Telebeads: Social Network Mnemonics for Teenagers

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ABSTRACT
This article presents the design of *Telebeads*, a conceptual exploration of mobile mnemonic artefacts. Developed together with five 10-14 year olds across two participatory design sessions, we address the problem of social network massification by allowing teenagers to link individuals or groups with wearable objects such as handmade jewelery. We propose different concepts and scenarios using mixed-reality mobile interactions to augment crafted artefacts and describe a working prototype of a bluetooth luminous ring. We also discuss what such *communication appliances* may offer in the future with respect to interperception, experience networks and creativity analysis.

ACM Author Keywords
awareness, communication appliance, crafts, creativity, mixed reality, social networks, tangible interfaces, wearable interfaces, synaesthesia.

ACM Classification Keywords
H5.m. Information interfaces and presentation, H1.b. Artificial, augmented, and virtual realities

INTRODUCTION
Teenagers have proven to be adept early adopters of new communication technologies, changing telephone use in the 1950s [5], electronic mail in the 1980's [49], and more recently, text and instant messaging and blogging [24, 18]. The rapid evolution of mobile and handheld devices has provided a variety of new opportunities for teens to communicate, allowing them to mix face-to-face and remote interactions and express themselves via diverse media. A teen chatting to her boyfriend may send their photo to a girlfriend, post a note on a blog or website or save the photo in a family album.

The social protocols associated with these communication devices are changing too: teens often exchange email and MSN addresses with acquaintances, multiplying the number of social groups to which they belong. These networks represent different relationships, from intimate social networks [6] of family and close friends to weak ties [16] with people they meet briefly. As a consequence, social communities' networks are huge [10].

Increased network size and complexity across devices creates problems for social interaction and for memory. Big screen solutions such as node-link graphs [19] don't scale down well to small screens, even when they do, users are forced to focus much of their attention away from co-present people and focus on the device, as in the Blackberry prayer [39]. We need an alternative strategy that helps people to better remember and keep track of these increasingly large and complex nets.

We have chosen to explore a simpler solution, more suited to a teenage lifestyle: interactive *telebeads*. Their form-factor allows 'crafting' [11] and symbolic exchange. As electronic devices, they can be creatively reconfigured and personalized to reflect their local rituals and social protocols [46]. Teens can create simple associations between a physical object, the telebead, and individuals or groups in the group. Beads may be collected and exchanged as souvenirs of a person or event, and later act as a mnemonic for keeping track of members of a particular social network.

This paper describes our exploration of *telebeads*, a mixed-reality communication appliance [30] that combines electronic beads with a mobile phone-based interface. We begin with a discussion of related work, followed by a description of two participatory design sessions we held with 10-14 year olds. We then describe a series of early prototypes that implement their ideas and discuss the perspectives of these emergent devices and related practices. We conclude with suggestions for future research.*

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RELATED WORK

Wearable computing

Research in wearable computing has expanded rapidly over the past twenty years. Early work focused on augmented glasses [15], in which the user sees both images of the real world and superimposed computer-generated images. Steve Mann's [33] research used not only augmented goggles, but various other pieces of clothing in an attempt to have access to the full power of his desktop computing environment in a mobile, networked form. Later work moved to other parts of the body, such as Matias' [34] 'wrist computer', and the personal area network [51].

We are particularly interested in a subcategory of wearable computing, i.e. that designed to be worn as jewellery. Here, the goal is not to replace the functionality of a desktop computer but rather to offer limited functions that the user finds entertaining and aesthetically pleasing. For example, *Staying Cool* and *Digital Mood Ring* [36] turn somatic information such as heart rate, body temperature and galvanic skin response into lights and sounds. The Blazer [29] is a soft, light-emitting, bracelet that takes advantage of human uses persistence-of-vision to compose shapes in the air as users move their arms.

Other researchers have focused on allowing users to create their own programmable jewellery. For example, *CodaChrome* [12] lets children create their own 'electro-jewels', allowing them to program their own interactive, animated color patterns using tricolor LEDs. Eisenberg and his colleagues [13] take a strong craft-oriented approach: users need not program on a computer but instead assemble parts from basic electronics and jewellery-making materials.

For example, children can use such materials to design *ejewels* [48] with lights that glow, flash, and change color. With *Quilt snaps* [11] Buechley lets children sew working electronic circuits into clothing and accessories, using conductive fabrics and electronic thread. Eisenberg and colleagues are exploring the use of 3d printing [13] as a resource for designing jewellery.

However, few projects have explored the communication possibilities of digital jewellery. An exception is the BabbleBauble project [47], although users must still configure it with software on a desktop computer. The BuddyBeads system [27] also explores remote techno-jewellery but is still a concept prototype. Mobile telephone manufacturers are moving into this area as well. Yet, devices such as Nokia's *Medallion* [38] still cannot communicate in real time with the network and use instead an infrared asynchronous protocol. We feel that adding communication functionality to jewelry is a promising new area in the domain of wearable computing.

Communication appliances

Another related research area concerns domestic technologies. Although most work is focused on entertainment and applications that bring broadcast information into the home, our emphasis has been on interconnecting family members. In the context of the *interLiving* project [23], a 3-year longitudinal participatory design project with distributed French and Swedish families, we developed a range of *communication appliances* [30,22].

Designed as extremely simple, single-function devices, they allow close friends and family members to stay in touch, by exchanging a variety of media (text, graphics, video, images, sound, etc.) over a continuously available link. For example, the videoProbe takes snapshots when there is no motion for 3 seconds, the messageProbe allows users to leave post-it note like messages with each other, Tok-i-Tok lets participants communicate simply by making knocking sounds, and the MirrorSpace [30, 42] blurs superimposed video images of local and remote participants according to a proximity sensor, allowing them to control the clarity of the image by moving forward and backward in space.

Other research in this domain includes devices for couples to communicate via a single bit [26] or causing a remote feather to float in the air when the remote partner arrives [45]. The Aura system detects rapid eye movement that occurs in sleeping and sends them to a musical box to let distant couple stay in touch over a distance [35]. The Casy system [52] is a system to increase connectedness between children and their distributed family that uses pillows and picture frames.

Other research has targeted local communication for enhancing social networking. For example, participants in a meeting can use *memeTag* [9] to beam short text sentences (64 characters) to each other in a social network meeting. The *iBand* [25] adapted this interaction to handshake. However, few communication appliances have been designed for or by children or teenagers. The next section describes our participatory design of telebeads with four young teens.

PARTICIPATORY DESIGN STUDIES

We are interested in user-created electronic jewelry that teens can use as mobile communication appliances to stay in touch. Our design goal is to make it easy for teens to create, modify and share this jewelry, as a way to communicate with others across and within different social circles. Ideally, teens should be able to create their own styles and fashions and develop new ways of communicating with each other.

We conducted two participatory design workshops with pre-teens and teens. In each case, we interviewed them, brainstormed ideas with them for novel ways to communicate and helped them develop rapid prototypes of their ideas. Based on these ideas and our own, we developed a working prototype and several design prototypes.

Workshop 1: Electronic Sewing Kit

This first workshop explored the potential of fabric-based electronic circuits for creating electronic clothing. We worked with Nwanua Elumeze, from the University

of Colorado who showed three boys, aged 9 to 13, the electronic sewing kit he developed with Leah Buechley and Sue Hendrix. Each kit contains a patch of fabric, a fabric switch, two LEDs, a needle, conductive thread, and a battery attached to snaps.

Figure 1: LED lights up when bag is opened

We showed the boys videos of a previous workshop for teenage girls, in which they drew their own designs onto a fabric patch with fabric markers and then sewed the lights and switches on to create a simple, working series circuit. We asked the boys to select familiar objects and to augment them in a similar way, based on using the components of the sewing kit.

The design

One boy chose a personal item, a small bag. The other two chose an umbrella and a conference bag, which were viewed as 'destroyable'. None of the boys knew how to sew, so the first activity was to teach them how to work with a needle and thread. After several tries, they all succeeded in sewing a working circuit. Then each considered how they would like to enhance the item they had chosen. One boy decided to address the problem of illuminating the inside of his bag. He pointed out that it is normally too dark to see the small objects inside, such as coins. After several attempts, he was able to sew a switch onto the bag and use it to illuminate the interior with an LED (Figure 2c, 2d).

Figure 2: Electronic sewing kit elements and the interactive bag created created by the youngest participant

Another boy explained how useful it would be, when it was dark and raining, to be able to open your umbrella, turn a switch and illuminate the inside of the umbrella. He sewed a switch to the handle and began the process of sewing a series of lights to the inside of the umbrella fabric.

The third boy sewed a fabric switch to the inside of the bag handle. He explained that he wanted to be able to squeeze the switch and light up the bag when he wanted to be seen by his friends (Fig. 1c, 1d). This is a nice example of teen's desire to control the image they broadcast to others: when and how they are seen by others and whether it is subtle or flashy. This tension between intimacy and 'extimacy' is characteristic of teenagers, who must develop strategies for managing conflicting social desires. Solving these social paradoxes helps teens become more autonomous and develop their future adult selves.

Note the 'bracelets' that appear on the wrists of the boy in the upper images of Figure 2. These are elastic bands, usually used for tying back hair, that he has chosen to wear because they 'look cool'. After he wore one that he found, his friends gave him several more, in various colors. He wears them all now them as a statement of his individuality (although says he no longer remembers specifically who gave him which bands).

We were somewhat surprised to see how much the boys enjoyed sewing, which is normally considered an activity for girls. But they were pleased by their ability to craft new artefacts that they could control, with lights and switches and electronic circuits. They liked being able to construct a physical artefact that addressed a concrete problem, while simultaneously imagining various design ideas at a more abstract level. This tension illustrates the classic issues found in the constructionist literature [41].

WORKSHOP 2: MNEMONIC ARTEFACTS

Interview

We conducted several interviews of a 14-year old girl who visited our lab for a week as part of a school program. She had participated in many earlier participatory design workshops (conducted over a period of three years, when she was 10-12 years old) as part of the aforementioned interLiving project. When she was eleven, she prototyped an umbrella communication appliance. The idea was to link two umbrellas: If it were raining and she opened her umbrella and her friend opened *her* umbrella, the two would be automatically connected. They could then walk in the rain and talk to each other.

We were particularly interested in how she uses communication technologies to communicate with her friends and family. She is an active user of text messaging, instant messaging (IM) and email. She also uses blogs so she can "to add pictures to the text" and has created three blogs, each with a different profile. She avoids using the mobile phone for voice communication, except with her mother. She explains that this is partly due to the cost and partly because she

genuinely prefers instant messaging for communicating with her friends. Her relationship to her mother is very close and different than that with her friends. She says they both prefer voice for staying in touch.

She is very careful about giving out her mobile phone number, reserving it only for her family and a few close friends. However, she is keen to distribute her email address, even to people she does not know and has three email accounts that are linked to different instant messaging channels. Although she limits her use of the IM service on her phone, for cost reasons, she likes being able to carry all her email contacts with her (over 200 entries). Most of the messages she receives are sent to her from friends using their desktop computers. She finds typing messages on her mobile phone to be too slow for real-time communication, but often sends text messages in asynchronous mode.

Brainstorming

We were struck by the impressive number of contacts and identities that this teenager was able to manage. We decided to run a brainstorming session on the topic of social contact management. She was already familiar with several approaches, through her own use of Instant Messaging and email lists and address books. We also showed her *FamilyNet* [32], our own tangible interface for managing social networks. FamilyNet cards use RFID tags to record unique identifiers for individual groups, using public key encryption. She found the system to be very simple and efficient, and spontaneously described how she would use it in several situations in her own life. She proposed using a mobile phone as a card reader, perhaps with a slot like those for USB flash memory devices.

However, she viewed the size of the cards as a problem. She explained that she could not possibly carry all of her social contacts with her using the large cards. She would prefer the cards to be smaller and proposed micro-cards to minimize the space used. We referred back to an earlier discussion in which she explained that the bracelet she was wearing (Figure 3) had been given to her by a friend. She and her friend had made bracelets for each other and they each wore those bracelets as a sign of friendship and to remember the other person. We discussed making the cards the size of the beads on her bracelet and reoriented the brainstorming accordingly.

We discussed how to use these beads as objects that link a person (or group) to a device or medium. She proposed using different colors to link different people and discussed how useful it would be to link her friend via these beads.

Figure 3: FamilyNet cards, microcards, nanobeads, which can be worn on her bracelet

IntiMates and ExtiMates

We explored various ways of interacting with this networked bracelet. She was concerned with the issue of privacy: sometimes she would want to keep the fact that she had received messages secret from everyone else. In addition to color change and illumination, she suggested using vibrations for secret messages. This highlights a distinction in how teenagers want to broadcast their self images. Sometimes, they want everyone to see (as in the illuminated conference bag in workshop 1), at other times, they want to keep their messages secret except for one or two selected individuals. Building upon Ackerman's [1] *animates*, or animated 'mates' for children, we propose two additional categories: *intimates*, for intimate, discrete or secret communication, and *extimates*, external, public and group communication.

Visual Concept exploration

After the brainstorming session, we asked her to sketch several concept ideas and to give each a name. She called the first *mobile group card* ("la carte groupe mobile"), showing the microcard form factor she wanted for the FamilyNet interfaces. She then visualized the interaction between a person and a *vibrating ring* (Fig.4*)*. Different people are represented by different images and she wrote that "when somebody sends a signal to the ring, it vibrates". Although the arrows are shown as bi-directional, in the ring-to-person direction, the information is hidden and one cannot guess what is happening on the other side.

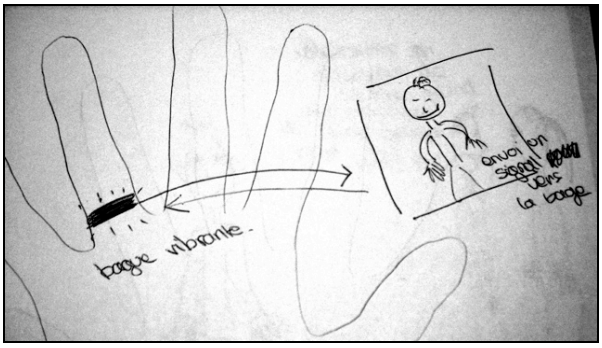

Figure 4: Vibrating ring

She illustrated the use of the *Digiblog* with a scenario (Fig. 6). She uses a microcard to publish a series of photos in her blog. After inserting a "blog card" into her digital camera, it adds a corresponding metatag to the picture file. Once a network connection is available (through wifi or a mobile phone), the digicam routes the file to the weblog service. In her scenario, the image is placed in a specific directory that she will browse while editing a text entry for her blog. The picture is not published automatically, but instead waits until there is a story into which it can be embedded.

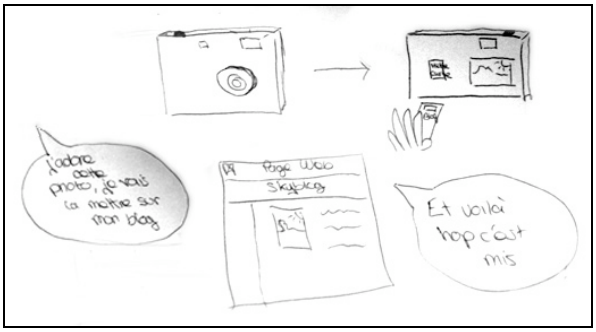

Figure 5: Digiblog

She used the above visual concepts to explain how the beads can be used not only as mnemonics but also as a communication appliance. We then realized that her beads may have a double function: representing a person while also acting as a communication medium. The third example also illustrates coordination with other devices popular among teenagers, such as digital cameras and mp3 players. She explains how to share a photograph with a friend's blog by putting a card in the proximity of the camera. The caption explains how simple and quick the interaction is and her scenario shows how a tangible object that represents a person may be used as a social pointer.

TELEBEAD PROTOTYPES

The participatory design sessions highlighted a primary issue that shaped our design explorations. We noted that teens are heavy users of social networks but often have difficulty managing all their contacts, especially as they include more and more acquaintances. How can we help teens remember whom they connected to?

For this, we turn to the concept of mnemonics, defined as devices used as an aid in remembering. The Greeks used various mnemonic strategies, such as the method of loci or Ars memoriae (art of memory) to remember long lists of related or independent items. Loci are physical locations or spatial connections that link unfamiliar information to a familiar set that can be easily recalled [50].

One way of using mnemonics in this context is the *body mnemonics* system [3], an interface design concept for portable devices that associates information to be recalled with the parts of one's own body. Ängeslevä proposes using an accelerometer to detect body gestures and a mobile phone to "position" this information onto the body.

We are working with a different use of mnemonics, in which we associate a physical *telebead* (Fig. 8) with a person or group of people in the network. *Telebeads* are natural mnemonics that can be exchanged and crafted into wearable jewelry. The next section describes our initial prototype, based on a luminous ring connected wireless to a mobile phone via bluetooth.

Proof-of-Concept 1: Bluetooth ring

The first *telebead* prototype took the form of a ring, with translucent plastic containing a surface-mounted LED connected via two isolated wires to a battery pack and a bluetooth headset (Fig. 6) that communicates wirelessly to a Linux-based PDA (or computer). The software uses the Bluez stack and the C/Python bluetooth server PyBluez [20]

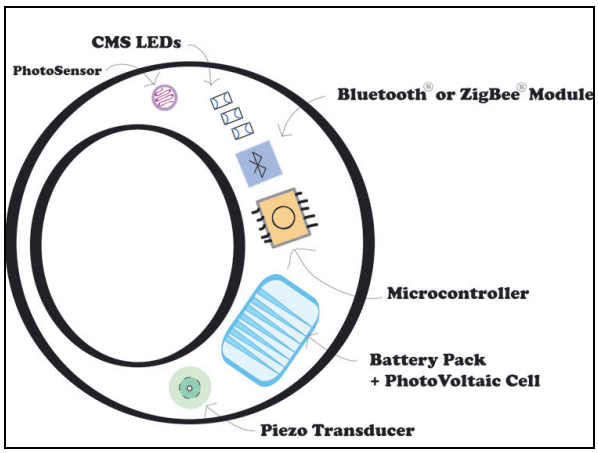

Figure 6: Illustration of telebead concept- Design View

The ring addresses two primary functions requested by the teens: providing a physical instantiation of a particular person in a wearable object and allowing direct communication with that person. The ring emits a unique signal which is recognized by the *telebead* software and associated with a corresponding bluetooth MAC address. The user can communicate by pressing a tiny switch located on the ring to send a signal pattern. The working prototype, shown in Fig. 7, acts only as a proof of concept, since it communicates only with the server for control commands and is too bulky for actual use.

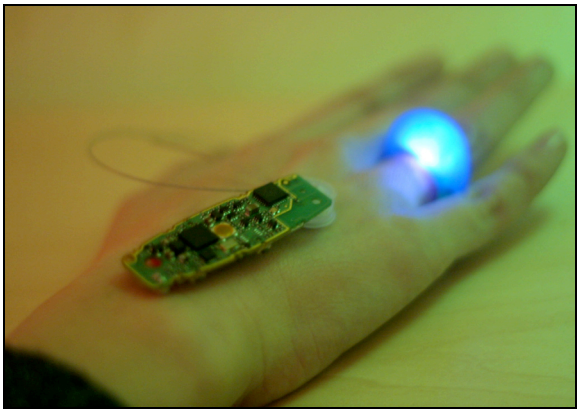

Figure 7: Bluetooth *telebead* ring

We have just completed an *ejabberd* server, running on Linux on a PDA, which will serve as a smaller, but more powerful *telebead* interface. We are also exploring additional media for communicating via the *telebeads*, including motion (using an accelerometer), heat detection and voice.

Commercially viable *telebeads* would require additional miniaturization that is beyond the scope of our research. However, the current prototypes are sufficient for us to explore the concept of a wearable, tangible social network. In the initial prototype, the ring was a single *telebead*. Future prototypes will allow us to string multiple beads together, creating not only traditional jewellery such as necklaces and bracelets, but also objects that can be sewn to articles of clothing, such as the straps on a pair of sandals or a bag.

Explorations of mixed reality mnemonics

One promising direction for future research is inspired by our earlier *a-book* [31] project in which a PDA acts as a physical *toolglass* [8] to create an interactive layer to paper laboratory notebooks. The system captures not only the handwriting on a page, but also the unique page number, a time-stamp and its precise location on the page and stores it in the PDA. When the PDA is moved over a particular physical page in the notebook, the system detects that page, displays it on the PDA's screen and superimposes associated information, including annotations, documents and active web links. From the user's perspective, moving the PDA's screen over the paper document is like looking through a transparent window at the document, but with the ability to interact with an additional layer of on-line information and links.

We are applying this concept to *telebeads*, using a phone equipped with a video camera to associate an image of the contact person to a *telebead* that represents her. The ring emits a unique pattern of light pulses (which are programmed in the microcontroller processing cycle) and is detected by the camera. Images of contacts are displayed on the PDA screen, either pre-existing images from the user's address book or perhaps a new image taken at that moment by the video camera.

The PDA acts as an interactive palette or *toolglass* whereas the ring serves as a pointer. Fig. 10 shows the user positioning her hand so that it points to the desired image on the screen. This bimanual manipulation of the ring and the PDA is very natural: positioning is easy and zooming is accomplished simply by increasing or decreasing the distance to the hand.

Figure 8: associating the ring and a contact image

Interaction techniques like drag 'n drop, which are already in their repertoire or easy to learn by imitation [10] can be extended to other devices that teenagers own. We can also consider *telebeads,* with their leds, as an alternative tangible interface to FamilyNet cards with RFID tags for interacting with *communication appliances*.

PERSPECTIVES

Our participatory design and prototyping sessions with users have led us to explore how best to help teenagers manage their growing lists of friends and acquaintances drawn from a variety of communication devices. Worn on the body as jewelry or sewn into clothing, *telebeads* provide a portable, aesthetically pleasing, highly modular interface for directly connecting to the people in on a contact list. However, they also serve as mnemonics, helping teens remember just who these people are and the context in which they met. For example, if I forget that a particular blue *telebead* was given to me by Susan at a party last month, I can either see her image when I place the PDA over that telebead, or else look up Susan in my contact list and identify the associated *telebead*.

As we move into a world with more and more devices offering a wider and wider range of communication possibilities, a number of interesting questions arise. We discuss here three concepts that help us think about the problem: interperception, experience networks and co-creativity analysis.

Interperception

Direct manipulation and focused interaction form the basis for most desktop computing interfaces. In contrast, *telebeads* or other tangible wearables allow a more subtle relation involving machines and humans. *Interperception* refers to the peripheral or even subliminal [7] awareness we have of each other and concepts such as media spaces, communication appliances and telebeads all build on this idea. As in the interaction concept, interperception puts the emphasis on the distributed and social aspects of computer-mediated human communication.

Experience networks

In contrast to abstract communication involved in interperception, Aoki's recent analysis [4] describes the figurative evolution of social networks: they envision experience sharing. Based on studies made on instant-messaging they show that textual communication often embeds visual narratives. In their view, communication should be seen as a fictional process where different media are sequenced in complex narrative structures. Similarly, we can change our conception of social networks, shifting to *experience networks* that could reap full benefit from advanced mnemonics systems to link media to people. Games are an interesting example of experience networks. According to Natkin [37], massively multiplayer online role-playing games are evolving in three directions: mass-media, ubigames and creative domains. If the three are combined, the emergent ludic artefacts will not be just in virtuality of the game, but also in the physicality of personal space. *Gameplay* will be extended by sharing real artefacts that embody complex properties: weapons, profiles, position, history, maps but also successful battles, action replay, machinima. In many ways, these elements reify the ludic experience. The players build, negotiate and share experience which adds in return a new perspective to the game. The game is then focused not only on social communication but also on artefact sharing as a ludic mechanism.

Co-Creativity analysis

Interperception and experience networks are complementary. They offer teenagers two different symbolic terrains: subjective and social. A device that simultaneously offers both characteristics may become a useulf creativity support tool [43]. Creativity research shows that innovative practices emerge at the border of individual and group spaces [17]. By analysing personal interperceptive patterns (quantitative) and experience networks (qualitative) we could explore an intriguing issue in creativity research: the genealogy of ideas. How do ideas emerge, evolve, and spread among individual and groups? In addition to research in creativity support tools, we propose to develop *creativity analysis tools* so as users could reflect on their innovative practices.

CONCLUSION

This article presents the design and modelling of *telebeads*, physical and digital objects that represent a individuals or a group. We discuss how mixed reality mnemonics use the body and objects on the body to facilitate the memorization of social. We conducted two participatory design sessions with teenagers and explored how and why they would use telebeads as personal communication appliances, so share information with remote friends and family. We describe the design of several telebead prototypes, including a bluetooth telebead ring and a PDA interface that acts as a 'magic lens' for creating and viewing social connections.

We are currently developing a new version of telebeads with smaller components, especially the bluetooth communication module. Our evaluations of the technology will explore memory issues related to this technique and compare telebeads to other types of social network mnemonics. Finally, we plan to observe the social patterns that emerge from the uses of these communication appliances in the context of creative activities.

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