CubeMate: A New Communication Device as Non-verbal Interface in a Shared Space

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Abstract. Communication is made of both verbal and non-verbal components. The latter often provide much more meaning than people realize. Nowadays communication is more often technology mediated, this occurrence is transforming rules and channels of human communication. In this paper we illustrate the design of a new communication device, CubeMate, which can be used as nonverbal mood interface in various contexts of shared space (house, office, shared flat). The design of CubeMate follows the Interaction Design process. Its design, embracing Weiser's Calm Computing, focus on the Calmness, using a non-verbal output that doesn't overburden users attention. During two Maker Faire we have collected unstructured feedbacks and qualitative evaluations through a prototype trial. On the basis of these considerations we could identify achievable improvements and define several and cross application fields.

Keywords: Non verbal communication · Calm computing · Interaction design process · Proactive computing · Emoticons

1 Introduction

Communication is a process of continuous exchanging of verbal and non-verbal messages. Pre-requisite of communication is a message. This message must be conveyed through some medium to the recipient. It is essential that the recipient must accurately understand this message. Thus, communication is incomplete without a feedback from the recipient to the sender on how well the message is understood by him. Feedback may be verbal (through words) or non-verbal (in form of facial expressions, sighs, etc.). Non-verbal elements of communication can give important clues to the recipient for the interpretation of verbal message. Non-verbal communication works in conjunction with the words that we utter in six ways: to repeat, to emphasize, to complement, to contradict, to substitute and to regulate. So nonverbal elements are an essential part of the total communication package, and sometimes could be the only one.

Traditional dimensions of non-verbal communication are eight: physical appearance [1], proxemics [2], facial expressions [3], gestures and posture [4], tactile communication [5], eye contact, paralanguage and chronemics.

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Two of the five primary functions of non-verbal behavior [3] are expression of emotion and communication of interpersonal attitudes. Regarding the first, emotions are expressed mainly through the face, body, and voice. About the second, the establishment and maintenance of relationships if often done through nonverbal signals. Planning our project we have focused on the facial expression dimension because non-verbal cues can regulate or control face-to-face interaction, conveying information about relational matters such as liking, respect, and social control.

In the past, some studies try to numerically quantify the contribution of each component in the communication process. The research on non-verbal messages conducted by Albert Meharabian in 1967 was often misquoted [6, 7, 9], diffusing the idea that the total meaning in every message is 7 % verbal, 38 % vocal and 55 % facial.

Lapakko [8] criticized this reduction of the complex world of communication into a tidy and precise quantification, because he supported that it is not possible to quantify the relative importance of the non-verbal and verbal communication.

Mehrabian [6, 7] also noted that this equation is applicable only to the communications of feelings and attitudes. Indeed, we can understand more about another person's feelings on non-verbal cues and less on the words that are used.

The fast changes and the evolving technologies at our disposal, have strong repercussions in the daily lives of each of us: we live, we communicate, we move really and virtually in the knowledge society and the network society [10]. Always, developments in technology and communications have gone hand-in-hand, and the latest technological developments such as Internet, Social Networking and mobile devices have changed rules and channels of human communication. In the past, people used to speak face-to-face. This communication paradigm allow them to read and pay attention to the body language, the facial expressions, the voice intonations and to understand the real meaning of that communication. Nowadays when we interact with others using EMC (Electronically Mediated Communication) we can do so asynchronously. This phenomenon makes the communication less spontaneous and more impersonal than in the past. The use of technology can be a great help to people in communicating, reducing the time it takes, but it can have consequence of reducing face-to-face interaction. There are differing views on the consequences of using technology in the communication. If on one hand there is the strict belief that the technologies are destroying human communication [11], on the other hand there is the opinion that using them does not mean that face-to-face interaction suffer. Rather, it is an extension of them [12]. It is certain that the communication with the introduction of the new technologies has changed the style and the syntax.

Words and graphics become more important in EMC than in face-to-face interactions, because when communicating electronically, you must rely solely on words to carry non-verbal messages. There is no tone of voice in the written message and it can be possible to see the facial expressions, body gesture and position of interlocutor. Everything, and the absence of all other paralinguistic elements, makes difficult to express emotions. So people use emoticons to provide emotional punctuation. The term "emoticon" is a blend of emotion and icon and even if originally they started as simple "pictographs", little by little they have become "non-verbal surrogates, suggestive of facial expression, and a further addition paralinguistic component to a message" [13] to

"indicate the writer's mood or feeling" [14]. Emoticons diffusion makes them a universal visual language.

Given this theoretical framework and according to the belief that technology can be an extension of the face-to face relationships, in this paper we illustrate the design of a new communication device, CubeMate, which can be used as nonverbal interface in various contexts of shared space (house, office, shared flat). In the Sect. 2 we describe the project and the Interaction Design methodology followed, through four steps. Firstly, we identified the user needs about the communication in the shared space and after we establish the requirements. Second, we develop alternative design, to suggest ideas that meet the requirements. The third step describes the building of the interactive versions, focusing on the design of the interaction and related concept of Calm Computing. Following section reports our experiences in two Maker Faire and the qualitative evaluation of CubeMate. Finally, Sect. 4 presents our conclusion and future work.

2 CubeMate Design Process

2.1 User Needs and Requirements

The design of CubeMate follows the four basic steps of traditional process of Interaction Design [15]: identify needs and establishing requirements, develop alternative designs, build interactive versions of the designs and evaluate designs.

According to this, the first step to design something to support people is to know who our target users are and what kind of support an interactive product could usefully provide (identify needs and establishing requirements).

Firstly we have decided to work on solutions for shared spaces. This choice is motivated by the personal experience in our lab, where eight/ten persons share the same room. Through an informal brainstorming session we have identified the main user's needs and some requirements to satisfy. The project idea starts from the strong consideration that is difficult to live together with acquaintances in shared spaces (home, office, shared flat) where some things, like moods or feelings, are very hard to express.

Thanks to our design users should let each other know how they feel, when they want to be alone or when they want to be approached. Thus, to improve living side by side avoiding misunderstanding and fostering respect of everyone's spaces.

During this stage we have established some requirements and features to keep in mind during the entire design process: a simple and minimalist design to suggest the right way to interact with the object itself; the introduction of engaging and interactive solutions to make the product interesting and the necessity to use of a universal visual language, as emoticons, to help colleagues, friends and flat-mates sharing feelings through a non-verbal understated language. On the basis of these observations we have designed *"CubeMate"*, which can improve communication process reinforcing empathy through nonverbal cues.

The name CubeMate is a fusion of the words "Cube" and "Mate". This blend has been chosen for two reasons: the first is to refer to the cube shape of the product, the

second is to emphasize the main task of the object that is to be an actual "mate" to the owner, helping his social life.

CubeMate is a small cube consisting of interactive and lighten faces. It displays facial expressions, through four emoticons, that correspond to four basic moods: happy, calm, angry and sad. Top faces of every single CubeMate are made in different colors to allow each person to choose the shade that best represents their personality, so as to feel more 'connected' to it. It can be placed in a common space of the office or the house so everyone can share his/her own mood through his/her own little cube.

2.2 Developing Alternative Designs

Later we focused on the development of alternative designs, to suggest ideas that meet the requirements. We have simultaneously developed the conceptual design, to describe what the product should do, and the physical design considering the details of the product, including the colors chosen, the materials used and the form factor of the object. In this stage we have explored several shapes and details in order to realize a product designed accurately in each of its parts. To reach this aim we have built two different physical prototypes. In both versions we focused on the strict relationship that exists between shape and function and we reflected upon the important role that the Affordance, perceived as an "aspect of an object which suggests how the object should be used" [16], plays during the design process.

The first prototype (A) of CubeMate was an 8,5 × 8,5 cm transparent Plexiglass cube. On the frontal face, there was placed a display for the smile. User could choose his/her mood interacting with a knob, whose rotation, to the right or the left, makes vary smile from the happy to the sad face.

The second version (B) consisted in an Opaline Plexiglass cube, opaque, 10 × 10 cm dimensions. On the frontal face, there was placed a LED display for the smile. The Polyurethane Gel covered the top face, under that we inserted a button. In this prototype, user interacts with cube with a simply touch on the top face changing LED displayed face.

2.3 Building Interactive Prototype

During the third step of the design process of CubeMate we have built the two-designed interactive prototypes. This step is more important and fundamental for the whole of the project. The most sensible way to evaluate and choose the fitting design for the stated function is to interact with it. We use the single-board micro-controller Arduino UNO that make it possible to build the most quick and interactive version of CubeMate.

Both versions of CubeMate, embracing Calm Computing construct [17], are *designed for the Periphery*, focusing on the Calmness. After the Mainframe era and the PC era, now we are living the Ubiquitous Computing era. The characteristic of this era, distributed computing in every aspects of our daily living, imposes a complete rethinking of "the goals, context and technology of the computer and all the other

technology" [17]. The essential challenge in a world where computer are everywhere is to design technology that calm and leave us "more time to be more fully human" [17]. The difference in the Calm technology is how it engages and manages user attention. Engaging both the center and the periphery of attention, user is always aware of what is happening by periphery processing, without overburden center attention.

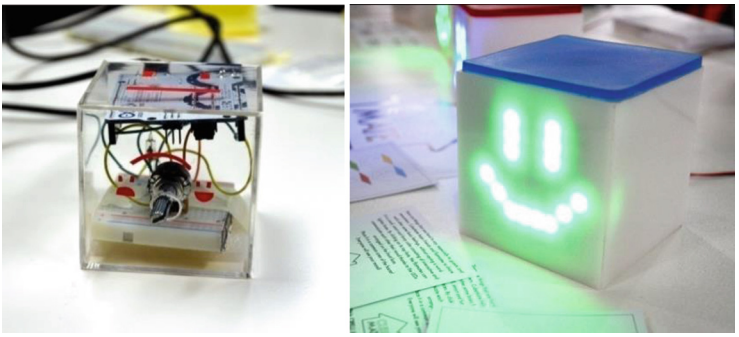

Fig. 1. At left Prototype (A) and at right Prototype (B)

Between the two prototypes (Fig. 1), according to the related Calm Technology notion of Affordances [16], we have chosen the prototype (B). This version is characterized by the more natural and intuitive interaction. It is characterized by a self-explained interaction, in a way that people naturally go to touch the top face of the cube, appealing from the Polyurethane Gel. The choice of specific materials as Opaline Plexiglass for cube's faces and Polyurethane Gel for the top face, besides on the basis of their intrinsic qualities, was made just considering the effect that they have on interaction: "the feeling when holding the object, the physical engagement with it, and the appropriation engendered by possessing one" [18]. In addition, the minimalist design allows an easy identification as a familiar device, which makes the user to be at ease with the cube. While with a rough version of the prototype (A) we immediately understood that the interaction was complex. User had to commit his/her attention totally on the interaction with the knob to choose the most representative smiley.

Unlike what was claimed by Weiser, CubeMate must be consciously activated by people involved in the communication process. By this way, this project realizes a shift "from proactive computing to proactive people" [19]. According to the Rogers proposal for an alternative agenda of the UbiComp Technologies, the main goal of this project is enable people to do what they want in a best way. In fact CubeMate provides information, through emoticon, that reinforce empathy and allows user to live a more engaged and actively communication. These different ways to design the UbiComp technologies are based on a different view of the users and its relationship with the technologies. For the traditional Ubiquitous Computing [17], technologies are embedded in the environment to reduce the need for humans to think yourself about every-day stuff, and doing it for them. In this view, users have only to react to the technology input that told them what have to do. Instead of the Rogers proposal, where

the UbiComp technologies are designed to create a collaborative ecologies of tools and resources that augment human intellect and "provoke us to learn, understand and reflect more upon our interactions with technologies and each other" [19]. In fact CubeMate project shares the Rogers idea of proactive users that knowingly choose and show his/her mood. So it may augment people ability to understand their own and the others feelings, to learn how to interact with them.

By this way, CubeMate cannot be defined as a typical device of the Ubiquitous Computing era. Actually it does not have any connectivity, neither to connect to other smart object nor at the Internet. CubeMate working is based only on the users input, it does not take any information from sensor or any network.

3 Evaluation from Maker Faire Experiences

The main goal of the interaction design is to develop interactive products that are usable. The last step of the Interaction Design process concerns precisely the evaluation of the designs. Evaluation generally concerns the easy to learn, the effective to use, and the ability to provide an enjoyable user experience.

On the occasion of the Maker Faire Rome, the European Edition (3–5 October 2014) we presented the first four high-fidelity prototypes of CubeMate. We also exposed CubeMate in Elephant & Castle Mini Maker Faire 2014 (15th November 2014). According to the Maker Faire Official Site definition "Maker Faire is the Greatest Show (and Tell) on Earth - a family-friendly festival of invention, creativity and resourcefulness, and a celebration of the Maker movement" [20].

The idea to expose CubeMate in these two Maker Faire was born when we chose the open source electronics Arduino for build the interactive versions of the product designed. Thanks to this platform and other related knowledge and abilities of the Maker Movement, everyone could actually build interactive things, and not only. In our case, this world of resources and tools gives to the CubeMate idea the possibility to become reality.

Capitalizing on these experiences, during the two fairs we made the last step of the design process, involving fair visitors through CubeMate prototype trial. Given the environmental characteristics of the fairs, we could collect unstructured feedbacks and qualitative evaluations through, first, the observation of the users and, second, talking with them. The advantage of exposing CubeMate in events like the Maker Faire was the possibility to have feedbacks from a very large and diverse sample of users, in terms of age, cultural background, education, skills and interests (Fig. 2).

In the first moments of the approach to the Cube, we left user free to interact with it without explain anything. During these moments we could observe if the interaction with CubeMate was clear and intuitive. We have seen that the majority of users approach CubeMate touching immediately its top face. Talking with these users, this first approach was explained by the attraction both for the general design of the object and texture and for the colors of the top face gel. Only few users did not touch the cube and, after a brief observation of the Cube, asked to us: "What is it?" or "How does it work?".

The first group of users, continuing to interact with the cube, discovered by yourself the four emoticons, recognizing for the mood each represents. After this, these users requested to us what were the goals of the cube. So if the interaction with CubeMate is natural and intuitive, the aims are difficult to understand. This difficulty can be explained considering CubeMate was out of context than its natural context of use.

Through the talk with the users, we have collected various observations. Many adult users acknowledge the usefulness of CubeMate as a non-verbal mood interface, especially for the negative moods, in a shared space with strangers and newcomers, like the office. By this way, CubeMate could allow an effective communication, free of some emotional influences that could alter its real meaning.

During both the Maker Fairs, especially in the Education Day of Maker Faire Rome, many children, young boys and girls (under 18 years old) have interacted with CubeMate. Very little children (0–5 years) have seen it mainly as a toy, even using it, if requested, as a means to show their parents how they felt. Many teenagers, coherently age period living, have reported they would use CubeMate for sharing your mood with your friends. If someone of them suggested photographing the smile chosen and sending it to the friends, many requested if there was the Internet connectivity to send it automatically.

On the other hand, teenagers parents have seen in CubeMate a simply tool to better understand mood of their own children, so as to decide how to interact with them.

In the next future, we are planning an evaluation phase carried out through a structured usability test. This kind of test allows us to study CubeMate in its designed contexts of use (house, office, shared flat), to identify the efficiency and the possible effects of social and psychological dynamics that subsist in these shared spaces.

Meanwhile, on the basis of Maker Fairs experiences we could identify some physical and technological improvements for the next versions of CubeMate. It is essential to work both on a stronger internal structure and form factor in order to guarantee the strut strength. Simultaneously a single-board microcontroller as Arduino does not ensure a reliability and efficiency required by an end-user product. In addition, we evaluate to implement the connectivity.

Finally, on the basis of the user considerations we could define another interesting application fields. CubeMate could be used as a user-friendly tool for collecting quickly evaluation, supporting the sentiment analysis in a customer satisfaction studies. Furthermore it could be used as a tool for the pain evaluation (through the Faces Pain Scale [21]), or as a communication aid for people with disabilities and linguistic impairments. Non-verbal people with autism have often difficulties to communicate using natural languages. They can, however, learn to communicate through specific symbols and images. Based on this fact, El-Seoud et al. [22] designed a mobile based application. CubeMate could be used similarly, helping autistic people to express and communicate their emotion. It will be indispensable, for each of these applications, suitable studies for the specific users, the different aims and features, identifying possible changes in CubeMate design.

Fig. 2. The four high-fidelity prototype of CubeMate during the Maker Fairs

4 Conclusions and Future Work

We illustrate the importance of non-verbal components in the communication process. Among eight different dimensions of non-verbal communication, the Facial Expressions are the most important non-verbal channel for expressing attitudes and emotions to other people. Nowadays communication is more often technology mediated, transforming rules and channels of human communication. The emoticons, a simple "pictographs", allow users to express their own moods and feelings through tech-mediated communication.

According to this theoretical framework, in this paper we illustrate the design of a new communication device, CubeMate, which can be used as nonverbal interface in various contexts of shared space (house, office, shared flat). Its aim is to help users sharing each other some basic feelings through the non-verbal communication. The design of CubeMate follows Interaction Design process: identify needs and establishing requirements, develop alternative designs, build interactive versions of the designs, and evaluate designs.

We firstly chose to focus on the difficulty of living together with acquaintances in shared spaces. After we have established some requirements: minimalist and simple design; interactive solution; the use of a visual language. So CubeMate is a small cube consisting of interactive and lighten faces. It displays facial expressions, through four emoticons. It can be placed in a common space, so everyone can share his/her own mood and see the others one, reinforcing empathy and avoiding misunderstanding.

The second step concerns the development of alternative designs, differing shapes, materials and details, prototype (A) and (B). In both versions we focused on the strict relationship existed between the design of the object and how it should be used (Affordance).

The third step describes the building of the interactive versions of the prototypes, thanks to Arduino UNO. CubeMate idea and physical design was inspired by the Weiser concept of Calm Computing. Indeed, CubeMate design focus on the Calmness, using a non-verbal output that doesn't overburden users' attention. On the other hand, the CubeMate idea was founded on the idea of proactive users, for a technology that enable people to do what they want in a best way. Between the two prototypes, we have chosen the prototype B, characterized by a self-explained interaction and the minimalist design.

On the occasion of the European Edition of Maker Faire Rome (October 2014) and the Elephant & Castle Mini Maker Faire 2014 (November 2014) we exposed the first four high-fidelity prototypes of CubeMate. During the fairs we have collected unstructured feedbacks and qualitative evaluations through a prototype trial. On the basis of these considerations we could identify some physical and technological improvements. Furthermore we could define several and cross application fields, from communication aid for autistic people and linguistic impairments, to sentiment analysis for customer satisfaction.

In the Interaction Design process applied, iteration through the four activities is inevitable and indispensable. So the CubeMate design process is to be understood still in progress. Thanks to the evaluation phase, it is possible to deduce many potentialities depending on the context of use and the application field. But first of all, it will be central to test usability in the designed contexts of use (house, office, shared flat) to ascertain our initial hypothesis that CubeMate could improves general communication reinforcing empathy through nonverbal cues.

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