Sticking Together: Handcrafting Personalized Communication Interfaces

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ABSTRACT

We present *I/O Stickers*, adhesive sensors and actuators that children can use to handcraft personalized remote communication interfaces. By attaching *I/O Stickers* to special wirelessly connected greeting cards, children can invent ways to communicate with long-distance loved ones. Children decorate these cards with their choice of craft materials, creatively expressing themselves while making a functioning interface. The low-bandwidth connections – simple actuators that change as the sensor stickers are manipulated – leave room not only to design the look and function of the card, but also to decide how to interpret the information transmitted. We aim to empower children to implement ideas that would otherwise require advanced electronics knowledge. In addition, we hope to support creative learning about communication and to make keeping in touch playful and meaningful. In this paper, we describe the design of the *I/O Stickers*, analyze a variety of artifacts children have created, and explore future directions for the toolkit.

Categories and Subject Descriptors

H.5 Information interfaces and presentation H.5.2 User interfaces: Theory and Methods

General Terms

Design, Experimentation, Human Factors

Keywords

remote communication, toolkits, paper computing

1. INTRODUCTION

Designers and technologists are actively developing new types of devices for people to connect to each other at a distance, with particular interest in the changing needs of young consumers. We wanted to open up this rich design space to the end users: what if children could invent their own communication interfaces?

This work presents the design and development of a remote communication construction kit consisting of wirelessly connected sensors and actuators embedded into stickers. These *I/O Stickers* enable children to create unique functioning communicating interfaces. An example of a possible *I/O Sticker* creation (a custom telegraph) is shown in Figure 1.

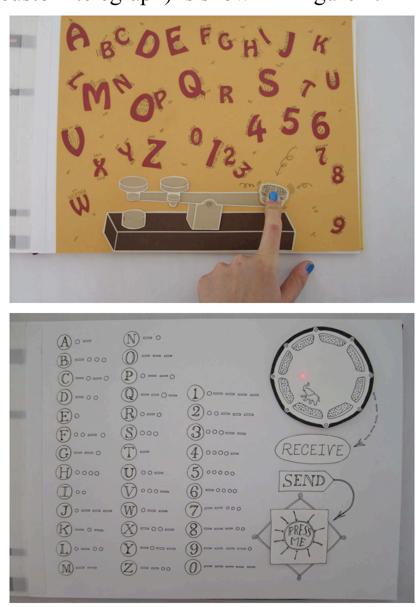


Figure 1. Example of two remotely connected *I/O Stickers* interfaces. As the user presses a sensor in one book, an LED lights up and a speaker buzzes in the remote book.

Our toolkit is motivated by the following goals:

- support creative expression with technology as a medium
- empower non-technical users to implement high-tech ideas
- enable personalized communication between loved ones
- promote reflection and discussion about keeping in touch

With this toolkit, children can use familiar craft techniques to add functioning electronics to an interface of their own invention, and use a variety of craft materials to personalize it. Simple sensor-actuator connections allow them to take ownership of the meaning of the communication through discussion and reflection prompted by inherently ambiguous messages. We hope that the ambiguous nature of the simple communication and the customizability of the medium will encourage children to creatively reflect and share in their area of interest - ranging from making interactive stories to designing secret communication protocols.

2. BACKGROUND

We situate the *I/O Stickers* toolkit between low-bandwidth remotely connected objects (or "phatic communication interfaces" [5]) and electronics construction kits.

There is a long history of research into communication interfaces that mediate intimacy and recreate the sense of presence that exists when people share the same physical space [2][8]. We argue that the most emotionally compelling interfaces in this genre are not those that most accurately replicate physical/spatial interactions, but those that fit specific users' communication needs the best. How then does one design an artifact for others to experience a sense of connectedness? A design paradigm that fits this goal is that of designing for ambiguity: creating interfaces that leave room for interpretation [4]. This is the motivation for using low-bandwidth connections: simple analog sensors connected to analog outputs, such as an LED or buzzing motor, with no built-in explanation or meaning. When the interface leaves space for interpretation, reflection and discussion about the meaning of messages becomes possible. An example of this idea is a study on the personal meanings users attributed to a simple shared button on a computer screen [6]. In this spirit, our toolkit is centered on the idea of letting kids invent their own connections and imbue them with meaning together.

In addition to supporting users in defining how the transmitted information should be interpreted, we also want to give them control over the design and function of the interface itself. Papert's theory of constructionism posits that learning happens most effectively when children are active participants in creating artifacts that they are personally invested in. Specifically, with LOGO he aimed to introduce "powerful ideas" of computing to children through hands-on creation [7]. Our toolkit supports that process by allowing children to create and customize their own functioning communication interfaces using their choice of craft materials. While our toolkit in its current stage is simple, the powerful ideas that might be explored with a remote communication construction kit range from the basics of electronics to concepts of computer networking and information transmission.

The *I/O Stickers* kit builds upon a number of construction kits for novice users, which consist of electronic components assembled into a ready-to-use kit so that users can focus on creating functioning electronic projects with minimal technical knowledge. Two examples are Lego Mindstorms and littleBits [1], both of which break down electronics into the most basic functions and encapsulate these functions into small, easy-to-connect blocks. However, both of these kits have rigid form factors that make them difficult to integrate with materials outside of the kit. Also, since the materials are limited, finished projects are often taken apart so that the components can be reused.

Toolkits that help users create permanent craft objects are the LilyPad Arduino and Teardrop [3]. These kits place electronics in a novel, creative context where users can make personalized electronic objects using traditional crafting techniques and materials. Studies of projects built using these toolkits show that the affordances of the medium result in very different types of creations than with traditional electronics, expanding the design space. Both LilyPad and Teardrop require the user to design the entire circuit, which is still a high barrier to entry for completely novice users.

3. THE I/O STICKERS TOOLKIT

The basic idea of the *I/O Stickers* is that users can place special electronic stickers onto contact points in pre-wired and preprogrammed pages, and the pages will transmit the state of the input (sensor) sticker to the corresponding remote output (actuator) sticker. For instance, a pressure sensor sticker varies the brightness of a light sticker at a distance as it is pressed.

3.1 I/O Stickers

Six types of stickers were constructed in this iteration of the project: switch, pressure sensor, light sensor, vibration motor, piezo speaker, and light-emitting diode. We relied on shape to differentiate input stickers from output stickers: input stickers have a round body and three tabs while output stickers have a square body and only two tabs (see Figure 2). The *I/O Stickers* were also designed so that they would blend in with the blank page, so as to influence resulting designs as little as possible and encourage customization, as shown in Figure 3.

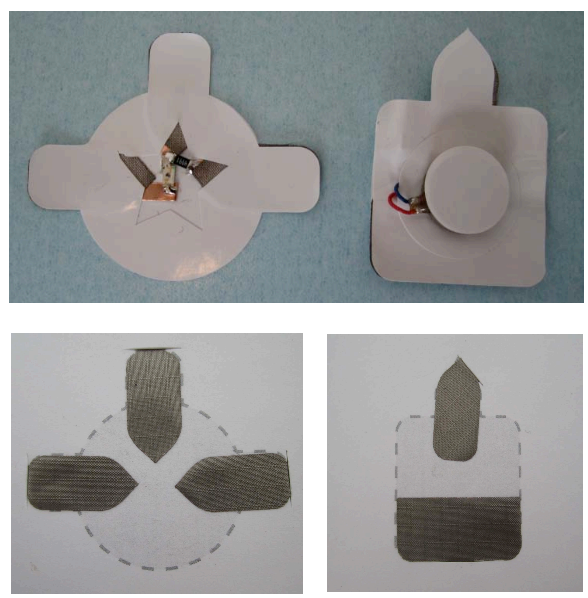


Figure 2: Input (left) and output (right) *I/O Stickers* and corresponding connection points

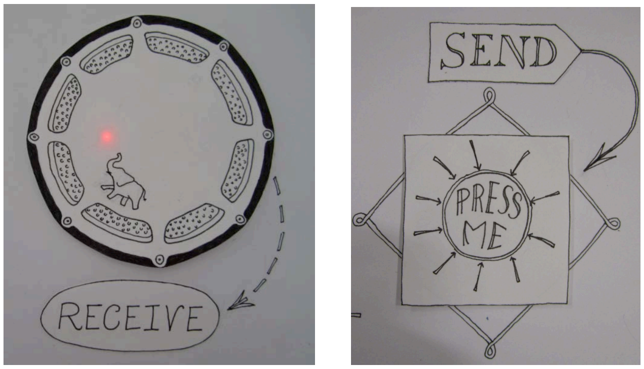


Figure 3: Decorated *I/O Stickers*

3.2 Pages

The pages with contact points for *I/O Stickers* come in the form of connected greeting cards: the *Tele-Postcard*s. To make the construction process feel as much as possible like crafting traditional greeting cards, we place all of the rigid circuitry onto separate base boards that the cards snap onto with small magnets. Only the sticker footprints and flexible circuitry need to be on the card, maintaining the look and feel of a paper greeting card.

3.3 Design Principles

*I/*O Stickers as a medium have all the affordances of traditional paper crafts in addition to electronic interactivity and long-distance communication. The flatness of the stickers makes them easy to incorporate other paper craft materials. The toolkit is designed to leverage skills that the users already have. Creating I/O stickers involves craft techniques that are familiar to most children, such as cutting, pasting and drawing. Stickers also feel replaceable enough to be used in permanent creations, and are already associated with collecting, sharing, and trading activities.

4. PILOT STUDY: TELE-POSTCARDS

4.1 Research Questions

The goal of our pilot study was to discover whether kids could understand and use *I/O Stickers* to produce personalized remote-communication interfaces, gauge their level of engagement, and discover what kinds of use cases they would come up with. With respect to the electronics, we wanted to ensure that the stickers clearly conveyed their functionality and mode of use. From a practical standpoint, getting the kit into the hands of children allowed us to test whether each sticker was robust enough to withstand multiple uses. Finally, we wanted to discover if the kit supported a wide range of creative styles, or whether anything in the design of the *I/O Stickers* constrained the projects.

4.2 Study Design

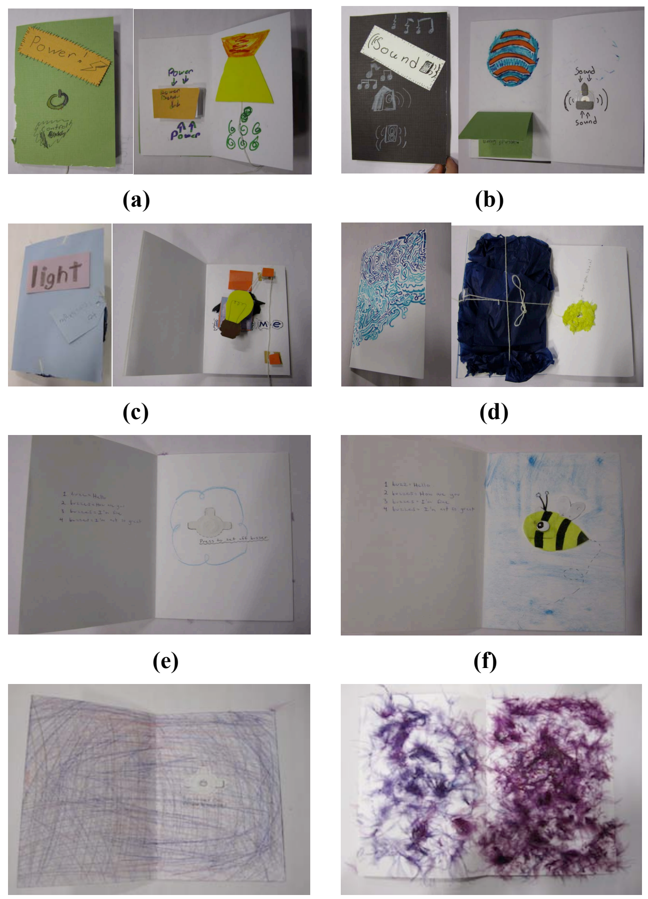
For the study, we chose to put one sensor and one actuator footprint on each page to keep interactions clear and simple as well as to leave enough blank space for personalizing the scene. Our pilot study group consisted of three girls and one boy, ages 10 to 12 years old - an age range we chose as an initial audience.

Each child was given the task of constructing two wirelessly-linked greeting cards, one to keep and the other card as a gift for someone they care about who is far away. The goal of this activity was to encourage kids to imagine how someone would react to the card when physically not present, and thus be thoughtful about the interaction and able to explain how the cards communicate.

We began the workshop by introducing the toolkit, demonstrating the functionality of the sensors and actuators. We then demonstrated how the stickers could be peeled off and replaced, to show that they could experiment until the right interaction was made. After the kids were comfortable with how each sticker worked, they were given time to make their own cards. The session lasted approximately two and a half hours.

4.3 Results of the I/O Stickers Workshop

Figure 4 shows the complete collection of cards that were created during the workshop, showcasing a wide variety of visual styles, communication ideas, and modes of interaction. We describe the cards and the building process in more detail below.



(a) (b) (c) (d) (e) (f) (g) (h)

Figure 4: Connected cards made during the *I/O Stickers* workshop. Input cards are on the left; their corresponding output cards are on the right.

The first pair of cards, made by the 10-year-old boy, focused on the function of the stickers. The cover of the input card was titled "power" for the on/off switch and the output card was titled "sound" for the speaker (Figure 4.a and 4.b. To clarify the interaction, he wrote a note explaining that when the speaker sounds, someone had pressed the "power" button on the other card (Figure 4.a). This participant also used standard electronics symbols such as the "power" symbol and arcs to signify sound.

The next pair of cards was made by a 12-year-old girl who was interested in pop-up mechanisms. She built a box and pulley system around the light sensor so that when the string is pulled, the top of the box opens and exposes the sensor to light, thus transforming the light sensor into a mechanical switch. With the idea of gift in mind, she decorated the output card with a gift tag and a package of tissue paper tied with string (Figure 4.c and 4.d).

The next participant, a 12-year old girl, created a simple communication protocol using a button on one card and a vibration motor on the other. She defined meanings for a certain number of buzzes of the vibration motor (see Figure 4.e and 4.f). She wrote this code out on both the input and output card. The information she put on the cards would be enough so that if she gave away either card, the person she gave it to would have the information he or she needed to communicate.

The last participant, a 12 year old girl, decided to make her card for a friend who had moved away. She used a switch on one card and an LED on the other (see Figure 7.g and 7.h). She decorated both in purple, covering the LED in snipped pieces of feathers to "spread the light out" (diffuse the LED light). This girl was very interested in how the electronics worked. She asked about how the boards communicated with each other, wanted to know about the circuit, and took a pressure sensor sticker apart to investigate.

4.4 Analysis

4.4.1 What Worked Well

We found that overall the form factor was easy to understand and facilitated a very diverse range of projects. The children felt comfortable covering the stickers completely with their own art. The stickers did not appear to be difficult to manipulate. Several children wanted to change their chosen stickers at some point during the workshop either to change their design or debug, and were able to successfully peel them off and change them. They also appeared to feel comfortable using as many stickers as they needed, going as far as taking one apart to see what was inside. All four children created a very different card and were able to focus on different aspects of communication or craft.

4.4.2 Room for Improvement

To at least one of the children, it was not initially clear that there were two types of stickers (this child tried to stick an actuator on a sensor footprint). Also, the stickers only functioned when there was a good mechanical contact between the sticker and the page and the interface lacked immediate feedback while crafting, so there were occasional connection problems.

5. FUTURE WORK

After incorporating the interface improvements we uncovered in the pilot study, we plan to implement data transmission over the internet so that the cards can be connected at arbitrary distances. This will enable us to truly study how the crafted objects are used and whether they successfully help long-distance loved ones stay in touch.

One potential future impact of our toolkit is to introduce STEM concepts - in other words, "powerful ideas - in an accessible way and with immediate real-life applications. Towards this goal, we will explore the idea of a programming environment for children to manipulate the streams of data between the books in real time, adding delays, filters, conditions, broadcasts, etc. This will enable both increased control over the custom communication devices and more opportunities for learning high-level concepts.

Another promising STEM learning application for this kit is the electronics themselves. Given our desire to elucidate as much as possible and the study participants' interest in learning more, we plan to evaluate the stickers as a material for teaching more complex electronics and circuitry, explain the construction process and make it possible for users to design their own stickers.

6. CONCLUSION

We designed the I/O Stickers toolkit hoping that children would be able to express themselves by creating their own functioning remote communication interfaces. Participants in our pilot study indeed did so, and surprised us with personal, beautiful, and unexpected creations. We found that the 10-12 year olds in our study were highly engaged, had many ideas, and were even interested in learning more about the construction of the kit itself.

We have not yet tested the I/O Stickers creations "in the wild." When they had finished inventing and customizing their communication interfaces, the children who helped test the toolkit really wanted to share and use them; this is both a validation of the work so far and an impetus for further work.

7. ACKNOWLEDGMENTS

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