatesh et al. (2003) identified four constructs as significant determinants of user acceptance and technology usage behaviour: *Performance Expectancy* (degree to which an individual believes that using the system will help attain personal gains in job performance, found to be the most important construct in Silic and Back's (2016) study); *Effort Expectancy* (degree of ease associated with the use of the system); *Social Influence* (degree to which someone perceives that others believe it is important to use the system); and *Facilitating Conditions* (degree to which an individual believes that an infrastructure exists to support the use of the system, where organizational culture has been considered an essential adoption factor (Silic & Back, 2016; Silic et al., 2014)). Brown et al. (2010), theorizes that users adopt collaboration technologies in the belief that it will improve their effectiveness and efficiency when performing a task (motivations that directly correspond to *performance* and *effort expectancy* constructs). Supported by these perceptions, the authors highlight three intrinsic technology characteristics to be considered for collaborative technologies that drive intention to use:

Social Presence: This is based on Social Presence Theory (Short et al., 1976), which states that there's a subjective contrast between technologies to convey psychological impressions of physical presence of their users. It states that a technology with a perceived higher social presence (by simulating the sense of *being together with another*, including responses to social cues, and the simulation of 'other minds' and their intentionality), are perceived as easier to use, increasing users' effectiveness, efficiency and overall satisfaction. Similar to Media Richness Theory (Daft & Lengel, 1986) and the naturalness proposition of Kock's (2004) Psychobiological Model, videoconference systems are presented as a media with a higher social presence, whereas e-mail and text messages are perceived as having lower social presence. In the case of multinational companies, where workers are dispersed internationally, findings reveal that social presence would not positively influence effort expectancy, though it still had a positive effect on performance expectancy (Silic & Back, 2016).

Immediacy of Communication: Recalling a task completion scenario and to be able to complete a collaborative assignment in a short amount of time, users expect to reach their colleagues in the quickest possible time, if not immediately. Even though video or voice calls have a high social presence, both of these mediums require synchronous communication, thus both participants should be available at the same time. In the case of asynchronous media (e-mail, voice messages, etc.), by allowing the addressee to answer in their own available time, communication eventually happens and the task at hand is completed faster than by trying to find a shared suitable moment.

Concurrency: "Concurrency is the ability of a collaboration technology to enable an individual to perform other tasks at the same time as using the technology." (Brown et al., 2010, p. 21). As with the previous characteristics, "concurrency is both a social and technological capability" (Brown et al., 2010, p. 21), the system as well as the user's social norms should allow for a concurrent use of a collaboration system.

The synchronicity construct

Despite the robustness of the 3 previous elements of a UC&C model, Social Presence, Immediacy of Communication and Concurrency, the holistic and unified perspective of meaning in the group interaction process still seems to be missing. This leads to the need of an augmented model supported by these 3 intrinsic technology characteristics and Dennis's, et al. (2008) *Synchronicity*. Focusing on communication performance, these authors state that a communication medium should have capabilities that enable users to achieve synchronicity, "a shared pattern of coordinated behaviour among individuals as they work together" (Dennis et al., 2008, p. 575). It should be emphasized that synchronicity is a medium characteristic and not a human communication category, not to be confused with synchronous communication, as stated: "Synchronous communication is necessary but not sufficient for synchronicity; although individuals may work synchronously, they may not achieve synchronicity" (Dennis et al., 2008, p. 581). These authors argue that communication in a work context is composed of two central processes: conveyance of information and convergence in meaning. Conveyance process relates to the sharing/transmission of new information in such a way that conversation participants create their own mental models, thus requiring time for information processing. Convergence conveys reaching an agreement between two or more parts on a combined meaning of pre-acquired information. This process requires less information processing, if the participants have similar understandings. Otherwise it would "require as much or more cognitive processing as conveyance" (Dennis et al., 2008, p. 580).

Cleveland et al. (2015), propose a *UCS Knowledge Exchange Model* diagram, where UC Medium Capabilities and Knowledge Dimensions are correlated with Dennis's et al. (2008) Interaction Processes. The diagram illustrates which medium capabilities and intrinsic interactions are better for conveying which kinds of knowledge. Conveyance processes, which require time for information processing, call for technology medium capable of low synchronicity (e.g., instant messaging or e-mail), whereas using a higher synchronicity medium may impair development of shared understanding because individuals will not have time to fully process information (Cleveland et al., 2015; Dennis et al., 2008). Convergence processes, on the other hand, benefit from technology media that facilitates high synchronicity (like videoconferencing or voice calls) (Cleveland et al., 2015; Dennis et al., 2008). Besides, the communication medium should also seek to motivate employees' trust in order to enable effective knowledge sharing (Yang & Chen, 2020). Considering the different technological needs for every communication process, "choosing one single medium may prove less effective than choosing a set of media" (Dennis et al., 2008, p. 596). That said, a contextual UC&C can prove to be a solution, provided that it can guarantee the adequate level of synchronicity for every communication need.

HUMAN-CENTRED DESIGN CONCERNS

Dennis et al. (2008, p. 588) proposed that media can influence and shape the way in which individuals use them. If a medium fits the user's needs, it is more likely to be appropriated and used. When corresponding to human-centred design concerns, rather than highlighting media characteristics, it is essential to consider the people that will actually use it (Walther, 1992), remembering that "the person, rather than the device, is the communication endpoint" (Lei & Ranganathan, 2004, p. 9). Walther (1992) argues that communication transcends media, communicators are motivated by the same drivers regardless of media used. Walther (1992) prompts Eco's dispute: "The medium is *not* the message; the message becomes what the receiver makes of it" (Eco, 2005), it is the receiver who interprets and gives meaning to a message, communicated through any medium.

Cognitive load theory

Employing inadequate levels of synchronicity can increase user's cognitive load (Te'eni, 2001, as cited in Dennis et al., 2008). Cognitive Load Theory (CLT) is based on the notion of a limited working memory capacity/schema use, related to an amount of information expected to be processed. The

cognitive load each person experiences differs because it is influenced by several factors such as social and environmental (Oviatt, 2006). There are though other situations such as the context of education and task management, where “higher cognitive effort sometimes leads to better task outcomes” (Salomon 1979 – 1991, Symbol Systems Theory, as cited by Kock, 2004, p. 334). The same happens in the entertainment context, where the creation of less efficient and more difficult interactions (higher cognitive effort), returns a greater motivation and joy from its users. In the design of web interfaces where the focus is a critical decision (e.g., e-banking), it is imperative to not oversimplify interactions – in this case a slight increase in the users’ cognitive effort empowers their sense of control and confidence, improving the overall experience. In order to achieve the interpersonal communications put forward in this paper, interaction designers should strive for an optimization of the cognitive effort of the service’s future users by increasing or simplifying interactions according to each contextual situation.

METHOD

PROPOSAL OF AN AUGMENTED UC&C MODEL

Supported by the previous technological definitions based on the UTAUT model and augmented with the Synchronicity element, we believe that a more robust model will be attained to deliver a human-centred approach in the creation of UC&C systems.

The previous theories and studies have demonstrated that “technologies have the potential to be minimally disruptive to one’s work in terms of time relative to alternatives, such as a face-to-face meeting, and potentially help increase productivity” (Brown et al., 2010). Without disregarding the importance of face-to-face communication as shown in Mark and Wulf’s (1999) study, the following outlined characteristics serve as heuristics on the development of human-centred, technology mediated UC&C. The core goal is to optimize the user’s cognitive load in organizational contexts so that collaborators can focus on the intrinsic difficulty of performing their assigned tasks.

Context is an essential element in human communication. Situational communication influences an individual’s perception of the transmitted message. Because it is an important human communication element closely related to ‘synchronicity construct’ (Dennis et al., 2008), situational context should be conveyed through media. Therefore, in order to capture and categorize it, context awareness technology and an autonomous and transversal presence management system must be an integral part of the system’s backbone. Knowing the communicator’s context, its space, time, subject and/or conversation trigger can better influence the medium through which the communication will be established and better prepare the receiver’s approach for collaboration (with convergence and conveyance processes). This is also the case in Lei and Ranganathan’s (2004) project, though their choice of media for each context is based on predefined user choices. The system should also be prepared for sudden changes in device or media selection during a conversation, for either the caller or the receiver (Lei & Ranganathan, 2004).

A system should therefore support and include means for multimodal, synchronous and asynchronous natural communication in concurrent adaptive interfaces where the system adjusts to its user and their performance status (Oviatt, 2006). This is achieved with an autonomous and transversal presence awareness management that redirects users to the collaborative communication channel most suitable for the context, objective and convergence or conveyance processes, while allowing user override by providing explicit input, as seen in Lei & Ranganathan (2004). Context informs two elements of the proposed model. It informs system characteristics for human collaborative *Synchronicity*, which in turn allows for a greater feeling of *Social Presence*. Summing up, instead of determining a particular use or operation automation, users and their context should play a big role in determining system functionality (Abrantes et al., 2018). Registration of communications and collaboration situa-

tions also allows for a more efficient re-contextualization in conversation extension cases, independently of time and space (or media used), which diminishes extraneous effort and thus optimizes user's cognitive load.

In any digital communication and collaboration platform, interface and interaction design should strive to convey features of *Social Presence* which empower users to choose whether it is appropriate to start a conversation at the moment (Lei & Ranganathan, 2004). It should also provide organizational support to counter the problem of employee social isolation (Silic & Back, 2016), while also minimizing extraneous distractions and unnecessary complexity.

Holistic characteristics of the augmented model

The UC&C design approach of this project uses the optimal cognitive load as a reference. This approach leads to UC&C functionalities that relate diverse information and communication technological instruments to preserve communication and collaboration instances, contexts and info-communication processes at all times (Abrantes et al., 2018).

To the existing UTAUT model, particularly to the three technology characteristics that drive use intention proposed by Brown et al. (2010), a fourth construct “synchronicity” (Dennis et al., 2008) is added, as suggested in Brown et al. (2010, p. 43). This additional construct of “synchronicity” emphasizes the collaborative aspect of UC&C, by reinforcing the notion of human-centered design and supporting convergence and conveyance processes – both of which are natural to human communication. Table 1 summarizes the four elements present in this augmented model, as well as their contribution to UC&C service design.

Table 1: Augmented Model for UC&C, references, elements, and their meaning for a UC&C service

| Augmented Model for UC&C | | |
|--|-----------------------------------|--|
| Reference | Element | Significance |
| <i>UTAUT</i> <i>Brown, Dennis & Venkatesh, 2010</i> | Social Presence | <i>Feeling of another</i> |
| | Immediacy of Communication | <i>Getting a message across instantly</i> |
| | Concurrency | <i>Allow to complete other tasks</i> |
| <i>Dennis, Fuller & Valacich, 2008</i> | Synchronicity | <i>Archive coordinated behaviour; to be in sync with another</i> |

To test the applicability of the model, a UC&C proof-of-concept prototype was designed and implemented in InVision. The following sections describe the prototype's design and analysis process.

APPLICATION OF THE MODEL IN A UC&C PROOF-OF-CONCEPT PROTOTYPE DESIGN

Rierner and Taing (2009, p. 328) introduce six key modules for Unified Communications: IP-infrastructure, Communication media, Media/channel integration, Presence signalling, and Collaboration and Contextualization. Stark (2015) argues that for a system to be labelled as a Unified Communication solution, it should provide at least one feature from each of the first four key modules.

Citing Scholtz et al. (2016, p. 309), “interface usability has a significant impact on users' perceptions of usefulness and ease of use which ultimately affects attitudes and intention to use”. To test the proposed UC&C model, a conceptual proof-of-concept was designed and prototyped in InVision. The prototype integrated user interaction narratives and graphic interface, driven by the model's structure and characteristics. Considering Rierner and Taing's (2009) proposed modules and what has been done so far on UC&C services in the market within the scope of communication, a range of

functionalities were included: IM, VoIP calls and video calls. On a higher scale, driven by a humanistic-centered approach and to include the necessary situational and communication context, one functionality and two new components were added to the prototype: a “subject” field was added to all communication interfaces to give the receiver awareness of the incoming conversation and decide whether it is the right moment to talk, and subsequent communication indexing (a feature that classifies into the model’s “Synchronicity” element). These new components acquire information from the archive and indexing functionality to generate a communication history timeline (chronologically organized by intervenient, subject and/or document/file) and a synchronous communication summary (displayed after a communication and accessible in the interaction history). The particular area of synchronous communications (audio and video) combined with collaboration functionalities promotes ‘concurrency of tasks’ (Brown et al., 2010).

Take as an example a scenario of the co-creation of a document between two co-workers, John and James. Consider a document that has been discussed in the past within a chat with the attribution of a subject. Now, in order to complete his assignment, John has to call James in order to clarify his work. In doing so, he chooses the previously assigned subject and calls James. Before accepting the call, James knows the subject and can decide whether it is a good moment to take the call. If he is too busy or in a meeting, he can quickly reply to his colleague with the information he believes John is looking for. If John chooses to accept the call, he can easily take notes or even record the conversation. Later, they can access the recording and any notes that may have been saved (or even files that had been shared during the call) in order to continue with their writing. This interaction is saved in John and James’ shared interactions history, but also on the subject and document timelines.

Assuming that “Moving traditional collaboration technologies to mobile devices would increase their concurrency” (Brown et al., 2010, p. 46), and without neglecting the relevance of a desktop version, a mobile-first proof-of-concept prototype was designed. The interaction between the screens and their functionalities are represented in Figure 1. Table 2 describes each functionality in more detail and its main characteristics, while Table 3 relates the prototype’s characteristics with the proposed model’s elements.

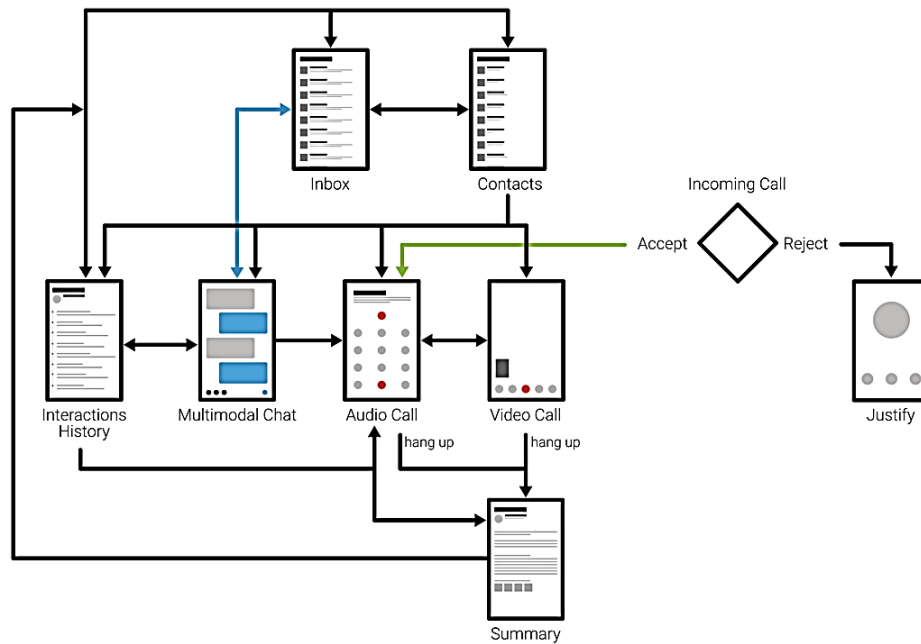


Figure 1: Symbolic interaction flow of the mobile UC&C prototype depending on its main functionalities

Table 2: List of prototype's main functionalities

| Functionality | Purpose and features |
|------------------------------|---|
| Contacts | Prototype's landing screen. Lists all contacts and their presence status. By clicking on a contact, calls can be initiated (audio and video), or an IM conversation can be started or continued. This functionality also gives access to the interaction history between the two users. |
| Inbox | The "Inbox" link is placed in the lower fixed-menu and is accessible from any interface (excluding synchronous calls). It lists the latest IM conversations, with presence status information for each contact and it is possible to search and filter in order to find specific conversations. |
| Multimodal Chat | The IM chat can be initiated with one or more users (group chat). Besides traditional written communication, other modalities can be used such as the inclusion of image, video, voice and document sharing to foster natural human communication. Synchronous VoIP calls (audio and video) are also possible, alongside other characteristics that access members' interaction history, search for content or enable the addition of extra participants in an interaction. By clicking on a specific old message, users can reply to it and the content of the original message will always be replicated. |
| VoIP calls (audio and video) | To initiate a phone call, users are required to introduce a subject (not only for indexing purposes, but also to indicate the purpose of the call to the one being called). This process is necessary in a primary phase (alfa moment) of system deployment/use so that it can learn, and later adapt to the user's context. During the call, eight actions are available: send a text message, attach a file, take notes, send an e-mail, take photos/video, convert into video call (or to audio if the conversation starts as a video call), add more participants and the option to record the conversation. These functionalities are important for collaboration, enabling Brown et al. (2010) Concurrency. |
| Summary | At the end of the call, a summary is displayed with information about the call's duration, subject, participants, notes and shared files. This summary is an important situational/contextual element and remains available to all participants throughout their interaction history and subject history. |
| Interactions History | Historical chronology displays all the interactions between the selected contact, subject or file, linked to the original purpose (subject) and overall context. A user can search by content, subject, communication medium and date. Using this function it is also possible to start a voice communication or private message. |
| Receive and reject calls | To reject a call, the user has to choose one of three available options: send a text message, a voice message or a reminder to call later, which on context change will remind the user to return the missed call. |

Table 3: List of prototype’s characteristics organized by model’s elements

| Element | Functionalities’ characteristics |
|----------------------------|---|
| Social Presence | 1. Transversal characteristic that displays and allows access to previous conversations, signalling users’ real time presence. Note: all functions/actions have an associated time stamp to keep the time track in an interaction context and understand the “social presence” in any past moment of time. |
| Immediacy of Communication | 2. Start a voice or video call 3. Option to send voice message on call rejection 4. Add participants (group conversation) 5. Send an audio, video or text message 6. Take a photo and send it within chat |
| Concurrency | 7. Take text notes or/and attach a document while on a phone call 8. Manage which calls to stop or pause during a group call |
| Synchronicity | 9. Access interactions history/timeline to recall/rebuild a context 10. When making a call, select subject of conversation (mandatory) 11. Send and receive files during communication 12. Search conversation contents/subjects/situations (contexts) |

UC&C AUGMENTED MODEL APPLIED IN PROTOTYPE EVALUATION

To test the proposed prototype in the light of the UC&C augmented model, UX qualitative evaluation sessions were carried out. These sessions were guided by 5 role-playing scenarios where participants were contextualized with several communication situations and invited to perform specific tasks by interacting with the prototype. The goal was to get the participants to visit all the prototyped interfaces and associated functionalities, encouraging them to speak freely about their overall experience.

A total of 9 individual UX sessions were carried out with a purposive sample. These took place in a closed and controlled setting. The technical setup included a smartphone with access to the InVision proof-of-concept prototype, a Tobii eye tracking system positioned in a mobile stand, a webcam and a desktop computer running the eye tracker software.

With participants’ informed consent, audio and facial expressions were recorded along with their eye-gaze behaviour and a top-view record of their interaction with the smartphone. As previously employed in Abrantes et al. (2018), this UX data gathering technique aims at comparing expectations and experiences of the participants whilst using the prototype, without limiting the analysis to the self-stated, explicit user inputs. User frustrations and interaction oversights were documented with face and eye tracking recordings, enabling a deeper and implicit understanding of the situations the participants were faced with.

A total of 18 interaction situations ($S_{i=1-18}$) were identified and classified according to 5 different perspectives of identification:

- Observation;
- Assistance required;
- User experience comment (usually something that was understood, but still had room for improvement from the user's point of view);
- Verbalization; and/or
- Facial Expression.

The identified problems were later clustered into 5 design analysis dimensions ($D_{i=1-5}$), informed by Nielsen's 10 heuristics for interface design: visibility of system status, match between system and the real world, consistency and standards, error prevention, recognition rather than recall (Nielsen, 1994a, 1994b), explicit in Table 4 associated to each dimension. These usability heuristics continue to be of great relevance for an analysis process, and continue to be one of the most popular references on the Nielsen Norman Group website (Nielsen, 1994a), with many of these heuristics being explained in recent articles, e.g. "Flexibility and Efficiency of Use" (Laubheimer, 2020).

Table 4: Design analysis dimensions ($D_{i=1-5}$) and encompassed interaction situations ($S_{i=1-18}$).

| |
|---|
| D₁. Non-Familiar Actions (<i>match between system and the real world</i>) |
| S ₁ – For four users the action of clicking on 'call' (<i>ligar</i>) after they had selected the contact was redundant and they expected that a connection would start immediately after the selection. |
| S ₂ – Two participants did not notice that they had to click on the record button to record a voice message. |
| S ₃ – Some participants had trouble understanding the (uncommon) selection of a subject before a voice call takes place, even mistaking it as an error. |
| D₂. Lack of consistency with misleading iconography (<i>consistency and standards</i>) |
| S ₄ – Iconography use of an X to hang up the call wasn't intuitive and in some cases it was understood to be an option to cancel the action they were taking while on the phone call (like taking notes, for example). |
| S ₅ – Seven participants tried to start a voice call with the send voice messages in the chat. |
| S ₆ – To send a video message, some participants started video calls without realizing it. |
| S ₇ – An arrow pointing upward was used as a button to send a chat message. This button was misinterpreted as a trigger to display more options in the chat. |
| S ₈ – The "more options" button in the chat interface was mistaken as an action to add more participants to the conversation. |
| S ₉ – One participant had trouble identifying the meaning and purpose of stop and pause functions in the record voice message interface (used to justify a refused call). |
| S ₁₀ – There has been some confusion in distinguishing the meaning of the iconography related to "send message" and "take notes" (both actions appear during a voice/video call). |

D₃. Lack of visual clues (*recognition rather than recall*)

S₁₁ – Opening a file that is sent during a voice call is not intuitive. The only element with a button affordance is the X which has the misleading associated action of “refuse to receive the document”.

S₁₂ – The interaction to reply to a specific message is too quick (clicking on the specific message opens up the reply input box) and users didn’t understand the action that took place.

S₁₃ – Two participants had difficulties in identifying how to reply to a specific message.

S₁₄ – After a request to send a screen snapshot, some participants couldn’t find how to access the camera in the chat interface.

S₁₅ – One participant had trouble and verbalized that he could not identify how to save a note taken during the phone call. After watching the eye tracker recording of this session it was clear that the icons that were presented before the save option received more attention.

D₄. Lack of feedback (*visibility of system status*)

S₁₆ – Contact list and inbox interfaces are very similar and users cannot identify in which graphical interface they are in.

S₁₇ – A participant looked for the interaction history in the inbox screen (instead of in the contacts list).

D₅. Button location problem (*error prevention*)

S₁₈ – The buttons to stop or end a call in a group voice call are too small and close together, causing the selection of unwanted actions.

As disclosed, most cases are related to graphical design, with prevalence for iconography (interconnected with a lack of consistency and standards) situations. The radar in Figure 2 visually represents the occurrence of Situations (identification sum in blue), layered by the number of single participants who were faced by such a Situation on the dashed line.

Each cell in Table 5 identifies the number of participants who experienced a specific interaction Situation according to the means used to identify it. Complementary to the holistic data representation in the radar of Figure 2, data in Table 5 pinpoints Situations with more occurrences which in turn determines which interfaces and functionalities require a thorough UX and UI design review.

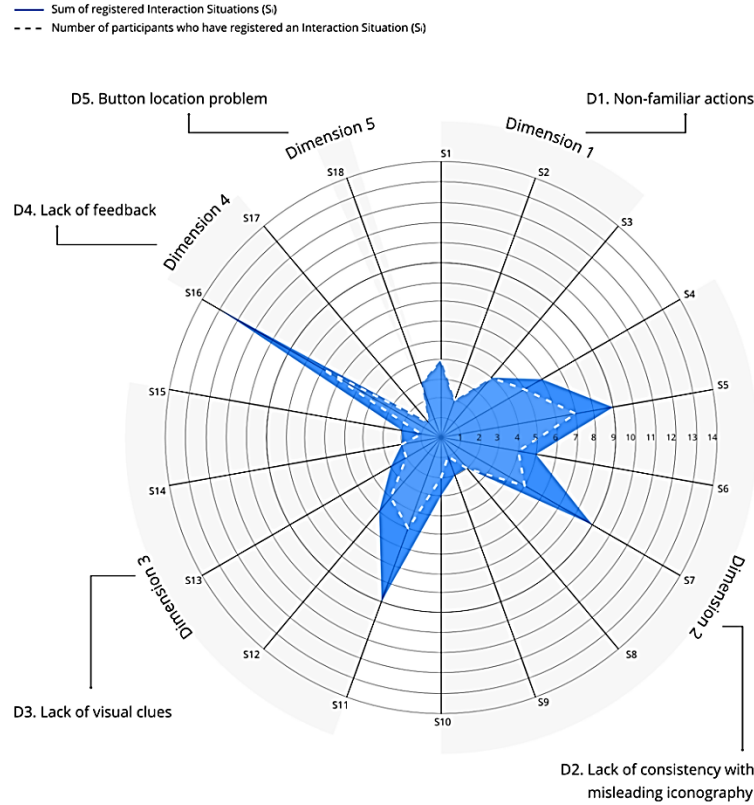


Figure 2: Sum of Interaction situations ($S_{i=1-18}$), occurrences and number of participants who encountered it on each radial axis. Each situation is represented in its dimension sector: D1: non familiar actions; D2: Lack of consistency with misleading iconography; D3: Lack of visual clues; D4: Lack of feedback; and D5: Button location problem.

Table 5: Sum and classification (D_i) of interaction situations (S_i) clustered by the means of identification (O, A, X, V, E)

| | D1 | | | D2 | | | | | | | D3 | | | | | D4 | | D5 |
|-------|----|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 |
| O | | | 2 | 1 | 5 | 4 | 3 | | | 2 | 5 | 2 | | 1 | 1 | 4 | 1 | 3 |
| A | | 1 | | | | | | | | | | | | | | 2 | | |
| X | 3 | 1 | 1 | 1 | | 1 | 2 | | 1 | | 1 | | 2 | 1 | | 1 | | |
| V | 1 | | 1 | 4 | 4 | | 4 | 2 | 1 | 1 | 3 | 2 | 1 | | 1 | 5 | | |
| E | | | | | | | | | | | | 1 | | | | 1 | | |
| Total | 4 | 2 | 4 | 6 | 9 | 5 | 9 | 2 | 2 | 3 | 9 | 5 | 3 | 2 | 2 | 13 | 1 | 3 |
| Part. | 4 | 2 | 4 | 5 | 7 | 4 | 5 | 2 | 1 | 2 | 5 | 4 | 2 | 2 | 1 | 7 | 1 | 3 |

Legend: O - Observed | V - Verbalised | A - Assistance Required | X - Understood, improvement needed | E - Frustration facial expression

To better understand the impact of such situations on user experience, a severity factor (Rosemberg, n.d.) was calculated with the multiplication of Frequency (F), Criticality (C) and Impact (I). Frequency (F) corresponds to the number of occurrences divided by the total number of participants, Criticality (C) of the task taking place, and situation Impact (I). The attributed values were based on

Sauro and Lewis (2012, p. 13) impact scores, but coded in the reverse order (the most critical scenario has the greater value score):

- 4: prevents task completion
- 3: causes a significant delay or frustration
- 2: has a minor effect on task performance
- 1: it is a suggestion from the participant

Table 6 represents the scores for each situation and their calculated severity.

Table 6: Calculating the severity of each interaction situation

| | D1 | | | D2 | | | | | | | D3 | | | | | D4 | | D5 |
|----------|-----|-----|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|-----|-----|
| | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | S13 | S14 | S15 | S16 | S17 | S18 |
| P | 4 | 2 | 4 | 5 | 7 | 4 | 5 | 2 | 1 | 2 | 5 | 4 | 2 | 2 | 1 | 7 | 1 | 3 |
| F | 0,4 | 0,2 | 0,4 | 0,6 | 0,8 | 0,4 | 0,6 | 0,2 | 0,1 | 0,2 | 0,6 | 0,4 | 0,2 | 0,2 | 0,1 | 0,8 | 0,1 | 0,3 |
| C | 4 | 2 | 3 | 4 | 4 | 3 | 4 | 3 | 2 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 3 | 4 |
| I | 2 | 2 | 2 | 3 | 4 | 4 | 3 | 2 | 2 | 3 | 4 | 3 | 3 | 3 | 2 | 4 | 3 | 3 |
| S | 3,2 | 0,8 | 2,4 | 7,2 | 12,8 | 4,8 | 7,2 | 1,2 | 0,4 | 2,4 | 9,6 | 3,6 | 1,8 | 1,8 | 0,8 | 12,8 | 0,9 | 3,6 |

Legend: P – number of Occurrences | F - Frequency | C - Criticality | I – Impact | S – Severity

Interaction Situations S16, S5, S7, S11, and S4 have the highest values of severity (positioned above 3rd quartile = 6, 6), pinpointing issues that were prioritized. Such issues belong to three dimensions: D₂ - Lack of consistency with misleading iconography, D₃ - Lack of visual clues, and D₄ - Lack of feedback.

The integration of both qualitative and quantitative methods have given us a better understanding of the underlying interaction issues and their severity on the overall experience.

In order to understand which UC&C elements are more compromised in the prototype, each identified situation was clustered into its corresponding functionality (previously associated to an element of the augmented model) where it was reported. Table 7 conveys the relationship between the identified situations, the functionality, and the augmented model.

Table 7: Relationship of problematic interaction situations (S_i) with the prototype's characteristics, clustered according to the model's elements

| Augmented Model's Elements | Functionality characteristics | Identified Situations |
|----------------------------|--|-----------------------|
| Social Presence | 1. Lists all previous chat conversations, signalling the user's presence | Null S _i |
| Immediacy of Communication | 2. Start a voice or video call | S1; S4; S5; S16 |
| | 3. Option to send a voice message on call rejection | S2; S9 |
| | 4. Add participants (create group conversations) | S8 |
| | 5 – Send an audio, video or text message | S6; S7; S12; S13 |
| | 6 – Take a photo and send it through chat | S14 |

| Augmented Model's Elements | Functionality characteristics | Identified Situations |
|----------------------------|---|-----------------------|
| Concurrency | 7 – Take text notes while on a phone call | S10; S15 |
| | 8 – Manage which calls to stop or pause during a group call | S18 |
| Synchronicity | 9 – Access interactions history/timeline | S17 |
| | 10 – When making a call, select subject of conversation (mandatory) | S3 |
| | 11 – Send and receive files during calls | S11 |
| | 12 – Search conversation contents | Null S _i |

Immediacy of Communication has the greatest number of identified situations with the most severe interaction issues occurring.

The next section details solutions that can be applied to each of the five most problematic interaction situations.

IMPROVEMENTS DERIVED FROM UX TESTING

All 18 issues previously reported were addressed, and interfaces were reviewed during the second design iteration. For the purpose of highlighting the solutions and improvements derived from the UX testing referenced by the UC&C augmented model, the 5 most problematic issues that occurred were chosen and reported.

S₁₆ – Contact list and inbox interfaces are very similar, and users cannot identify which screen they are in.

Compiled in the “Lack of feedback” design dimension, this error relates to Nielsen’s (1994a) first heuristic for user interface design, Visibility of System Status. Due to its lack of transparency, this interface does not inform users of their location within the app and hinders the augmented model’s “Immediacy of Communication”.

Compared to the Inbox, there is no other indication of location beyond the title (Inbox has both title and an emphasis on its corresponding icon in the lower menu). Thus, in order to distinguish the contact list from the message’s inbox, the display of the top icons was re-designed. The “contacts” list link was placed in the bottom menu, separating the search and filter actions from the contacts link (represented in Figure 3). This small adjustment allows the user to reach their contacts list within any segment of the prototype, and because it is positioned alongside the Inbox link, it is easier to understand and navigate between the two components.

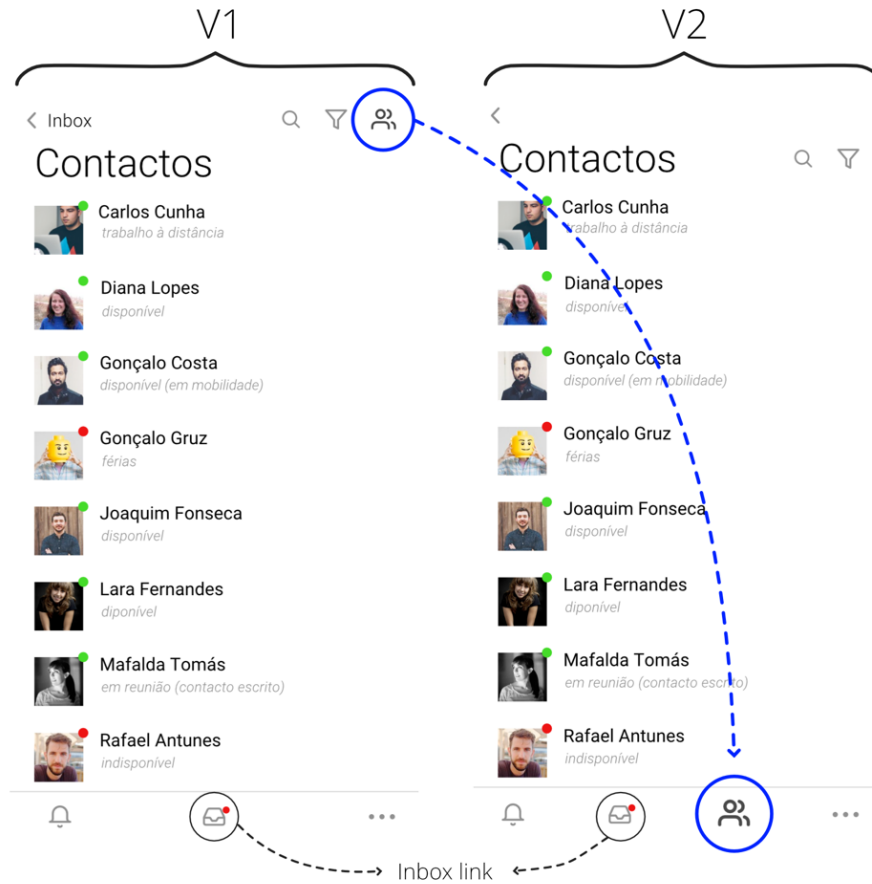


Figure 3: Comparison of “contacts” screen in prototype version 1 (v1, left) and the re-designed version 2 (v2, right)

S₅ – Seven participants tried to start a voice call with the send voice messages in the chat.

This problem is closely related to the previous situation. One of the tasks participants had to complete was to call a specific colleague. As noticed in the recordings, participants would start this task in the inbox screen as it was the position derived from the previous activity. As reported in S16, these participants did not notice that a contacts list existed. As the selection of a contact is usually the first step in the most common “make a phone call” mental model, not having access to such an explicit option led participants to try and make the call through the chat. Believing this was the only place where they could complete the task, users would select the colleague’s chat and, not seeing any other reasonable option (like a phone icon, for example), participants would proceed in tapping the microphone icon (bottom of screen in Figure 4), which would start a voice message recording. Even though sending a voice message through a multimodal chat directly relates to the augmented model’s Immediacy of Communication element, in this case, the obligation of audio communication with a colleague (establishing a synchronous communication) and not being able to do so, hampers this element.

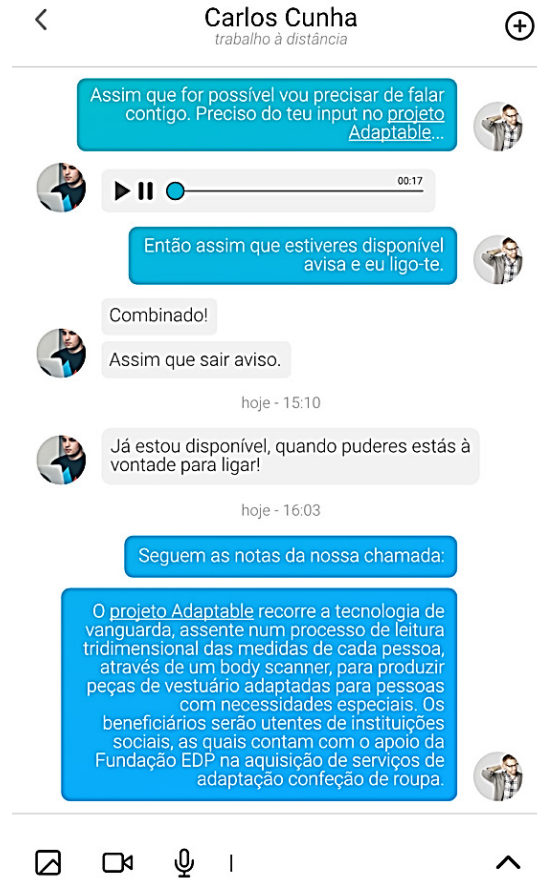


Figure 4: Chat in version 1

Because this problem was not associated with the icon itself, having the contacts link in the bottom menu should make the component more noticeable and correct this interface affordance flaw.

S₇ – An arrow pointing upward was used as a button to send a chat message. This button was misinterpreted as a trigger to display more options in the chat.

Nielsen's (1994a, 1994b) heuristic for consistency and standards is clearly missing and the send message button was badly represented as an arrow pointing upward. This representation was being interpreted and used as a navigation button (see top left corner of Figure 6), confusing users and leading them to believe that the associated action would 'open' the bottom area of the screen and display more options, which would subsequently delay users from reaching their contact. This problem was then labelled as an obstruction to the augmented model's Immediacy of Communication element.

The button was promptly changed to a more common and unambiguous iconography of a paper plane, as represented in Figure 5.

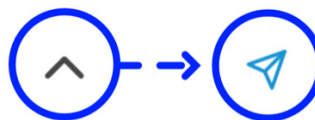


Figure 5: Iconography change of the send message button. Prototype Version 1 (left) and re-designed version 2 (right).

S₁₁ – Opening a file that is sent during a voice call is not intuitive. The only element with a button affordance is the X which has the associated action of “refuse to receive the document”.

Sharing documents during a mediated communication is an important functionality to achieve Synchronicity. In the first prototype version, when a document is received through a voice call, there was no direct option or button to download and open it, though there was a noticeable option to reject or cancel it. Original design expectancy was that users would just click on the download icon to open it, but it was instead interpreted as a design element and not a button. This led users to reject the document, preventing them from reaching a state of Synchronicity between colleagues.

Figure 6 represents both versions 1 and 2, where the latter shows the design amendment with accept (Aceitar) and reject (Rejeitar) buttons.

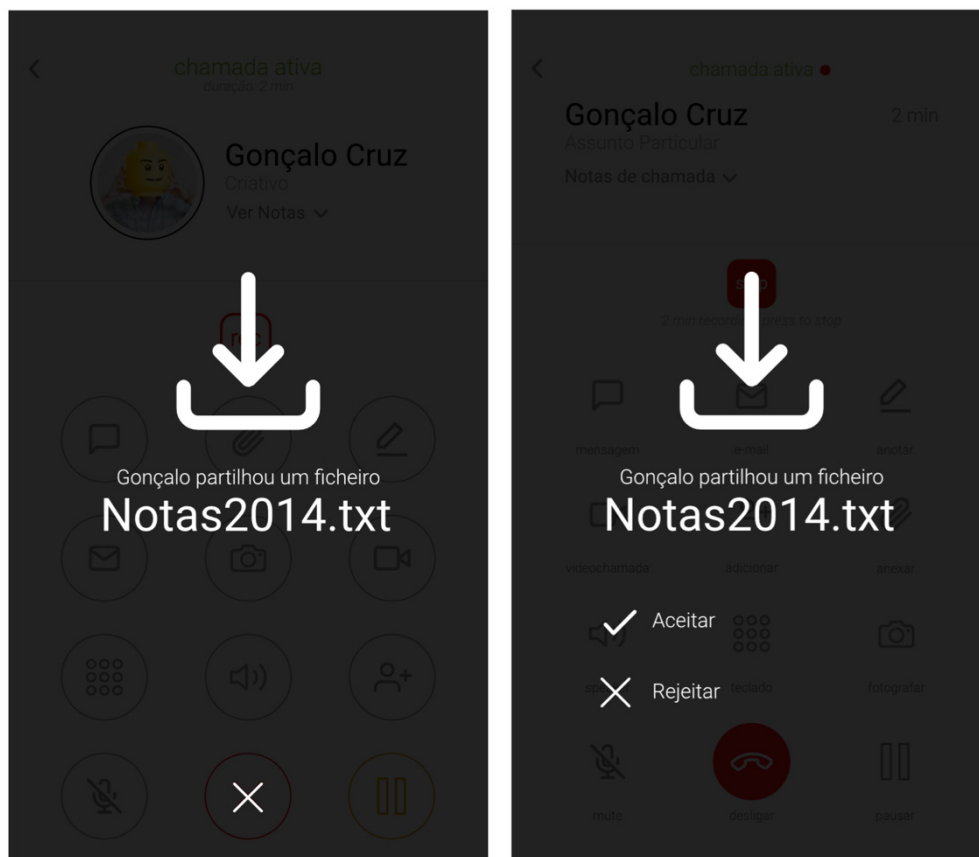


Figure 6: Original Version 1 (left) and corrected Version 2 (right) of the received file during a phone call interface.

S₄ – Iconography use of an “X” to hang up the call wasn’t intuitive because in some cases it was understood to be an option to cancel the action they had engaged in during the phone call (like taking notes, for example).

The hang-up button was very similar to other actions present in the phone interface, where its criticality wasn’t highlighted. The X icon was also used in other contexts, such as to cancel interaction, so once again the prototype lacked consistency between icons and their associated actions. Consequently, participants confused it with a normal cancel option, instead of the hang up call.

This issue could be grouped into both “Immediacy of Communication” and “Synchronicity” elements, as it is not only related to the hang-up action, but to all actions available during a phone call (some related to Immediacy of Communication, as is the case of sending a text message, and others like taking notes or sending a file actions, related to Synchronicity).

Figure 7 represents the improvement of interface aesthetics achieved by the second revision iteration. Furthermore, to aid the user interpretation of all 13 buttons and their associated functions, subtitles were added and were logically grouped according to their main actions. The problematic hang-up icon was also changed, and the button was highlighted in red to distinguish it from the other non-critical interactions.

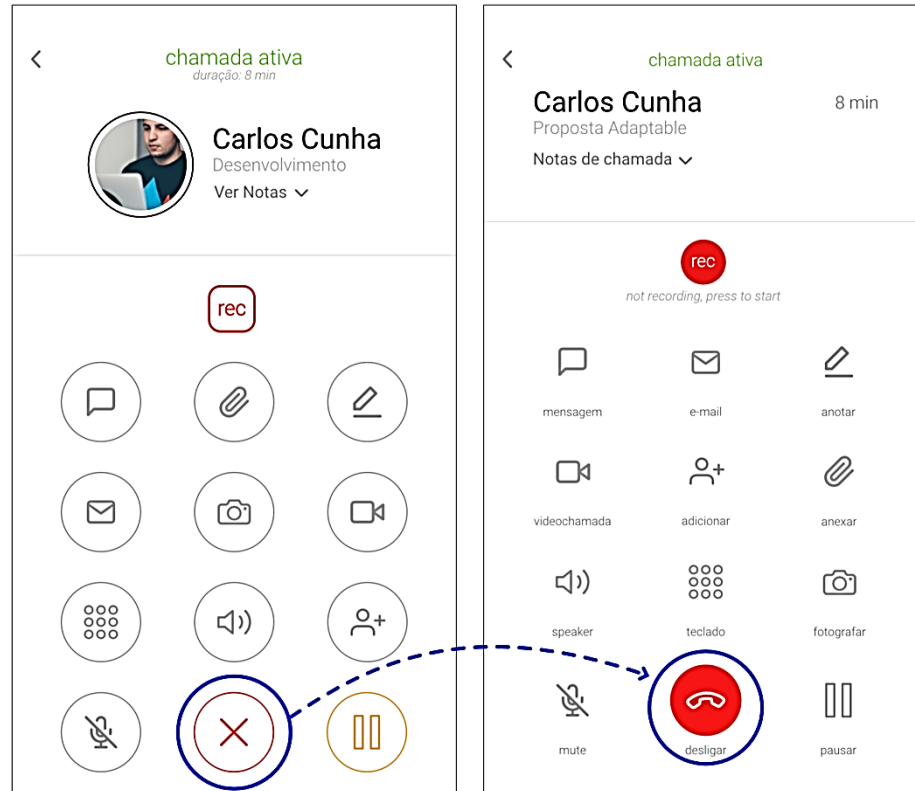


Figure 7: Original Version 1 (left) and re-designed version 2 (right) of the voice call interface, with a focus on the hang up button design amendment.

FINDINGS AND DISCUSSION

The application of the model, included in this work, reveals a first iteration of evidence concerning the validity of the proposed UC&C augmented model as a reference for human-centric design and evaluation of digital unified infocommunication services.

The model’s elements clearly fostered a holistic view of all pertinent issues. Rather than merely highlighting interaction problems and graphic inconsistencies, the augmented model proved to be effective in the process of clustering and relating these interaction issues with the prototype’s components and the interpersonal infocommunication elements that could be at stake (Table 7). Beyond the user-centered design concerns, the augmented model was in fact able to act as an underlying reference and a reminder for human communication needs in digital mediated infocommunication for collaboration, conveying the stated objective of delivering a human-centered approach in the creation of UC&C systems (Table 3). Though it needs further testing and additional research, the combination

of UX methods in the design and evaluation stages also used and reported in this article, has the potential of meeting the second goal of optimizing user's cognitive load in organizational contexts.

Supported by significant literature and previous studies, the model was seen to be capable of supporting a comprehensive understanding of which elements of human interpersonal communication are in jeopardy, because of the inherent design of an UC&C artefact.

The model's elements of Social Presence; Immediacy of Communication; Concurrency and Synchronicity, based on the works of Brown et al. (2010) and Dennis et al. (2008), are proposed to be used as a basis to develop new methods or frameworks to analyse UC&C products based on human needs. The model's application procedure described in this paper serves as a suggested process rather than the "procedural rule". Further research could focus on the proposal of evaluation methods based on the augmented model. Moreover, the applied evaluation method could be greatly improved by capturing and including metrics related to interaction overload and communication deficiency, in order to fully comply with the study's objectives.

What really matters here is the technology mediated communication sphere. In this ever-evolving field, periodic research could be undertaken in order to understand and sustain how the model's elements could fit future technological applications, aiming to meet human communication needs more effectively. Collaboration also has the potential to be affected by other services that can be included in a UC&C system, such as scheduling meetings or in task management. Future research will still need to examine the application of the augmented model to design or evaluate such system elements from a human-centred perspective.

CONCLUSION

This paper proposes an augmented UC&C model to reference the development of new digital infocommunication technologies by integrating two key theories, Brown et al. (2010) technology characteristics for use intention and Dennis et al. (2008) Synchronicity. The authors believe that this augmented version of the model will pave the way to improving research and development of useful and practical infocommunication products, capable of truly serving users' needs.

Secondly, the authors applied the model to design and evaluate a proof-of-concept unified interpersonal communications prototype that aims to aid organizational collaboration through frictionless communications and cognitive load optimization. The prototype's functionalities were designed and linked together with the augmented model's proposed elements in mind, and their pertinence in representing the human interpersonal communication phenomena: Social Presence; Immediacy of Communication; Concurrency and Synchronicity.

The UX design and evaluation process applied to the prototype, with an intentional sample of 9 subjects, is reported and critically revised considering the UC&C augmented model's elements and design dimensions based on Nielsen's (1994a, 1994b) usability heuristics for interface design. As a result of the qualitative research and data analysis, used to test the applicability of the augmented model, 18 distinct interaction situations were clustered. The severity calculation technique was used to identify the five most problematic interaction situations, exclusively related to interface design issues which compromised two of the augmented model's elements. Though most of the issues were design-related, they hinder the achievement of the proposed model's elements and thus, the unified infocommunications and collaboration completeness. This article contains evidence that the augmented model acted as an underlying reference capable of highlighting human communication needs in digital mediated infocommunication for collaboration on a product (conceptual prototype) development funnel containing design, evaluation and analysis stages.

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