Empathy Objects: Robotic Devices as Conversation Companions

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Abstract
We present the notion of Empathy Objects, ambient robotic devices accompanying human-human interaction. Empathy Objects respond to human behavior using physical gestures as nonverbal expressions of their "emotional states". The goal is to increase people's self-awareness to the emotional state of others, leading to behavior change. We demonstrate an Empathy Object prototype, Kip1, a conversation companion designed to promote non-aggressive conversation between people.

Author Keywords
Tangible interfaces; social robots; behavior change; companion devices; ambient devices.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
When people interact, they are often unaware or only partially aware of the effect their behavior has on others. To address this issue, we propose the notion of *Empathy Objects*: Interactive robotic devices that reflect aspects of the human-human interaction around them, in real-time, through subtle physical gestures.

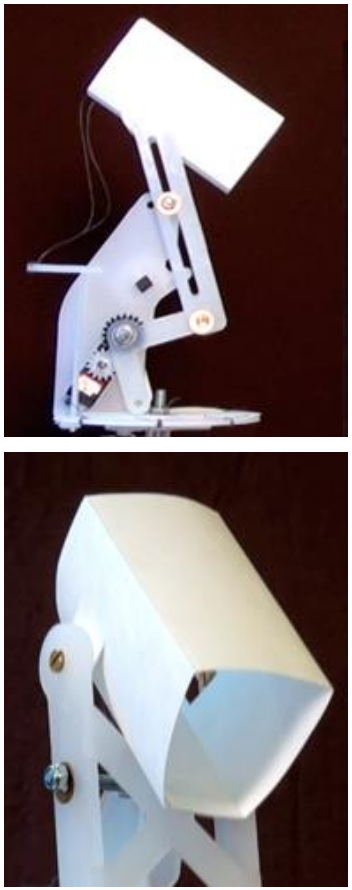

Figure 1. Kip1 our first Empathy Object, shown in a cowering position indicating fear by lowering its "head".

Empathy Objects differ from much of human-computer and human-robot interaction, which is concerned with either the direct interaction between people and technology, or with the technology serving as a communication medium between humans. In contrast, Empathy Objects are designed to peripherally supplement human face-to-face interaction. They are built to subtly influence and enhance it, rather than replace it, mediate it, or distract from it. Empathy Objects thus can also be thought of as a kind of embodied ambient interface for multiple co-located interacting users.

We exemplify our notion of Empathy Objects by presenting the Kip1 prototype. Kip1 is a robotic object listening in on people's conversation. Kip1 was designed to promote calm, non-aggressive conversation between people. The robotic object is designed as a small desktop structure, reminiscent of a lamp (Fig. 1).

When a conversation is taking place near Kip1, it monitors the nonverbal content of the conversation, e.g., speech timing, silences, and loudness. Kip1 tracks the conversation state, and maintains an internal emotional model of its reaction to the conversation. This internal state is then reflected using physical gestures, designed to evoke empathy among the human conversants and hopefully promote a change in their conversation style.

Kip1 exemplifies Shaer and Hornecker's TUI principle of "providing tangible representation to digital information" [18]. The robot's physical gestures are tangible representations of its emotional model, which is the digital information reflecting the conversation happening around the device. Kip1 also follows the Objects for Change [22] principles of implementing established behavior change techniques in the design of a TUI device.

In our first implementation, Kip1 tracks speaking vs. silent segments, and the ongoing and incidental loudness of the conversants. If there is no ongoing conversation, Kip1 is in a calm state, indicated by slow, deep "breathing" gestures. If an ongoing conversation is at a medium or soft level, Kip1 gradually shows curious interest by stretching upwards. If, however, the conversation becomes too loud—interpreted as aggression—Kip1 retracts into a cowering position and indicates fear by shivering and lowering its "head" towards the ground.

Related Work

Kip1 can be thought of simultaneously as an ambient kinetic tangible, a socially expressive robot, and a conversation monitoring interface, and thus relates to these three domains.

Ambient interfaces and kinetic tangibles

Ambient interfaces use visual and auditory cues designed to be processed at the periphery or "background of awareness" [12]. AmbientROOM, for example, is an architectural space displaying data via simulated ripples of water or light patches [12]. In the Water Lamp and Pinwheels projects, subtle changes in light, sound, and movement represent digital information in an ambient way [5]. While AmbientROOM and Water Lamp use projection of light, Pinwheels uses tangible representation, made of folding fiberglass and small motors, mapping digital information to physical motion, thus being a "kinetic tangible". Kip1 continues this tradition, but in addition

monitors real-time local information. For a review of "kinetic tangibles" from the early Pinwheels to recent work, see: Ishii *et al.* [13].

Robotic nonverbal expressions of emotional state
Socially interactive robots use both verbal and nonverbal channels in order to express their emotional state. In fact, Fong *et al.* describe the capability to express emotions as one of the indicators of socially interactive robots [7]. In anthropomorphic robots, facial expressions are often used to express emotions, either on a screen [8, 16] or using actuated facial features [1, 4, 15]. Robots that do not have an expressive face or are non-anthropomorphic can use gestures to express emotions [2, 10]. For some robots that have no social articulation at all, such as flying robots, path planning has been used to express emotions [19]. These systems are used either for direct human-robot interaction, or for entertainment robotics. Our work differs as we use the robot's nonverbal expression as an ambient companion to human-human interaction.

Technology mediated conversation
Prior work in technologies that mediate conversation are usually screen based technologies. DiMicco *et al.* used a shared display in a group interaction, showing how much each participant contributed to the conversation [6]. A similar study by Bergstrom and Karahalios used a "conversation clock" screen that visualized the time each participant talked [3]. In contrast, our system does not use screens, but ambient embodied gestures, a tangible modality.

The Kip1 Prototype: System Design

From a technical point of view, Kip1 is a two degree-of-freedom robotic object using a smartphone as its main sensing and computing hardware [9]. A IOIO microcontroller board links the smartphone to two servo motors, driving a number of mechanical linkages designed to express the robot's gestures. In order to maintain the focus of Kip1's users on each other, our design process refrained from using screens as part of the interaction paradigm. Kip1 is similar to some other recent desktop robots that use mobile devices as their sensor and processing platform [9, 14]. Usually the screen shows expressive face-like features and animations, or displays text. We made the design decision to express all feedback through physical gestures alone. This was based on the consideration that to support direct human-human interaction, physical gestures are less distracting than screens. Also, if our aim is a gentle nudge towards behavior change, gestures can play a more subtle role than on-screen information. Finally, as Kip1 is supposed to be in the background, embodied spatial movement is more easily read in peripheral view than on-screen feedback.

The smartphone runs a single application, constantly recording real-time audio and measuring the volume of the audio coming in. It then compares this audio with a baseline room-level and generates a conversation state and resulting emotional model, both in the form of finite state machines. The FSMs are connected to the volume detection subsystem and to each other. The conversation states include SILENCE, STARTED, and ONGOING. The emotional model includes CALM, CURIOUS, and SCARED. The emotional model drives a gesture control system, which triggers gestures, including breathing, stretching, contracting and shivering. This is achieved using a layering of ongoing and one-off parametric motor plans. A full technical

description of the robot is detailed in a separate publication.

Usage scenarios

Designing Kip1, we considered various usage scenarios.

Couple's scenario: Couples at home can sometimes get into aggressive communication patterns. Kip1 could be placed in a strategic location around the house, where most of the discussions are taking place. It would constantly monitor ongoing conversations, and when a conversation starts, the "breathing" animation will change to the "curious/interested" gesture, encouraging the couple to talk more to each other. If a conversation is interpreted as "aggressive", Kip1 will retract and shiver, hopefully influencing the couple to change their communication style.

School scenario: In classrooms, both teachers and students are prone to raise their voices, many times unconsciously. Kip1 in a classroom can serve as an objective "referee", reacting to loud voices of both teacher and students, helping both sides increase their awareness to their tone, and setting the ground for mutual responsibility and goal-setting towards a more "volume-controlled" classroom.

Mediation scenario: In mediation sessions, two parties meet in order to resolve a known conflict. Conversation tones and loudness has a strong effect on the other party in such situations, and an escalation may occur at any moment. Kip1 in a mediation session's room can serve as an emotion regulation or "temper regulation" device that objectively maps the temper level in the room, and influences both parties to be more aware to the consequences of their tone.

Future Directions

Kip1 is our first prototype illustrating the Empathy Object concept. Future Empathy Objects will extend current work along these four dimensions:

Interaction and affordance design

Our current implementation of Kip1 is highly focused on one aspect of TUI, providing a tangible representation to digital information, but it does not enable direct physical manipulation. A future version could enable gentle physical manipulation of Kip1 to gradually shift its emotional state (e.g., from scared to calm). This builds on Ishii *et al.*'s idea that "dynamic changes of physical form can be reflected in digital states, and vice versa" [13].

Behavior change research

With respect to Norman's *experiential* and *reflective* modes of cognition [17], we want to evaluate if our affordance design is able to promote a shift towards reflective cognition. Keeping a balance between effective affordances and reflection is not easy, as "inviting affordances and tight mappings tend to discourage reflection" [11].

Reactive materials

Another direction in which we plan to extend our current work is in the reactive properties of Empathy Objects. Inspired by Ishii *et al.*'s Radical Atoms [13] we plan to explore the implementation and integration of combined mechanisms and materials that could affect a stronger emotional reaction among users. We intend to explore materials such as soft textiles, rubber, paper or foams and combining them with new embedded mechanical structures.

Conversation analysis capabilities
In order to pick up on more complex vocalic cues, we are now working to analyze pitch together with loudness to categorize vocal affect. Past work has successfully been able to classify vocal affect in deliberate and spontaneous speech [20, 21]. Combining speech duration patterns with vocal affect could deliver more precise detection of aggressive speaking behavior and thus more expressive feedback.

Future scenarios
Building on the abovementioned extension to our current work, we envision a broader range of human-human situations Empathy Objects can accompany:

Business meeting scenario: A business-focused example is a meeting room discussion. An Empathy Object in a meeting room can listen to the ongoing conversation and track the speakers. The object could subtly cue "stage takers" that they are talking too much, and encourage reserved speakers to speak up.

Teen chat scenario: A group of teen friends meeting at home to socialize. During their chat, an Empathy Object can listen to the conversation and mirror the emotions it recognize. The Empathy Object can help less social people feel more socially accepted by reacting to their participation or mirroring it, promoting a feeling of social bonding.

Additional future scenarios may include interactions between parents and children, dating, negotiations, and more.

Conclusion

We presented the notion of Empathy Objects: a combination of interactive objects and robotic companions aimed to support human-human interaction. We introduced our first Empathy Object prototype, Kip1, a conversation companion designed to promote non-aggressive conversation between people. We presented a future vision of Empathy Objects as part of human-human interaction at home and at work.

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