From Breakage to Icebreaker: Inspiration for Designing Technological Support for Human-Human Interaction

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ABSTRACT
This paper explores why and how accidental breakage of technologies can promote humans to interact and ultimately lead to positive behavioral, emotional, and relational change. Through a set of research activities, including meta-synthesis of daily anecdotes, design workshops, and a case study, we gain insights into what may hinder or trigger human-human communication, and propose the conceptual and actionable process of Breakage-to-Icebreaker (B2I) design. Instead of intentionally breaking a technology, B2I design embeds mechanisms into existing products and services, creating opportunities for users to interpersonally interact online and/or offline while enjoying the original features and functionalities. Finally, we envision a broader and extended use of B2I thinking in everyday design research and practices.

Author Keywords
Breakage; icebreaker; human-human interaction.

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

INTRODUCTION
Pervasive use of information, communication, and mobile technologies enables people to build more connections and constantly stay connected [50]. However, the interpersonal relationship formed in the information age is typically shallower [36] with greater emotional distance [27]. In this paper, we draw insights from how accidental breakage of technologies improve interpersonal interaction, and propose a different thinking and tactics for designing support of human-human communication.

Despite the increased size and diversity of their social network [50], more and more people felt that they could not find anyone to discuss important matters with [25]. Prior research has shown that always remaining plugged erodes the quantity and quality of conventional offline human-human interactions [39]. A survey in 2013 suggested that 61% of people tended to keep checking emails, sending messages, and making calls after work – even when they are on vacation [10]. This not only cuts short their time with family and friends, but also makes them persistently stressed about other things during offline social interactions [1]. Although computer-supported cooperative work (CSCW) and computer-meditated communication (CMC) tools e.g., email, video / audio conferencing, and social media allow users to socialize beyond the constraints of space and time [22], they are a leaner means of communication compared to talking face-to-face [9]. The varying availabilities of social cues and degrees of responsiveness in CMC give rise to different depths in online relationships, some being more random, short-lived, impersonal, and superficial than the others [4, 48, 49].

Many researchers and practitioners have attempted to stimulate and foster online as well as offline interpersonal interactions by improving or inventing technologies, from social media (e.g., [41]), tangible interfaces (e.g., [19]), mobile applications (e.g., [45]), to public displays (e.g., [24]). These systems mainly emphasized on creating new channels or props for people to interact, such as providing richer media [19], prompting topics [24], and suggesting conversational partners [45]. Existing research has suggested that, without adequate motivation, people are reluctant to leave their comfort zone and take the desirable actions [14]. Therefore, the strength and endurance of the effects of these technological methods on supporting human-human interactions are yet to be studied.

On the contrary, some people have experimented with a different, "unplug" approach – physically or conceptually detaching heavy users of technology from all of their media devices to force them to socialize in person – in research [26] as well as in real life [44]. The "Phone Stack" game at dinner tables is one of such tactics [44]. In a broader sense, we might all have experienced in everyday life that some unintended breakage of technology leads to an unexpected breakthrough in social relationship. For example, control-swapped thermostats installed in two neighboring flats can increase the residents' chance of hanging out together, as they have to help adjust each other's room temperature. By breakage we mean accidental **functional, usability, or user experience breakdown**, e.g., no battery, unstable Internet collection, non-legible interface, or misleading appearance.

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Note that we define breakage rather broadly. In some cases, the technology is intact, but users have a bad experience due to the context. Although breakage of technology may only be temporary, it may lead to enduring improvement on interpersonal relationship. This raises the question whether the underlying mechanisms that turn a broken technology into an icebreaker can be applied to design positive experiences with technology, which sounds like a paradox.

Extending James Pierce's framework of undesigning technology [35], we explore how to transfer insights from breakage of technology to thoughtful design of technology, particularly for **restoring, reinforcing, or promoting online and offline interpersonal communication** in the scope of this paper. We refer to this process as *Breakage-to-Icebreaker (B2I) design*, i.e., **embedding icebreaking mechanisms into existing products and services to create opportunities for users to interact and reflect while enjoying the original functionalities**. Note that although such mechanisms are inspired by abnormal, inconvenient, or uncomfortable experiences with a technology, our aim is not to reproduce such defects. Different from conventional affirmative designs that invent dedicated CMC systems, B2I design can use any technology as design materials. It encourages a novel way to view machines' role in mediating interpersonal interaction – a concern of the 3rd paradigm of Human-Computer Interaction (HCI) [18, 6].

Though breakage of technology in daily life is accidental and probably not repeatable, it is worth investigating the underlying factors in order to design positive experiences with technology. We conducted assorted activities to explore the conceptual and actionable process and techniques for the B2I design that gives people a "ticket to talk" [37, 42], including 49 anecdote interviews, material-oriented and goal-oriented design workshops with eight designers, and a case study. By analyzing the materials generated in these activities, we identified attributes of the potential user groups and scenarios, types of products and services that can serve as design materials, inhibitors and motivators of human interaction, effective icebreaking methods, and evaluation rubrics of design outcome. We further propose a set of design considerations and envision the use of B2I design in a broader context. The main contributions of this paper include:

1. We explore the design of technology to support online and offline human-human interaction based on insights drawn from examples of breakage of technology that accidentally serve the purpose in daily life.
2. We experiment with material-oriented (i.e., reshaping a given technology to reach a desirable state) and goal-oriented design (i.e., fulfilling a given goal by exploiting any existing technology) through two design workshops.
3. We evaluate, through a case study, a proposed conceptual and actionable process of B2I design of human-human interaction technologies derived from the meta-synthesis of anecdotes and the two design workshops.

RELATED WORK

In this section, we review existing use of technology to assist human-human interaction, and the movement of recycling, reusing, and repurposing a design.

Technological Support for Human-Human Interactions

Whether technologies benefit or impair interpersonal relationship remains controversial [25, 17]. Some early research indicated that lacking non-verbal cues in CMC may result in less social and emotional communication than face-to-face interactions [40]. In contrast, the hyperpersonal model proposed in [48] argues that CMC also evokes social and emotional exchange and is more socially desirable.

Leaving aside these debates, researchers and practitioners have affirmatively devised various technologies to foster interpersonal interactions. Examples of such intentionally introduced digital artifacts include intelligent interface for groups [19], gamified system to persuade personal contact [23], mobile applications to enhance sociality [45], and public displays to spur offline interaction [24]. However, there are occasions where "technological intervention results in more trouble or harm than the situation it's meant to address" [2], such as group dinner and family time [44].

Undesigning Technology

To address the above-mentioned situations, Pierce proposed the concept of undesigning technology, i.e., "intentional destruction, removal, or inhibition of an existing technology or the foreclosure of future technology" [35]. Undesigning technology is particularly feasible when the target activity does not necessary require the intervention of a digital or interactive technology, such as face-to-face meeting. However, when technology is a must-have component of the activity, whether it is to facilitate communication or for other purposes, could designers transfer the insights from breakage of technology to their design of positive utilization of technology? Our ultimate goal is to evoke reflection on and lasting improvement of interpersonal relationship rather than just faster, richer communication.

Recycle, Reuse, and Repurpose Everyday Design

The core concept of radically reshaping broken objects is somewhat different from the idea behind the research initiatives on designing repairable technologies, e.g., sustainable interface design [5, 30]. B2I design focuses more on transforming the essence of a technology according to the context in which it is used [31]. It attempts to leverage relationship-promoting properties uncovered in breakage that may be conventionally disfavored by the Human-Computer Interaction (HCI) community to evoke positive behaviors, experiences, and reflections. For example, Gaver et al. argued that ambiguity can facilitate designing for appropriation [15]. Dunne advocated for design with defamiliarization to bring in new perspectives [13]. Odom et al. showed that slowness can provoke reflection on relationship with domestic technology [31].

We seek to embed icebreaking mechanisms into existing products or services rather than intentionally re-creating technologies with flaws or troublesome situations (unlike [20]). Similar to the concept of everyday design introduced by Wakkary et al. [47], B2I design acquires the resourceful surroundings as design material for alternative use [30, 33, 20] – supporting interpersonal interaction. The mechanisms may be counterintuitive [36], but we try to maintain and leverage the ordinary functionality of the design materials.

In the rest of the paper, we present three activities that we conducted to extract insights of B2I design. First, we collect and analyze anecdotes in daily life about how unintentional breakage of technology triggers human-human interaction. Then, we describe two design workshops and a case study to evaluate the transfer of knowledge. We also derive a set of implications for future B2I design in a general setting.

LEARNING FROM EXPERIENCES: ANECDOTE STUDY

To gain an in-depth understanding of how a broken technology may turn into an icebreaker, we followed Wright and McCarthy's method [51] and engaged users and designers in dialogues centered on their experiences related to this phenomenon. More specifically, we collect and analyze 49 anecdotes from ordinary information technology users to gather concrete examples of participants, technologies, events, situations, thoughts, and feelings related to B2I incidents in daily life. These anecdotes contain rich information that might inspire and help communicate thinking behind the designs.

Method

In order to better guide the story-telling process, instead of having participants fill out questionnaires, we had conversations with them in person, either face-to-face or online. We first asked interviewees to recall their activities on a normal weekday especially with the use of a particular technology. This was a warm-up exercise for them to relax and get familiarized with recalling life stories. Later, we invited participants to share some personal memorable experience related to B2I. When participants finished eliciting their stories, we prompted them, through questions, to clarify and further elaborate on details concerning the context (e.g., time, place, original task), the broken technology, all parties involved, the actions and reactions, their emotional experiences during the process, the outcome and long-lasting effects (if any). We took notes and audio recorded the conversations which were transcribed into text.

Participants

We recruited participants through word-of-mouth and advertisement on various social media, e.g., Facebook, Weibo, and WeChat. We scheduled face-to-face, phone, or video interviews with 53 people who expressed interests in sharing past experiences with "some technical breakdown leading to the improvement of relationship with others."

Prior to the interview, we gathered basic demographic information from the 53 participants, among whom 31 were female, and 43% were in the age range of 18 and 25 (18% below 18, 28% in 26-35, 4% in 36-45, 5% in 46-55, and 2% above 55). These interviewees were regular information and communication technology users originally from 11 different countries and regions. Ten of them were high school students while the rest all had at least some college education in 15 different majors. The respondents' current occupation varied from student to faculty, engineer to designer, manager to official, and consultant to sport coach.

Data Processing

We extracted a total of 49 anecdotes. We excluded stories that were either with no technology directly involved or the final outcome of which had no strong association with human interaction. Below are some selected anecdotes.

A1. My phone has no GPS signal and I have to use a paper map. → More people come up to ask if I need any help.
A2. When I was pregnant, I could not see the readings on the weight scale. → My husband always helped me with it. We chatted more about my pregnancy.
A3. The printer in our office is really slow. → People waiting for printouts by the machine get to chat a lot.
A4. I accidentally put my digital watch to power saving mode and it goes to sleep after an hour. → People cannot help coming up and asking me if the battery is out.
A5. Our company's reimbursement system is extremely hard to use. → The HRs form an online support group.
A6. The text input of my WeChat was broken and I had to use voice chat with a co-worker discussing an urgent issue. → We felt closer and became friends later.
A7. The air condition in our classroom was super cold one day. → The boys were gentleman enough to lend us their jackets, though we seldom talk to each other before.

Here, A6 showcases functional breakage, and A2 is an example of user experience breakdown due to special context. We used a mix of qualitative and quantitative methods to analyze the anecdote transcripts. The three authors collaboratively applied the grounded theory method [8] to explore the data. Through iterative comparison and integration, we compiled a set of analytical, relational categories to summarize insights from the B2I anecdotes:

- Relation (who): relationship among the participants
- Location (where): context of B2I incidents
- Attribution (why): type of breakage of technology
- Function (what): medium of interpersonal interaction
- Rationale (how): inhibitors of interpersonal interaction
- Sequence (how): triggers of interpersonal interaction
- Means-end I (mechanism): verbal approach
- Means-end II (mechanism): physical approach
- Cause and Effect I (consequence): emotional outcome
- Cause and Effect II (consequence): Relational outcome

We are aware of the potential culture differences, and thus conducted a descriptive statistical analysis to investigate the frequency of the different analytical categories among the 49 anecdotes from diverse interviewees. Note that a story may involve multiple factors in the same category.

Insights into Breakage-to-Icebreaker Design Process

Table 1 summarizes the grounded theory results from anecdote study and interviews. We present example quotes and percentage count for each of the 10 analytical categories. In this subsection, we share some insights into some essential factors of B2I design.

Understanding Target and Context for Embodied Interaction

Based on the stories and feedback from the respondents (Table 1), we learned that B2I occurs more frequently and is more effective among weak ties (93.9% of the anecdotes). These are relationships that people often ignore or are less motivated to maintain, including strangers (30.6%), familiar strangers [34] such as people working (36.7%) or living (6.1%) in the same building, as well as acquaintances such as classmates (8.2%) and not-so-close friends (18.4%). Unlike strong ties such as immediate family (2.0%) and significant other (4.1%), people are less likely to actively initiate social interactions with weak ties in person or via CMC tools. As one person put in his story, "*I never thought that this uncle (a distant relative) would care about me, so I rarely contacted him. (A23)*" Another respondent also commented "*Who talk to their neighbors these days? If it were not for the broken WiFi, I may never knock on the neighbor's door. (A19)*" However, there are still occasions when B2I can make a difference in close relationships which is more critical than connecting with a weak tie. One designer provided an example, "*It (B2I) can serve as a good excuse to resolve a fight with my girlfriend (A6).*"

Furthermore, designers should take the target relationship into consideration when selecting design materials that can provide embodied interactions naturally occurring "in real time and real space" [11]. One interviewee gave her explanation, "*If my own computer is broken, I am more inclined to bother a good friend. I will not grab a random person in the building to help me fix it, as it is personal. But if a public computer goes wrong, anyone who might use it could help, right? (A33)*" More specifically, we analyzed the cases collected and found that 82.5% the relationship breakthrough between weak ties were initiated by some problem of certain information technologies for public or shared use, e.g., smart coffee machine, public WiFi hotspot, administrative software, and online store. In other words, a B2I design can utilize interactive systems that already locate in a common hang out area of the target users, to benefit from their innate tangibility and sociality [11].

Identifying the Inhibitors and Possible Motivators

There are many barriers that prevent people from having more interactions with others. Our analysis of the anecdotes highlights six key reasons why people do not talk to each other (Table 1): 1) physical isolation (12.2%); 2) social isolation (28.6%); 3) technological isolation (12.2%); 4) social awkwardness (20.5%); 5) social inappropriateness (16.3%); and 6) emotional indifference (10.2%). For instance, a female high school student commented that, "*A typical boy girl thing. We sit separately and mostly hang out with those of the same gender. What's worse, these boys are not cute enough and don't know how to speak to a girl in a good manner. Some are just too shy (A42).*"

The interviewees also shared some insights into what may force them to cross the interaction barrier. Urgency (22.4%) and inconvenience (20.4%) are both effective motivators for strong and weak ties, and the former is timelier. "*I was not so familiar with that guy, and normally we do not communicate via voice message. It's a little awkward. But I was very anxious to get the work done (A28).*" Emotional discomfort (20.4%) and physical pain (14.3%) are two other irresistible triggers. "*People just couldn't help warning me that my watch was dead, whether they knew me well or not (A4).*" "*The mosquitos really bother me, and I do not mind approaching someone who can keep these monsters away (A9).*" If interaction can bring in mutual benefits (16.3%), people seem to be more willing to talk to each other. "*I usually won't email someone not in my division this often. But in this case, we have to do so as both of us need to ensure that the emails get to the right person (A35).*" Some other possible factors include curiosity (12.5%) and financial concerns (8.2%), especially when they are substantial. "*It was until they saw a robot in the lobby talking by itself, did the students start asking me questions (A8).*" "*No one wanted to pay the cancelation fee, so we had to make sure that everyone was happy. We made calls and met for the first time just to go over the hotels (A31).*"

In a word, inhibitors to human-human interaction are diverse, and some are easier to overcome than the others. It is necessary to provide internal and/or external motivation to get people to step out of their comfort zone. The selection of motivating factors should relate to the intended scenarios and characteristics of the target relationships.

Choosing Mechanisms that Enhance Sensorial Presence

A person's sensorial experience with the other party's presence affects their understanding and relationship [46]. There are many ways to shorten the social and emotional distance. According to the Proxemics Theory [16], people use haptics, kinesics, vocalics, and chronemics to define territories during interpersonal communication [28]. It is particularly important to "*say the right thing, and do the right thing (A45)*," or it may lead to negative consequences.

Our respondents mostly mentioned the use of verbal and sensory channels (Table 1). Verbal communication can promote better understanding via instrumental dialogues (87.7% of the anecdotes, e.g., information exchange, demonstration / instruction, coordination, and warning) and

Category	Code	# Codes	% Anecdotes	Examples
Relation (Who)	Colleague / Officemate / Labmate	18	36.70%	Intern in the lab, HRs, co-workers, etc.
	Stranger	17	30.60%	Pedestrian, passengers, driver, people nearby, etc.
	Friend	9	18.40%	Female friends, a close friend, etc.
	Classmate / Schoolmate	4	8.20%	Boys in my class, etc.
	Roommate / Neighbor	3	6.10%	The guy next door, our neighbors, etc.
	Significant other / Date	3	6.10%	Boyfriend, my date, etc.
	Family / Relatives	2	4.10%	Uncle, my parents, etc.
Location (Where)	Office / Classroom	14	28.60%	In my department, in my class, in the lecture hall, etc.
	Transportation	7	14.30%	On the bus, in the subway station, etc.
	Online only	7	14.30%	Facebook, WeChat, online forum, etc.
	Restaurant	5	10.20%	Have a group dinner, café, etc.
	Public place (indoor)	5	10.20%	Museum, lobby, etc.
	Public place (outdoor)	5	10.20%	On the street, in a park, etc.
	Apartment / Dorm / Hotel	4	8.20%	In my flat, hotel in Greece, etc.
	Home	2	4.10%	At home, etc.
Attribution (Broken Type)	Failed operation	16	32.70%	Power off, no announcement, no GPS signal, etc.
	Difficult / Unfamiliar usage	12	24.50%	New coffee machine, hard-to-use interface, etc.
	Limited / Uneven resource	9	16.30%	Weak Wifi signal, only cools part of the room, etc.
	Missing function	7	14.30%	No speech output, no filter, no personalization, etc.
	Conflicted / Confused usage	6	10.20%	Swapped control, mistaken email address, etc.
	Uncomfortable usage	2	4.10%	Annoying sound, either too hot or too cold, etc.
	Unexpected outcome	2	4.10%	Random message, a pile of wasted paper, etc.
	Misguided appearance	2	4.10%	Looks smart, as if it were out of battery, etc.
Function (Medium)	Face to face conversation	38	73.40%	Discussion, shopping together, walk with me, etc.
	Messaging / Online chat	6	12.30%	Got a text, chatting online, etc.
	Social network	5	10.20%	Form a WeChat group, join a forum, etc.
	Phone call	3	6.10%	Called me up, etc.
	Email	1	2.00%	Emailed me
Rationale (Barrier)	Social isolation	15	28.60%	From another school, boys seldom talk to girls, etc.
	Social awkwardness / Shyness	10	20.30%	Geeky guys, too shy, etc.
	Social inappropriateness / Rudeness	8	16.30%	Cannot force him out of the cubicle, etc.
	Physical isolation	6	12.20%	Long distance relationship, in another city, etc.
	Emotional indifference	5	10.20%	Not interested in talking to him, etc.
	Technological isolation	5	8.20%	Everyone plays with their phones, etc.
Sequence (Trigger)	Urgency	12	22.40%	Need to get work done, cannot find my way, etc.
	Inconvenience	10	20.40%	Difficult to reach, have to go there each time, etc.
	Emotional discomfort	10	20.40%	Really frustrated, pretty nervous, stressed, etc.
	Mutual benefit	8	16.30%	Emails sent to the right person, both enjoyed it, etc.
	Physical discomfort	7	14.30%	My feet hurt, cannot bend down, etc.
	Curiosity / Fun	5	12.50%	Interested to see, give it a try, very curious, etc.
	Financial concern	4	8.20%	Get a discount, pay the bill, too expensive, etc.
Means-End I (Verbal)	Exchange information	17	34.70%	Exchange names and ideas, discuss possible ways, etc.
	Demonstration / Instruction	13	26.50%	Show me how to use the machines, give a demo, etc.
	Coordination	10	20.40%	Synchronize the control, take turns, arrange seats, etc.
	Compliment / Greeting / Blessing	4	6.10%	Compliment on the taste, say hello, etc.
	Warning	3	6.10%	Warmed me the risk of wrist sprain, point out the hole, etc.
	Complaint	3	6.10%	Complain about the system, etc.
	Joke	3	6.10%	Tease myself, joke about it, etc.
Means-End II (Physical)	Shared object	15	30.60%	Shared Wifi hotspot, shared air condition, etc.
	Shared space	9	18.40%	Share the area with lights, etc.
	Body / Voice contact	8	14.30%	Holding hands, send me a voice message, etc.
	Gifting	3	6.10%	Get me a new headset, lend us their jackets, etc.
Cause and Effect I (Emotional)	Grateful	15	30.60%	Cannot get it done without him, really thankful, etc.
	Pleased / Satisfied	10	20.40%	Had a great trip, got to practice my English, etc.
	Fun / Interesting	10	20.40%	Never experienced this before, interesting to see, etc.
	Touched / Sweet	6	12.30%	It is so sweet, I am moved, etc.
	Surprised	6	12.20%	People did come up to me, she is not that hard to work with, etc.
	Sympathy / Empathy	3	6.10%	Sorry for the blind passenger, pity guy, etc.
Cause and Effect II (Relational)	Stronger emotional connection	27	53.10%	He really cares about me, we became close friends, etc.
	Better understanding	19	38.70%	Know my colleagues better, share our interests and tastes, etc.
	More interaction	16	32.70%	Interact more with the locals, participate in the conversationss, etc.

Table 1. Summary of codes of anecdotes, scenarios collected from focus group, and design examples.

stronger emotional connection via affective conversations (18.3%, e.g., greeting, compliment, complaint, and joke). In particular, voice brings people closer than written text. As one story noted, "*It was the first time I heard his voice. Voice message is definitely more personal than text (A28).*" We notice that all parties in the stories were taking a constructive attitude towards the breakdowns. It suggests that an effective icebreaking mechanism for B2I design should prevent destructive behaviors such as simply blaming the product or each other, and shift users' focus to reflecting on their interpersonal relationship.

Direct physical interactions (14.3%) create an even stronger sense of presence and intimacy [16]. It makes people feel that they are emotionally closer, which in turn reinforces interpersonal interactions. However, given the social norms, physical contact may be more suitable for stronger ties except in special occasions. "*I only hold on to the arm of my parents'. But if I sprained my ankle, I guess I would not mind borrowing the arm of someone nearby (A5).*"

In comparison, indirect contact in the physical world through shared object (30.6% of the anecdotes), shared space (18.4%), or gifting (6.1%) is of a wider use. Indirect physical contact may affect individuals' perception and behaviors in various ways. One respondent used being locked up together in a broken elevator as an example to elicit some of the mediating factors, such as a shared dedicated goal, an isolated non-distracted environment, common experiences and feelings, and common grounds of conversations. Several interviewees mentioned that some sensory stimuli which can easily invade a space, e.g., light, temperature, smell, and sound, and thus may stimulate shared emotional and social responses. "*We were hiding in our own cubicles, but the false fire alarm easily went through the dividers and dragged us all out. (A19)*"

Introducing Sustainable Outcome

All respondents agreed that a successful B2I design should lead to long-lasting emotional, behavioral, and relational change. People indicated in their personal stories that (Table 1), in the end they knew more about the person experienced B2I with them (38.7%), felt more emotionally connected (53.1%), and were more willing to interact with others in the future (32.7%). In some cases where the interaction only occurred once, particularly with strangers, the participants adopted a more positive, active attitude towards social interaction, as said in an anecdote, "*I love this city. People are so friendly. I interacted more with the locals during my visit which never happened before. (A38)*" In other words, a good B2I design should either reinforce the motivation and engage people in repeated, longer-term interaction, or leave a prolonged emotional impact.

LEARNING FROM PRACTICES: DESIGN WORKSHOPS

We have gained many useful insights from the daily experiences of target users, and would like to transfer the knowledge to actual designs practices. We consider B2I design to be a kind of everyday design [47]. For one thing, B2I design leverages the resourceful daily technologies as the design material. For another, B2I design does not necessarily need a professional designer, but can involve anyone who is willing to think critically and innovatively. We conducted two activities to transfer theories to practices: I) a material-oriented design workshops with three everyday designers and I) a goal-oriented design workshop with five everyday designers. The participants were recruited via word-of-mouth and advertisement on social media such as Facebook, Weibo, and Wechat.

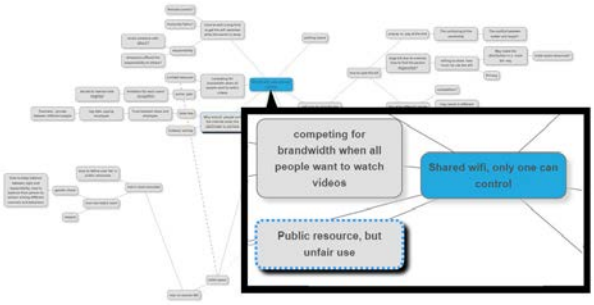

Figure 1. A mind map on shared WiFi hotspot from the material-oriented design workshop.

Material-oriented Design Workshop

We conducted a material-oriented design workshop to explore the use of B2I thinking in actual design practice with three everyday designers (D1, D2 and D3) who liked to make things in their spare time. D1 (male, aged 26) was a master student in HCI, D2 (male, aged 22) was completely new to the field, and D3 (female, aged 30) was a professional designer with seven years of practices.

Session I: Warm-up Brainstorming

In the first part of the workshop, we organized a 40-minute warm-up brainstorming session to make sure that all the three designers correctly understood the basic concept of material-oriented B2I design. We presented them the design considerations derived from the anecdote study. We encouraged the designers to pick an ordinary product encountered in everyday life and creatively turn it into something useful for social interaction without worrying about feasibility or usability issues. The designers were able to generate many ideas with the help of mind maps [7]. The designers brought up seven examples of B2I design:

1. A set of water taps with swapped proximity sensors.
2. An emoticon-only chat tool.
3. An ice bucket that will block the WiFi signal around the table when having a bottle of beer in it.
4. A pair of stiletto that can detach the heel via a phone.
5. An automatic glass door that only opens when people on both side smile at it.
6. A TV that can only be viewed from a particular angle.
7. A children's game with random tasks for the parents.

We observed that their design materials were not restricted to interaction design; rather, the designers were better at

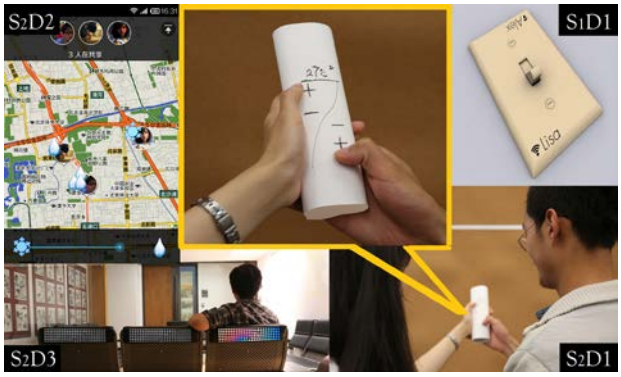

Figure 2. Results of parallel prototyping.

repurposing breakdown of everyday objects e.g., shoes and water tap. Additionally, many of the design outcomes were not only relational but also utilitarian or hedonic. In other words, the designers assigned B2I a broader definition.

Session II: Parallel Prototyping

We provided two products / services as the initial design materials, i.e., WiFi hotspot and air conditioner for a shared space. They both occurred several times in the anecdotes. In this session, the designers first collectively generated a mind map (Figure 1) for each case (45 min each), with emphasis on but not limited to our proposed B2I notions in Table 1. This process did not produce any specific design, but rather awareness of the issue and its linkage to other aspects relevant to social interactions. Mind mapping results served as design materials for parallel prototyping [12] (60 min each), during which the three designers independently proposed new B2I designs for each case.

Results of Parallel Prototyping

We share the six designs proposed by the designers for the cases of WiFi (S_1) and air conditioner (S_2) (Figure 2).

S_1D1: *WiFi Teeterboard* is a physical switch that mediates network speed between a team of two. Like a teeterboard, when flipped to one end, it gives one of the users high WiFi speed (e.g., 10MB/s) and a poorer speed (e.g., 1MB/s) to the other, and vice versa. Members have to communicate more about their current Internet usage and future plans.

S_1D2 : *Internet Exposer* grabs the URL that each member currently browses, and tries to expose it to all. However, users can sacrifice some of their bandwidth to cover up their URLs. In addition, employees are supervised by "social influence" rather than a compulsive URL screening, more beneficial for group dynamics and working culture.

S_1D3: *Share for More* is a network resource redistribution system that aims to increase sociality and sharedness. Limited network resources are not distributed evenly across a team. More are allocated to those who share information that they obtained from the Internet with others.

S_2D1: *Remotouch* is an air-conditioner remote design for rooms where family and friends get together. *Remotouch* only activates when two people hold it together. It reminds people to care for others' feeling, with their own hand, every time they want to change the temperature.

S_2D2: *Cool Map* is an application that indexes a map with users' perceived feelings of temperature rather than the actual temperature. Users can update their feelings with a slide bar and see others' feeling around them. It aims to encourage more icebreaking social interactions.

S_2D3: *Sense Me, Chat with Me* is a bench design in public space. The chair obtains users' physiologic and emotional status by sensors and the users' self-input, and visualize it at the back side of the bench, and can only be seen by others. The bench provokes icebreaking interactions among strangers when people care about others.

Designers' Reflection on Material-oriented Design

After the workshop, we interviewed the three designers and derived several implications from the interview.

Brainstorming a broad range of phenomena, mechanisms, experiences, values, and consequences related to design materials is essential to B2I design. Many ideas generated in this workshop were stimulated by more than one "spark". For example, D1's *Remotouch* incorporated the notions of "shared objects", "physical contact", and "mutual benefit". Various combinations may yield different design outcomes.

Interestingly, S_2D2 and S_2D3 exploited the concept of temperature rather than the initial product air-conditioner as the design material. The designers reported that their personal experiences inspire them to transplant the concept to another technology. D3 shared her thought process, "*Talking about air-conditioners' uneven cooling, it reminds me of another incident. My hands are cold when the room temperature is low. None of my friends knows about it until one day a thermal image camera accidently exposed my body temperature heatmap. The unexpected leak of my 'body index' turned out to be a good thing, because thereafter many of my caring friends offer to warm my hands from time to time. This is where the 'Sense Me, Chat with Me' idea comes from.*"

The three designers stressed several keys to the material-oriented design process: "*utilizing the power of habit and social norms (D1)*", "*repurposing everyday objects and devices (D2)*", and "*taking advantages of heuristics to naturally and seamlessly integrate the different elements together (D3)*". Take the automatic glass door proposed in the warm-up session as an example. The transparent glass allows users on both sides to see each other's smile, turning a mutual command for a mechanical operation into a social cue. Similarly, placing beer bottles into an ice bucket is a common practice, which is used to signal the start of a party both socially and technically (by blocking WiFi signals).

In the end, the panel of everyday designers made a remark that the material-oriented design process enabled them to "*think more out of the box*". "*Given a broken design, people's first instinct is to repair it. Sometimes we recycle*

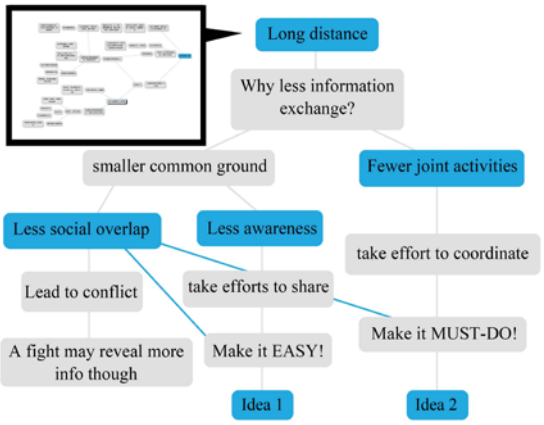

Figure 3. Simplified mind map in the goal-oriented design workshop (full mind map on the upper left).

some pieces to build a better system, but it is only near transfer. Finding a completely new use is unnatural, and the ideas generated could be somewhat arbitrary. But this is fun (D3)." This quote also indicates that B2I material-oriented design is a bottom-up process, which may not have clear patterns. On the contrary, the designers felt that a top-down, goal-oriented design may have a conceptual and actionable process to follow. Therefore, we conducted a second design workshop to explore the idea.

Goal-Oriented Design Workshop

We invited another five everyday designers (D4~D8, a least one year of everyday design experiences, Avg. age = 25.6, SD = 2.88 yrs., three females) to a goal-oriented design workshop. This workshop followed a traditional design process: specifying and solving a target problem. Designers were free to choose any design material.

Procedure

We asked designers to solve the problem of "*lovers going cold in a long-distance relationship (A34)*" in this workshop. The goal was to reinforce the ties and reactivate the interaction between lovers whose relationship is weakened by physical isolation (Table 1). Although close-ties were only mentioned in a small portion of the anecdotes, interviewees stressed that problems with a close-tie are more devastating than with a stranger. In addition, prior work showed that romantic partners were less satisfied with their relational quality than family or friends when communicating over various media [3]. The designers reviewed the categories in Table 1 and built a mind map (Figure 3) to explore the links among factors associated with a cooling-down long distance relationship. Designers could easily adapt mechanisms from the anecdotes that have fixed similar problems for their own design.

Goal-oriented Design Process and Outcomes

When sketching out the mind map, the designers found that although existing CMC tools can support low-cost, frequent communication between long-distance couples, physical isolation still causes inevitable damage to the relationship. For example, social overlap and common ground decrease as the distance enlarges, resulting in potential conflicts and misunderstanding. Also, remote couples are less motivated to coordinate and participant in joint events to pursue a shared goal, posing a challenge to their sense of belonging. "*We do not have much to talk about. He doesn't know the people or the context of some of the recent events. It will take me a long time to explain everything in order to avoid possible confusion, which I don't feel like doing. (D7)*" Such problems cannot be adequately addressed by scheduled conversations daily and meet-ups from time to time. The designers seek alternatives that could target these issues at a deeper level. Later, the designers got inspired by the notions and cases presented in Table 1 and came up with two designs, one for expanding social overlap and the other for promoting joint activities.

Idea1: *Random Messenger* takes random snapshots of all chat history throughout the day, and users can pick a few to send to the other party daily at their own will. It provides an opportunity for long-distance lovers to learn more about each other's social circle and recent activities. The design adopts notions such as "exchange information," "shared object," "curiosity," and "better understanding" in Table 1.

Idea2: *Solo-Media Player* is an online player that requires two people to synchronously watch the same video together, as one person only has the key to the video stream while the other can only unlock the audio. This design aims to encourage remote couples to watch video programs together online, and exchange thoughts and feelings. It can find references to notions e.g., "coordination," "shared object," "mutual benefits," "more interaction," etc.

Designers' Reflection on Goal-oriented Design

The designers proposed a five-phase tactics for B2I goal-oriented design: 1) specifying the target relationship and the desirable state; 2) locating the barriers; 3) identifying a suitable context or channel; 4) designing a mechanism that can provide sufficient motivation and provoke appropriate actions; and 5) reinforcing positive experiences.

The designers identified two ways to embed icebreaking features in an existing technology: as a *byproduct* (Idea1) of or as a *prerequisite* to the original functionality (Idea2). The former has less impact on the design material, but can be easily bypassed. In contrast, the latter better imposes the idea but can be viewed as counterfunctional [36] with "*the risk of arousing complaints against the product. (D5)*"

In addition, the designers highlighted some critical factors to be carefully managed, e.g., privacy and ethics. They did not want B2I design to trigger wars between lovers or with other parties that may be involved in the use of technology. However, they also indicated that a fight may sometimes heat up the relationship, as it "*reveals the 'true self' and communicates emotion and information intensely. (D8)*"

CASE STUDY

We conducted a case study on *Random Messenger* from the goal-oriented design workshop with three long-distance couples (Avg. age = 24.3, SD = 1.03 yrs., three females). The three couples (C1~C6) have been in a relationship for an average of 3.3 years and have not been co-located for 1.8 years on average. We held online interviews with each couple after they had tried Random Messenger for a week.

Case Study Process and Feedback

The three couples noted in a pre-study interview that distrust and lack of common topics are the two most urgent problems for long-distance relationships. Participants' feedback showed that Random Messenger could adequately remove these barriers, however, in an "abnormal" way.

Many reported that sharing chat history is an effective way to stimulate communication, especially for introducing new topics. "*I'm obsessed with analyzing the tone she talk to other people, someone I don't know, and guessing their relationship. We discussed a lot about this and I get to know more of her friends (C3).*" "*I saw his dialogue with a mutual friend. It caught my interest. We then continued with the topic raised in the conversation with this friend (C6).*"

Case Study Results and Implications

In the study we found that, due to the randomness, many of the chat snapshots were not "informative" enough for the other party. "*Before, we occasionally sent each other a snapshot that we thought was interesting. Random snapshot is different. It can be some information that the other party cannot follow at all (C1).*" However, all the three couples stated that it is exactly the non-informative feature that may better evoke interaction. "*Reading conversations out of my knowledge actually allows me to see a different side of her (C1).*" "*We both find the snapshots nonsense sometimes because of the lack of context; however, they successfully arouse our curiosity to know the story behind (C4).*" In other words, randomness is a useful ice breaker.

Random Messenger also intensified the issue of trust. Being unselective itself, Random Messenger put a test on both sides. C1 (male) shared an incident, "*Once, a snapshot of a female friend and me talking about having lunch together popped up. I hesitated for a while, but decided to send it to her. It was actually no big deal, though she might view it differently.*" And C1's girlfriend C2 added, "*Indeed. I think the girl likes him. I can take it because I can feel the trust between us.*" The couple recognized Random Messenger's active role in maintaining their mutual trust.

"Suspicious conversations" leaked by Random Messenger may stimulate jealousy, which was another common feeling besides curiosity as the participants noted. Fierce jealousy may be destructive, but a slight one is "*good in general, as it keeps us more passionate (C6).*" While curiosity incites interests in learning more about the other party, jealousy opens up an opportunity to regain a deeper understanding of self and feelings towards the relationship. "*In one snapshot, she told a boy that she would go to his place for the weekend. I was so jealous that I did not notice that the boy was a friend of mine and she was actually going to visit his girlfriend. Hilarious mistake. It made me realize how much I care about her, and I am not as mature as I thought (C3).*"

In summary, instead of trying to stabilize a relationship, Random Messenger gets users to experience the feeling of something "*being a bit out of control. (C5)*" Actually, Random Messenger incorporates the concepts of ambiguity [15] and defamiliarization [13] to reenergize social interactions, by critically adding excitement and challenges to a relationship that might be bland or is going cold.

The case study demonstrated the effectiveness of B2I design, and the feasibility of reshaping breakage of technologies. A near transfer with proper target- and context-based adaptation may quickly expand the use of existing B2I tactics. For example, some designs for long-distance relationship could also apply to other scenarios, e.g., left-behind children and their parents.

DISCUSSION

In general, B2I is a method to create antifragile systems that "benefit from shocks" and will "thrive and grow when exposed to volatility, randomness, disorder, and stressors and love adventure, risk, and uncertainty" [43]. Such systems have been found in molecular biology, finance, physics, etc. It suggests that B2I thinking can be applied to repurpose any object to foster target behaviors in a new domain, as long as designers can tolerate and carefully design counterfunctional mechanisms in a traditional sense.

Note that the antifragile mechanisms in B2I design, e.g., ambiguity and defamiliarization, might take the blame for interfering with the user experiences of the design material. Designers should ensure that the negative effect serves as the ticket to talk as shown in anecdote A5, which is only temporary and will ultimately lead to better outcomes.

Embedded B2I Feature should not Overrule the Product

Instead of developing technologies dedicated to promote interpersonal interaction from scratch, B2I design inserts features into exiting products and services shared among the target users, and repurposes part of the design materials. This approach has several benefits. First, B2I design can take advantage of the user base of the host product / service [11]. As designer D1 suggested in the material-oriented workshop, "*People need to use WiFi. In that sense, we don't have to persuade them to try out our feature.*" This is particularly true for the prerequisite type of B2I design. Second, the besides the intended improvement on interpersonal relationship, better experience with the design material can also serve as a motivator for the users. D1 gave an example, "*Eventually, our design (S_1D1: WiFi Teeterboard) allows users to avoid potential conflict over bandwidth and make better use of the WiFi service.*" More

specifically, the designers proposed two approaches to leverage the original function of the design material as an incentive for active engagement in social interaction: 1) to secure resources and maintain service quality, e.g., S_1D2: *Internet Exposer*; and 2) to earn extra resources or higher priority, e.g., S_1D3: *Share for More*.

However, designers in both workshops stressed that the embedded icebreaking features should not detract the design material from its original purpose in any case. For example, D6 reflected on the design of Idea2: *Solo-Media Player* in the goal-oriented workshop, "*The (Solo-Media) player should work just like an ordinary video player, or with even better image and sound qualities when the remote couples are coordinated. Nobody wants to watch a crappy video after going through all these hassles. In addition, our design should be able to tolerate technical problems such as Internet delays or instability.*" As D4 remarked, "*We want the users to think our (B2I) designs as fun, perhaps helpful, add-ons to things that they have been so familiar with. Users are very picky. As soon as they find a decline in the service quality, they will turn to some other product. If that happens, we (as B2I designers) will be in trouble.*" In a word, B2I design might require some unconventional practices, but it should ultimately lead to positive experience with technologies and with humans.

Choice of Mechanism should Fit the Target and Context

The icebreaking features introduced by B2I design can be viewed as a trigger for desirable behaviors [14]. Whether the trigger serves as a facilitator, signal, or spark, is determined by users' motivations and abilities [14]. When users are willing to make changes such as in the long-distance relationship scenario, B2I design may take a more explicit, proactive approach. When users do not feel like socializing such as in a public place surrounded by strangers, B2I design can implicitly help establish common ground and mutual awareness, which can potentially turn into spark of human-human interaction. D3 explained her intent behind S_2D3: *Sense Me, Chat with Me*, "*My choice of public bench was inspired by the experience of a friend. Once he was sitting in a freezing cold waiting room. He wanted to get someone to adjust the temperature, but was not sure if other people in the room felt the same. He was afraid that asking around would make him seem demanding. My design would show that he was not the only one without having to ask. It creates a sense of togetherness and belonging, and people may be less reluctant to talk.*" All the designers agreed that B2I design should be noticeable but not intrusive. As D3 positioned her S_2D3 design, "*After all, it is a nice piece of interactive art.*"

Stronger Stimulus may be Needed for Significant Barriers

As shown in the anecdotes and reflected by the designers, sometimes the barrier that hinders interpersonal relationship is so thick that a gentle nudge will not break it, and thus it is necessary to apply a stronger stimulation. S_2D1: *Remotouch* is such an example. D1 justified his underlying design rational, "*When the two people fought over the control of air-conditioner (referring to one of the anecdotes), they insisted that the other person was being unreasonable and not considerate. By forcing them to touch each other's hand, Remotouch gives them a chance to really put themselves into the other person's shoes.* "

However, a strong stimulus should only be used when necessary. As D1 further added, "*Remotouch only requires users to hold the remote control together when it senses that there is a conflict, such as the temperature setting going back and forth. Once people achieved mutual understanding and reached consensus, it will returns to the normal mode. Otherwise, it will become annoying.* "

Violation of Ethics and Social Norm should be Reduced

There are usually multiple parties involved in the use of B2I designs. Designers should be conscious of any potential violation of ethics, and try to protect the rights and benefits of all the users. For example, the screenshots of chat history taken by *Random Messenger* not only concern the privacy of the remote couples, but also a third party that appears in the conversation. Therefore, *Random Messenger* does not send the screenshot automatically. Instead, the action needs to be screened and approved by the users.

In summary, B2I encourages designers to rethink the role of technology in humans' life. We need to critically take the view that a B2I design is a player in the ecologies between object, people, and environment [29], rather than merely a medium or tool for communication.

CONCLUSION AND FUTURE WORK

This paper presents the prosperity that insights from broken technology can be leverage to provoke humans to interact and ultimately lead to positive behavioral, emotional, and relational change. Via anecdote analysis, design workshops, and a case study, we gain insights into the conceptual and actionable process of Breakage-to-Icebreaker design. We derive a set of tactics to leverage antifragility without impairing users' relationship with technology. In particular, we identify two methods (byproduct and prerequisite) for embedding B2I mechanisms in existing technologies to exploit their innate tangibility and/or sociality. The goal is to evoke different embodied sensorial experiences of presence that affect perception of interpersonal relationship.

The insights presented in this paper were drawn from a limited number of examples. There should be an easier way to efficiently update and expand this collection, such as gathering data from social media to keep up with the latest innovation and locate better design materials. In addition, we will apply B2I design to other contexts such as persuading sustainable, healthy behaviors in the future.

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