# Human-to-Human Interaction: The Killer Application of Ubiquitous Computing?

Salvatore Sorce[1], Stefano Ruggieri[2], Vito Gentile[1], Antonio Gentile[1], and Alessio Malizia[3(✉)]

[1] Dipartimento dell'Innovazione Industriale e Digitale (DIID), Università degli Studi di Palermo, 90128 Palermo, Italy
{salvatore.sorce, vito.gentile, antonio.gentile}@unipa.it
[2] Independent Researcher, Charlottesville, USA
stefanoruggieri@gmail.com
[3] Human Centred Design Institute (HCDI), Brunel University London, Uxbridge, Middlesex UB8 3PH, UK
Alessio.Malizia@brunel.ac.uk

**Abstract.** Twenty-five years past the Weiser's vision of Ubiquitous Computing, and there is not a clear understanding of what is or is not a pervasive system. Due to the loose boundaries of such paradigm, almost any kind of remotely accessible networked system is classified as a pervasive system. We think that is mainly due to the lack of killer applications that could make this vision clearer. Actually, we think that the most promising killer application is already here, but we are so used to it that we do not see it, as a perfect fitting of the Weiser's vision: the Human-to-Human Interaction mediated by computers.

**Keywords:** Ubiquitous computing · Social factors · Computer-Mediated communication

## 1 Introduction

The Weiser's vision of Ubiquitous Computing (UC) [1] is hard to be framed within a clear definition because it is a multi-disciplinary research field, it addresses many facets of our lives, and overall, it is not only about what Weiser wrote.

Often we refer to the UC-derived paradigms to understand the Weiser's comprehensive vision, such as the Pervasive Systems or the Internet of Things. Scientists and researchers, from all around the world and throughout the last twenty-five years, largely discussed psycho-social factors and both software and hardware technologies needed in order to fulfill and implement the original vision of pervasive systems.

Nevertheless, the common perception of this paradigm has loose boundaries, so that almost any system relying on a network of two or more devices, equipped with a bunch of sensors and somehow remotely accessible, is frequently classified as a pervasive system relying on an IoT.

By contrast, according to the actual Weiser's vision, in the Ubiquitous Computing world, common objects are equipped with some additional features, thus becoming 'smart'.


M. Kurosu (Ed.): HCI 2017, Part I, LNCS 10271, pp. 86–93, 2017.
DOI: 10.1007/978-3-319-58071-5_7

They should seamlessly react to changes occurring within the surrounding environment to provide useful and personalized services to their users. Access to ubiquitous systems should become as transparent and natural as wearing eyeglasses.

For example, a table equipped with load sensors should alert when it is near its breaking point; a coffee cup equipped with NFC and sensors should alert its owner when the coffee inside is too cold or when it is almost empty. These examples are what we consider good examples of UC according to the Weiser's vision. However, they are quite distant from what is currently available. Indeed, in most cases sensors are attached to everyday objects, to detect some parameter of the surrounding environment (i.e. something not strictly related to the object nature or purpose). Moreover, "smart things networks" are mainly based on proprietary protocols, with evident limitations in terms of interoperability and proactivity, that is their capability to self-discover, configure and cooperate as a whole.

We think that one of the main reason why there is no clear understanding of what a pervasive system is hitherto, and also perhaps of what a pervasive system is not, consist in the lack of killer applications. The most promising applications (pervasive advertisement and service provision in public places [12]) are strictly related to social factors and behaviors, but they are not as "pervasive" as in the Weiser's vision [2]. This is the main reason why human-to-human interaction, which is more and more mediated by one or more networked devices, seems to be the best candidate to become the application that will bring the pervasive vision at everyone's hands.

## 2 Social Factors

Many studies have shown the theoretical limits of Human-Computer Interaction (HCI) approaches based on cognitive ergonomics [3], which focuses its attention almost exclusively on the interaction between a single user and a technological system.

Therefore, over the last decade, a relevant number of studies have been aimed at analyzing the role of interaction with other people when it is made through the use of technological tools. The computer and the Web, therefore, represent a tool capable of assisting interaction between individuals through the medium. In this respect, a key role is played by the introduction of models and analysis tools derived from social psychology, which has a long tradition in the study of the interaction between individuals, including interaction that takes place through distributed computer systems.

Alongside the HCI model, there is that of Computer-Mediated Communication (CMC) which originated with a reflection on a specific phenomenon of the Web: the use of the network as a means of interpersonal communication [4]. As regards the communicative aspect, the two paradigms refer to two different models of interaction: interaction "with the medium" and interaction "through the medium".

The basic assumption of the interaction *with the medium* is that it involves a user and an environment; they are located within a common area and interact through an interface having "mediation functions" that establishes a shared code inspired by the logic of the human mind. The interaction is aimed at achieving a goal and it is often possible to assess the effectiveness of the exchange in terms of how close the user comes to achieving that goal. Not surprisingly, to address the issue of the usability of

an interface, quantitative criteria tend to be used most, and they are expressed in terms of effective performance. By way of example, we cite a few commonly used indicators like those that measure the time required to complete a task, the number of errors committed or the percentage of sub-goals achieved, or those not achieved or achieved only partially.

In terms of the interaction *through the medium*, the scenario changes because the interaction involves human users located in remote areas, who communicate through an interface and whose task is to define and establish a shared context in which the actions of the participants are intertwined. The interactivity of a virtual space, from this point of view, is defined by the effectiveness with which its users make contributions and interventions consistent with the multiple lines of development of the issue, allowing communicative exchanges and the establishment of relationships between the participants in the interaction.

In contrast to the previous type, communication through the medium invokes a complex and reticular type of communicative exchange in the development of interaction between users of the system. Relationships develop between the users, whose rules are defined within the system that is the mean of communication. Common indicators are the number of communication exchanges or the use of a formal or informal communication, or the satisfaction to interact with others.

## 3 Interaction with the Medium

Nowadays there are several modalities for using interactive systems. Considering displays, for instance, the new technological advances allow for interacting via keyboards and mice, as well using touch-based interactions or even touchless ones. If we shift the focus on more general media, a plethora of modalities may be considered.

As explained in the previous sections, the naturalness of the interaction is one of the most promising features that can facilitate HCI paradigms to emerge. We can see today a lot of interfaces designed more to amaze people than to make them interact with the system in easy, intuitive ways. Introducing new interaction modalities, such as the use of in-air gestures (easily recognized by wearable devices), should be only due to their naturalness.

The HCI paradigm is strictly related to the need of using some device, wearable or not, that constitute the aforementioned "medium" by mean of which users will interact. With this in mind, gestural interaction seems to be one of the most adequate modality, both for its naturalness and because of the recognition capabilities of the currently available technology [5]. Indeed, in order to recognize gestures via Kinect-like devices [14] (with more "traditional" algorithms), many issues arise due to the need of controlled or semi-controlled environments where the recognition can be performed. Using wearable devices, such problems fade away: accelerometers and gyroscopes can be used as data input for gesture recognition, with no need of using cameras.

A more difficult issue to solve is the cultural dependency and constraints of the gestures. From a mere technical point of view, interacting with a device should be the same in every part of the world, to ease both the implementation and recognition tasks. Actually, several issues related to customs and traditions need to be overcome instead.

For instance, the same swipe gesture explained to two different people, is usually performed in slightly different ways. The difference (which can be easy to understand for a human) may be difficult to be discerned with an algorithm.

The pressing needs of communication, everywhere and every time, regardless of the distance among people, are pushing the boundaries of actual implementations towards the overcoming of such technical and social constraints. This is the reason why we are witnessing the evolution of adaptive interfaces, to take into account variations due to culture and other social factors, physical factors, users' profiles, etc.

## 4 Interaction Through the Medium

In recent years, there have been many studies that have analyzed the dynamics of social groups that work or interact in various ways online. This came about for two reasons. First, these studies have the merit of having analyzed theories and models of social psychology, but in areas very different from those where they originated. Virtual environments increasingly exist alongside real life, and it is, therefore, necessary to test the ability of psychosocial models to explain how interaction in these new environments works. Secondly, research on computer-mediated groups (CMG) has a strong empirical character, especially for those who design systems for virtual interaction, with the aim of optimizing processes in function of the objectives to be achieved.

The analysis of these studies is essential for all those who design systems for virtual interaction, given that an understanding of the dynamics of the social functioning of groups that collaborate and interact remotely is of fundamental importance. One can thus truly speak of social ergonomics, which together with cognitive ergonomics designs these contexts from a perspective of individual usability, that is, a perspective characterized by rules and guidelines to follow in order to accurately design the communication environments. All this with the aim of optimizing the interactive process in accordance with the goals to be achieved, and in such a way that the CMC can produce the best results in terms of interaction, user satisfaction, performance, efficiency, but also stability and cohesion among the members of the group.

It is precisely the definition of these contexts of use that will pave the way for social ergonomics, by which, in accordance with the theoretical assumptions and the most recent studies of CMC and HCI, we mean the rules, models and guidelines to be followed and implemented in order to accurately design interactive environments (for recreational, educational and professional purposes, among others). All this, with the aim of optimizing the communication process in relation to the objectives of the context in which the individual works, the target audience where the action is directed, the time frame available and the type of task that must be completed.

Thus, an understanding of the dynamics that govern, for example, leadership, status, cohesion in virtual teams and decision-making can assist in making a careful choice of the most appropriate methods and tools for planning and organizing virtual interaction environments. A key role is played by the concept of the environment and the different meanings with which it can be understood. In fact, there are different types of mediated environments that have their own peculiar characteristics and thus are different from those on which many HCI studies focus. Clark and Brennan [13]

distinguish certain characteristics of communication environments that characterize the real nature of interactions:

- *co-presence*: group members occupy the same physical location);
- *visibility*: the possibility of seeing each other;
- *audibility:* the ability to hear each other;
- *co-temporality*: communications are received more or less as soon as they are sent;
- *simultaneity*: the members of the group can send and receive messages at the same time;
- *sequentiality*: members of the group usually speak to each other in a sequential manner.

A paradigmatic case is the development of Learning and Content Management Systems (LCMS), which, in just a few years, have reached high levels of standardization. This has created a new profession, the instructional designer, a systems designer for training courses, who operates in online environments and contexts in order to achieve the best combination between the environment and the learning process. The opportunity to program the LCMS allows the instructional designer to create, for each context, the most appropriate tool for the group that will benefit from it. In this sense, the crucial aspect upon which the success of the teaching/training project depends is the ergonomics of the social system created, i.e. the ability of the system implemented to ensure the effective use and the socialization of the knowledge it contains, as well as the ability to create new and innovative knowledge through mutual exchanges. Thus, by analyzing (1) how to enact the dynamics of leadership – i.e. the status, (2) the creation of social ties, (3) group cohesion and decision-making in virtual environments, it will be possible to make a careful choice of the most appropriate methods and tools to be used for specific purposes. For instance, the designer could decide whether to use tools for synchronous communication (chat, video conferencing, etc.), or for asynchronous communication (mailing lists, forums, etc.); or decide whether members of working groups are thoroughly described or identified by a generic alias; or decide whether to adopt a collaborative rather than a competitive approach, to name just a few features that can be systematically analyzed according to the canons of social ergonomics.

It goes without saying that this process cannot be implemented exclusively by using electronic tools, but instead requires careful work: first research, and then design.

### 4.1 Status in Virtual Interactions

Years of research have shown that the *status* is one of the most salient aspect influencing interactions within groups [6]. In general, individuals with a higher status more frequently assume the position of leader, speak quickly and often with little hesitation, dominate the conversation, tend to centralize resources, exert a decisive influence on decision-making, maintain eye contact during interaction and are also perceived as more competent [16, 17]. In contrast, members of low status exert less influence on the decisions of the group, they tend to let others make the decisions, they care more about being accepted by members of high status and they conform more.

The theme of status within CMGs has produced a wealth of results, particularly related to the principles of democracy and equality, which the Internet has always declared as its watchwords.

Not all research, however, has produced converging results, demonstrating that technological mediation is not always able to reduce the effects of status.

How to explain these contradictory results? To provide an explanation, authors have suggested that the process of technological mediation can interact with the status at least on three different levels. The first, consistent with the average richness theory [10], is represented by the reduced transfer of status-related social cues through electronic media with respect to FTF contexts. Media richness theory is a commonly used theory for explaining how different communication media affect task performance. A rich medium allows for: (1) transmitting multiple verbal and nonverbal cues, (2) using natural language, (3) providing immediate feedback, and (4) conveying personal feelings and emotions. The richest medium is FTF communication, followed by telephone, chat, e-mail, and print communications. Newer technologies, such as video conferencing, are thought to rank above telephone communication, but below FTF communication, in terms of media richness. Technologies that allow the recipient(s) to see physical gestures and facial expressions are thought to increase the richness of the information conveyed, thereby contributing to the greater richness of the video conference, as compared to telephone or text-based media.

A reduced amount of information is an obstacle for the correct identification of the status. Thus, when the identity of the members is made visually evident, status differences persist even in a CMC setting. A second possibility is that the effect of status indicators is different in the two contexts. Visual clues, such as visible exchanges, the free flow of gestures and the tone of voice characterize FTF interaction. Replacements for these indicators, although they may be present in technologically mediated contexts, may not have the same impact. Some studies have shown how gestures can lose some of their meaning if they are produced in the form of visual technological mediation [18]. A third aspect refers to the rules governing the process of status acquisition. When a failure to respect the hierarchy of status occurs within a group, there is generally a reaction against those who committed the violation. Typically, in FTF interactions, we observe an exchange of glances that usually end up in the classic “dirty look”. This and other reactions meant to bring those who violate status-imposed standards back into line are significantly weakened in CMC interaction. It is likely that these three levels can actually act together, and thereby give rise to the contradicting results we find in the literature.

One aspect that seems to be decisive in the creation of bonds of status is the temporal context. Typically, in groups of unequal status, the status structure develops rapidly, while in groups whose members share equal status, development is slower, given that it is a function of the contributions made by the members of the group during their interaction. This has important implications for the life of a group. In particular, it was found that in groups that interact over a long period of time, the strong initial impact of status decreases, while the interaction becomes increasingly modeled by the quality of the contributions made by the group’s members. The effects of the technological mediation and translation of the observable indicators of status thus become less relevant for team interaction with the passage of time [9].

Those who design devices to support the activities of a work group should consider not only the purely technical aspects but include a priori a way to manage the status in virtual groups. In order to exploit the various effects of this variable, hierarchical user profiles should be designed, while to ensure interaction based on equal status, an environment should be built that masks these differences.

## 5 Concluding Remarks

The Weiser's vision of UC is a paradigm so wide and so comprehensive, that it is difficult for common people to clearly identify what can be classified as one of its implementations or not. On the other hand, we are experiencing a growing need for interaction among humans at any time and at any place. This need can only be completely fulfilled if computers somehow mediate the interaction.

The design of virtual communication environments is most clearly affected by discoveries achieved in all the involved research fields. The goal is to optimize the interactive process on the basis of the objectives to be achieved so that Computer-Mediated Communication can produce the best results in terms of fluid interaction, user satisfaction, performance, and efficiency, but also in terms of the stability and cohesion of the group's members. All this is to be considered in function of the objectives of the specific context, the target group to which the action is directed, the available time frame, and the type of task to be completed.

The human-to-human interaction mediated by computers is a field that involves all the above-discussed aspects, both from the technological and social points of view. In the next future people will probably interact among them unconsciously by means of an interaction media the same way they wear their eyeglasses to enhance the vision of the surrounding world. One promising way of computer-mediated interaction among humans is the gesture-based one. People are used to interact with the support of body gestures, and in some case, gestures are the only way to convey information, for example in the case of language or physical hindrances. There are several studies in the field of the HCI by means of gestures, and a lot of them are aimed at the intuitiveness of such interaction [15]. This is the needed preliminary step to achieve the goal of a gesture-based HHI mediated by computer.

All these aspects need to be considered by future research with the fundamental goal of giving online groups the benefits of a carefully designed workplace and learning space, as well as the benefits of optimal conditions for communication. Such benefits are based on the principle that certain contexts are more suitable than others for achieving group objectives, given that they follow a logic of affordances determined by the type of interaction used in the operating environment.

The HHI mediated by computers and networks seems the best candidate to become the killer application of Ubiquitous Computing, because it is an actual, pressing and largely shared need, and it must have all the features envisioned by Mark Weiser to be effective. At that point, we should talk about an Internet of Humans, instead of an Internet of Things.

**Acknowledgements.** This paper is funded on a research grant by the Italian Ministry of University and Research, namely project NEPTIS (Grant no. PON03PE_00214_3).

## References

1. Weiser, M.: The computer for the 21st century. Sci. Am. **265**(3), 66–75 (1991)
2. Krumm, J.: Ubiquitous advertising: The killer application for the 21st century. IEEE Pervasive Comput. **10**(1), 66–73 (2011)
3. Norman, D.A.: The Invisible Computer: Why Good Products Can Fail, the Personal Computer is So Complex, and Information Appliances are the Solutions. The MIT Press, Cambridge (1998)
4. Boca, S., Gentile, A., Ruggieri, S., Sorce, S.: An evaluation of HCI and CMC in information systems within highly crowded large events. In: Sixth International Workshop on Intelligent Interfaces for Human-Computer Interaction (IIHCI-2013), pp. 600–604, Asia University, Taichung, Taiwan, 3–5 July 2013. doi:10.1109/CISIS.2013.108
5. Gentile, V., Malizia, A., Sorce, S., Gentile, A.: Designing touchless gestural interactions for public displays in-the-wild. In: Kurosu, M. (ed.) HCI 2015. LNCS, vol. 9170, pp. 24–34. Springer, Cham (2015). doi:10.1007/978-3-319-20916-6_3
6. Brown, R.: Group Processes: Dynamics Within and Between Groups, 2nd edn. Blackwell, Oxford (2000)
7. Levine, J.M., Moreland, R.L.: Progress in small group research. Annu. Rev. Psychol. **41**, 585–634 (1990)
8. Ruggieri, S.: Leadership in virtual teams: A comparison of transformational and transactional leaders. Soc. Behav. Pers. **37**(7), 1017–1022 (2009)
9. Driskell, J.E., Radtke, P.H., Salas, E.: Virtual teams: effects of technological mediation on team performance. Group Dyn. Theor. Res. Pract. **7**, 287–323 (2003)
10. Daft, R.L., Lengel, R.H.: Information richness: A new approach to managerial behavior and organization design. Res. Organ. Behav. **6**, 191–233 (1984)
11. Doherty-Sneddon, G., Anderson, A., O'Malley, C., Langton, S., Garrod, S., Bruce, V.: Face-to-face and video-mediated communication: A comparison of dialogue structure and task performance. J. Exp. Psychol. Appl. **3**, 105–125 (1997)
12. Genco, A., Sorce, S., Reina, G., Santoro, G.: An agent-based service network for personal mobile devices. IEEE Pervasive Comput. **5**(2), 54–61 (2006)
13. Clark, H.H., Brennan, S.E.: Grounding in communication. In: Resnick, L.B., Levine, J.M., Teasley, S.D. (eds.), Perspectives on Socially Shared Cognition, pp. 13–1991. American Psychological Association (1991)
14. Gentile, V., Sorce, S., Gentile, A.: Continuous hand openness detection using a Kinect-like device. In: Proceedings of the Eighth International Conference on Complex, Intelligent and Software Intensive Systems (CISIS), pp. 553–557. IEEE (2014). doi:10.1109/CISIS.2014.80
15. Malizia, A., Bellucci, A.: The artificiality of natural user interfaces. Commun. ACM **55**(3), 36–38 (2012)
16. Zigurs, I.: Leadership in virtual teams: oxymoron or opportunity? Org. Dyn. **31**, 339–351 (2003)
17. Hambey, L.A., O'Neill, T.A., Kline, T.J.B.: Virtual team leadership: The effects of leadership style and communication medium on team interaction style and outcomes. Organ. Behav. Hum. Decis. Process **103**, 1–20 (2007)
18. Heath, C., Luff, P.: Media space and communicative asymmetries: preliminary observations of video-mediated interaction. Hum. Comput. Interact. **7**, 315–346 (1992)