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The Distant Gardener: What Conversations in the Telegarden Reveal about Human-Telerobotic Interaction*

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Abstract **We investigated human interaction with a specific telerobotic installation: The Telegarden, a community garden that allows users to plant and tend seeds in a remote garden by controlling a robotic arm through a web-based interface. Based on an analysis of 3 months of associated online chat (347 participants, 16,504 postings), results showed the following: (1) conversations focused on nature (13%), technology (22%), and human relationships (69%); (2) patterns of conversation appeared to follow patterns of physical activity in the Telegarden; (3) as individual participation in the chat room increased, conversation decreased about nature and technology within the Telegarden and increased about nature and technology beyond the Telegarden; and (4) users did not personify the robot arm (or robotic installation). Discussion focuses on the emerging possibilities in human-robotic interaction of using telerobotics instrumentally to help foster healthy, life-affirming relationships with the natural world.**

Index Terms – community, human-robotic interaction, human values, nature, online chat, robotics, Telegarden, Telerobotics

I. Introduction

A large body of diverse research shows that direct experiences with nature have beneficial effects on people's physical, cognitive, and emotional well-being. Studies have shown, for example, that even minimal connection with nature – such as looking at a natural landscape – can reduce immediate and long-term stress, reduce sickness of prisoners, and calm patients before and during surgery [14, 28]. Thus it appears to be no accident that people go to great lengths to stroll along beaches or mountain paths. The need and propensity for humans to affiliate with nature appears great [29].

Technological mediations of the natural world, however, are increasingly being inserted into such human-nature interactions, or have the potential to be inserted. Think, for example, of "nature" programs on television. They offer a visually mediated experience, usually of recorded and condensed material of distant locations (e.g., of animal life on the savannahs of East Africa), wherein the flow of information is unidirectional, from producer to audience. As the pervasiveness and sophistication of such technological mediations increase, important questions need to be answered. Can such technologies engage humans in meaningful ways? Is it the case that through such mediations we can achieve similar psychological effects to their non-mediated natural counterparts? If so, then technology will provide a powerful and pervasive means to foster human well-being. Or is it the case that in some ways, perhaps many ways, such technologically mediated interaction with the natural world falls short?

Toward approaching these questions, we focused on the user experience of nature as mediated by a telerobotic installation, the Telegarden. This installation was developed at the University of Southern California in 1995 under the co-direction of Ken Goldberg and Joseph Santarromana. In 1996 the Telegarden was moved to the Ars Electronica Center in Linz, Austria, where it remained online until August of 2004 [12, 27]. The garden itself is a small plot encircling an industrial robotic arm (see Figure 1). A web-based interface (see Figure 2) allows users to

Figure 1. The Telegarden. Co-directors: Ken Goldberg and Joseph Santarromana. Project team: George Bekey, Steven Gentner, Rosemary Morris, Carl Sutter, Jeff Wiegley, Erich Berger. (Photo by Robert Wedemeyer.)

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Figure 2. The World Wide Web interface to the Telegarden. The image on the left provides a composite view of the entire garden region and the image on the right is captured by the camera on the end of the robotic arm. Users can move the robotic arm by clicking on locations in the various images.

activate the robotic arm, view the garden through a camera mounted on the robotic arm, change the view, plant a seed, water it, and (if one is a successful gardener) water the resulting plant on an on-going basis. Many thousands of remote users have interacted with the Telegarden in such ways.

Human-telerobotic interaction is beginning to emerge as an important area of study [6, 19, 22]. For example, Roussou and his colleagues [25] built a telerobotic tour guide (TOURBOT) to be used in a museum setting, such that remote users could issue commands to the robot to visit specific exhibits or to be guided through portions of the museum. Based on observational data during a pilot study and demonstration, the robot's physical appearance and tone of voice played important factors in the robot's acceptance. In another study [13], researchers linked an advanced humanoid robot (NASA/DARPA's Robonaut) on top of a Segway transportation system, and sought to have users control the robot through immersive telepresence. Based on a minimal user study, they found it highly effective to feed images to the user from the perspective of the robot. To our knowledge, no study has yet investigated how telerobotics may help people affiliate with nature in an experiential way (in contrast to a scientific study of nature, as in say the Mars Rover).

Potentially, users' interactions with the Telegarden embody some of the human experience and value of gardening itself. For example, Schultz [26] in *Garden Design Magazine* writes "though drained of sensory cues, planting that distant seed still stirs anticipation, protectiveness, and nurturing. The unmistakable vibration of the garden pulses and pulls, even through a modem." Yet it remains an open empirical question whether such writing conveys more writer's exuberance than fact in terms of the user experience of the Telegarden.

In addition to creating a Telerobotic installation that connected people to nature, the designers of the Telegarden sought to foster the experience and value of community (not unlike a community garden) by making users aware of each other, and aware of the impacts of their actions on the garden and other users. Toward this end, the site provided information about who is currently visiting the site, what they are doing, and what actions users have taken in the garden recently. In addition, the site had a corresponding unmoderated chat room, where users could engage – as in many chats – about topics relevant to the installation, and any other topic of choice.

The purpose of this study was to investigate users' experience and conceptions of this telerobotic installation. We did so by building on a method employed successfully by Friedman, Kahn, and Hagman [11] who analyzed people's relationships with their robotic dog (Sony's AIBO) through conversational analyses of all archived postings for a 3-month period from 3 major online AIBO discussion forums. Similarly, we conducted a line-by-line analysis of 3 months of chat discourse from the chat room associated with the Telegarden.

Four overarching questions structured our investigation. First, to what extent did the Telegarden actually engage users in nature-oriented experiences? Second, were such experiences grounded by the physicality of the Telegarden itself, or largely focused on nature beyond the Telegarden, in, for example, the physical location of each user? Third, how did users experience the technological aspects of the installation, particularly the robotic arm that was the mechanism for acting in the garden? Fourth, did users' experience of the Telegarden change, and perhaps deepen, with increased participation?

II. Methods

A. *Data Source*

Data was collected from an archive of postings to the Telegarden chat room, located on the Telegarden website. A 3-month (13-week) period, comprised of 22,952 posts, was selected for coding. These 3 months represent a period of robust use and exploration of the Telegarden site, soon after the installation was relocated to Austria. From this group of 22,952 posts, we then excluded all posts that were written in a non-English language or that were exact repeat posts (which was common due to the slow response of the server). The resulting data source for analysis comprised 16,504 posts.

B. *Coding*

To develop a coding system for the Telegarden chat data we drew on methods from developmental psychology for coding qualitative interview data [14] that have recently been extended to online discourse [11]. The coding system [16] was first generated from postings in the archive outside the 3-month period selected for coding. Once finalized, the coding manual was used to code the 3-month data set. If a single post included several instances of a single category, that category was coded as "used" only once. It was also possible for several codes to apply to a single post, to account for the expression of a range of topics and attitudes within one statement.

C. *Reliability*

To assess reliability of the coding system, an independent scorer trained in the use of the coding manual recoded 15% of the total postings (3,452 postings) across the 3 month period. Intercoder reliability was assessed through testing Cohen's kappa at the .05 significance level. All tests were statistically significant. For the lowest level of the coding hierarchy, $k = .70$, and for the highest level of the coding hierarchy, $k = .82$.

Conversational Category	Percentage of Postings (16,504 total posts)
1. Conversations about Nature	**13**
1.1 Experience of Garden Within Telegarden	6
1.1.1 Geography	*1*
1.1.2 Watering	*2*
1.1.3 Planting	*2*
1.1.4 Overcrowding	*1*
1.1.5 Other	*2*
1.2 Nature Beyond the Telegarden	7
1.2.1 Gardening in General	*0*
1.2.2 Weather	*3*
1.2.3 Seasons	*1*
1.2.4 Environmental Issues	*1*
1.2.5 Other	*3*
1.3 Other	0
2. Conversations about Technology	**22**
2.1 Experience of Technology Within Telegarden	9
2.1.1 Robot	*0*
2.1.1.1 Biological Description	*0*
2.1.1.2 Agency	*0*
2.1.1.3 Social Standing	*0*
2.1.1.4 Moral Standing	*0*
2.1.1.5 Other	*0*
2.1.2 Interface Widgets and Gizmos	*5*
2.1.3 Interaction Design	*1*
2.1.4 Museum Staff Intervention	*1*
2.1.5 Other	*3*
2.2 Technology Beyond the Telegarden	13
2.3 Other	0
3. Conversations about Humans	**69**
3.1 Experience of Community Within Telegarden	13
3.1.1 Friendship and Interpersonal Support	*2*
3.1.2 Inclusion/ Welcoming/ New User	*2*
3.1.3 Origin Stories/ History	*2*
3.1.4 The Chatroom and Chat	*5*
3.1.5 Other	*3*
3.2 Social Life Beyond the Telegarden	58
3.2.1 Identification	*1*
3.2.2 Friendship Beyond the Telegarden	*1*
3.2.3 Family	*2*
3.2.4 Work	*3*
3.2.5 Travel/ Vacation	*2*
3.2.6 Chit-Chat	*45*
3.2.7 Other	*8*
3.3 Other	0
4. Uncodable	**7**

Note: The percentages reported in **bold** refer to usage of the overarching category; percentages in plain text refer to the next sub-level in the hierarchy; and percentages in *italics* refer to the lower levels. Within each level of the hierarchy, postings that contained more than one sub-category are only counted once in the overarching category.

Table 1. Percentage of postings by conversational category (postings = 16,504; number of members posting = 347)

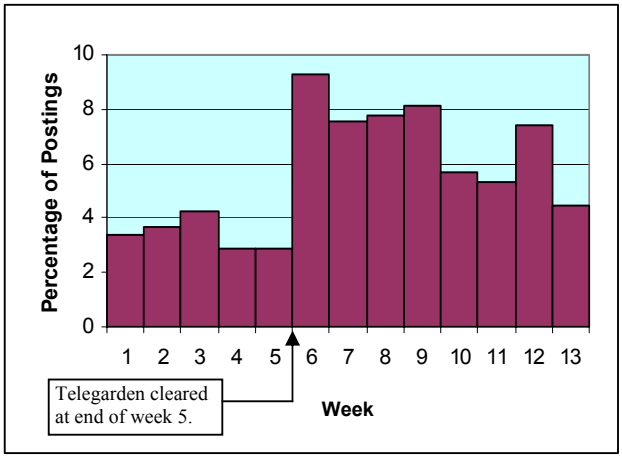

Figure 3. Percentage of postings by week coded as Experience of Garden Within Telegarden (Category 1.1 in Table 1). Note: For this category, the average number of postings per week was 1270.

III. Results

A. *Conversational Categories in the Telegarden*

As shown in Table 1, three overarching categories of conversation in the Telegarden characterized most of the discourse: *1. Conversations about Nature* (13%) referred to users' discussion of actual nature (often connected to gardening) within and beyond the Telegarden. As users wrote: **"**It's fun to sometimes catch site of a lady bug crawling about in the soil"; "What is cool is that we are moving and I can take my garden with me!" We coded for but found no (0%) evidence of dialog that plants deserved care or respect, or statements of users talking to their plants. *2. Conversations about Technology* (22%) referred to users' discussion of technology within and beyond the Telegarden. As users wrote: "The image to the left is one you use to shift the robot… you can tell if the space is occupied by the green dots."; "aren't you just a bit amazed you can actually control a robot in a foreign country through the use of a computer from the comfort of your own home?" We coded for but found no (0%) evidence of dialog about the biological, mental, social, or moral standing of the robotic arm (or robotic installation) itself. *3. Conversations about Humans* (69%) referred to users' discussion of an interpersonal connection within and beyond the Telegarden. As one user wrote: "she's such a lovely girl, now that I've met her I know I cannot be without her, she means so much."

We coded for insulting or abusive language (flaming) but found virtually none (0.1%, 21 out of 16,504 postings, with 20 out of the 21 postings coming from a single user).

Some other events that struck us when reading through the chat discourse include the following: Users sometimes asked other users to water their plants while they (the initiating users) were on vacation (and presumably offline). Users on occasion planted strategically to be nearby specific other people. The weather in a user's own location was commonly shared in conversations. There was a death of a user in the Telegarden, and the community responded by diffusing the information to the community and expressing

Conversational Category	1st Qrtl. R = {1-2} N = 110 P = 140	2nd Qrtl. R = {3-6} N = 74 P = 313	3rd Qrtl. R = {7-21} N = 77 P = 941	4th Qrtl. R = {22+} N = 86 P =15110	*p*-value
1. Conversations about Nature	**20**	**17**	**18**	**15**	**.315**
1.1 Experience of Garden Within Telegarden	16	13	13	8	.005
1.2 Nature Beyond Telegarden	3	3	6	7	.004
1.3 Other	1	1	1	0	n/a
2. Conversations about Technology	**9**	**25**	**21**	**21**	**<.0005**
2.1 Experience of Technology Within Telegarden	5	19	14	10	<.0005
2.2 Technology Beyond Telegarden	4	5	7	12	<.0005
2.3 Other	0	1	0	0	n/a
3. Conversations about Humans	**72**	**63**	**70**	**69**	**.301**
3.1 Experience of Community Within Telegarden	20	16	17	13	.166
3.2 Social Life Beyond Telegarden	52	49	55	57	.123
3.3 Other	0	0	0	0	n/a
4. Uncodable	**7**	**7**	**6**	**6**	**.911**

Notes: (1) R = range of postings per member; N = number of users per quartile, P = number of postings per quartile. (2) Quartiles for each of the four groups were established as evenly as possible based on the number of postings per member. (3) When postings contained material from more than one category, all categories were coded; thus the sum of the percentages of postings across categories maybe greater than 100. (4) The percentages reported in **bold** refer to usage of the overarching category; percentages in plain text refer to the next sub-level in the hierarchy. Within each level of the hierarchy, postings that contained more than one sub-category are only counted once in the overarching category. (5) *p*-values were obtained using weighted least squares ANOVA to compare mean percentages across the four quartiles. Statistically significant differences are highlighted in gray.

Table 2. Percentage of postings for each quartile by conversational category

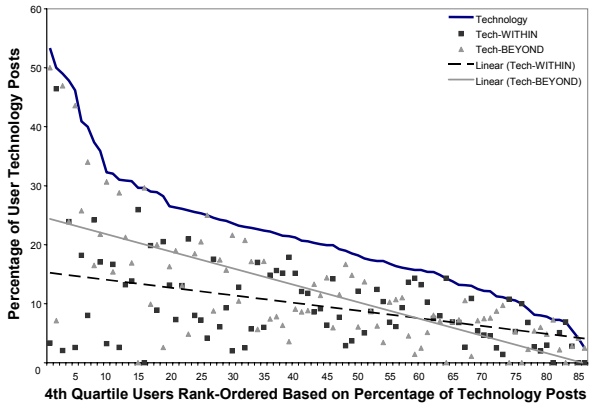

Figure 4. Conversations about Technology (Within versus Beyond Telegarden). X-axis represents users in 4th quartile rank-ordered based on their overall percentage of Technology posts. Y-axis represents percent of user posts (out of that user's total posts) that involved (a) Technology combined, (b) Technology Within Telegarden, and (c) Technology Beyond Telegarden.

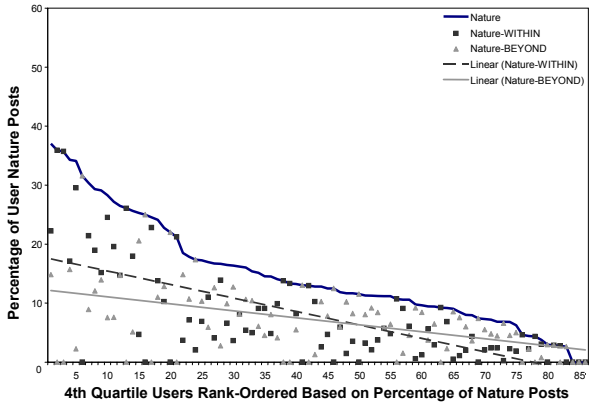

Figure 5. Conversations about Nature (Within versus Beyond Telegarden). X-axis represents users in 4th quartile rank-ordered based on their overall percentage of Nature posts. Y-axis represents percent of user posts (out of that user's total posts) that involved (a) Nature combined, (b) Nature Within Telegarden, and (c) Nature Beyond Telegarden.

sorrow. There was a marital engagement in the Telegarden community, and the couple maintained the Telegarden as their meeting ground even though they often would use other means to communicate. The Telegarden also provided a means for people to garden who physically could not tend to a real garden. As one user wrote: "I am recovering from neck surgery and can not do anything. The place has been a life saver for me…almost like meeting in a community garden!! A community of world gardeners, I guess!!"

B. Conversational Response to Physical Activity in the Telegarden

One striking feature of telerobotics in general, and the Telegarden in particular, is that one acts remotely in a real physical world (as opposed to a virtual world). Thus in terms of human-telerobotic interaction, we kept an eye open to how conversations shifted and coalesced based on real events in the garden itself. For example, on occasion, the Telegarden would become too full of plants, and the garden itself was physically cleared by the Telegarden administrators, to allow room for new plantings. One such clearing occurred during this 3-month coding period, at the end of Week 5. As shown in Figure 3, immediately after the clearing of the garden, conversations tripled (from 3% to 9%) concerning the experience of the garden within the Telegarden (Category 1.1. in Table 1). For example, one user said: "Hey it works...planted my seed!!! I am really glad to see … the "new"-new beginning of the garden...I'm sure I'll get to see alot of the oldtimers drop by now...News travels rather fast in these parts."

C. Differences in Conversations with Increased Participation

To investigate how users' conversations varied with increased participation in the Telegarden, we segmented users into quartiles (four groups as evenly as possible based on the number of postings per user). As shown in Table 2,

as individual participation in the chat room increased, conversation decreased about nature and technology within the Telegarden (e.g., "there is sure a pretty flower"), and increased about nature and technology beyond the Telegarden (e.g., "seems everything is blamed on El Nino now"). This finding might make it seem that, with increased participation, the Telegarden itself – the actual garden and installation – engaged users psychologically less and less. But it seemed to us that what was actually happening was that the less involved users (those in the 1st and 2nd quartiles who posted less than a total of 7 times) were unduly focused on getting up to speed with planting and learning how to use the technology, thereby muddling the picture of what engaged participation with the Telegarden looked like.

Thus we conducted a further exploratory analysis focused on only the users in the 4th quartile (86 users total), those who posted at least 22 times. We rank-ordered these participants based upon their percentage of overall posts on technology (Figure 4) and nature (Figure 5). We then plotted their respective percentages of posts within the Telegarden and beyond the Telegarden. Next, we overlayed the scatter plots with linear regression lines. A visual inspection of the resulting graph suggests the following. As seen in Figure 4, the more a user's conversations were about technology, the more likely it was that the user talked about technology beyond the Telegarden versus within the Telegarden. In contrast, as seen in Figure 5 the more a user's conversations were about nature, the more likely it was that the user talked about nature within the Telegarden versus nature beyond the Telegarden.

IV. Discussion

Telerobotics will increasingly find its way into mainstream human-robotic interaction, and people's daily lives. Currently, for example, through telerobotics, surgeons engage in remote surgery, scientists (and school children) explore the depths of the oceans (e.g., the TROV project), and NASA can roam on the surface of another planet (e.g., the Mars Rover). On the consumer side, a telerobotic site recently made media headlines: People can go online to control, aim, and fire a real gun, and also engage in "telehunting" [24]. On the military side, "telewarfare" is on the horizon. To date, however, very few studies have been conducted on the user experience of telerobotics [22]. Against this backdrop, we sought to understand the user experience and conceptions of one specific telerobotic installation, the Telegarden.

Based on our analysis of 16,504 posts, results showed that users engaged in conversations about natural, technological, and social issues, and that those conversations (almost always cordial) were responsive to users' level of participation in the Telegarden. Moreover, in terms of human-robotic interaction, the Telegarden embodied an extraordinarily interesting feature. Namely, it was not designed to be used by a single user, or by a small group of users co-located (as can occur in tele-surgery), but by many users, remote not only from the telerobot but from one another. Results, in turn, showed a resulting bidirectionality of interaction. That is, users acted through the telerobot to impact the real garden (e.g., planting seeds, watering plants), and those actions in turn could and often did impact other users.

That said, several findings mitigate against over interpreting the psychological robustness of this telerobotic installation. For the most part, the chat discourse seemed "thin" – lacking seeming depth that could arise in other content domains, such as medical chats focused on treatments for anterior cruciate ligament (ACL) [23] or senior online communities [21]. Too, our results showed that only 13% of the postings involved a relationship with nature, either connected to gardening within the Telegarden or any other nature discourse beyond the confines of the installation.

A difficult question emerges, however, of how to understand this 13% figure. The Telegarden was the first of its kind, using rudimentary technologies with slow response time and limited capabilities. The visual interface (see, again, Figure 2) was also poor, as it provided the user with little sense of the garden as a whole, of its texture or configuration, or of individual plants themselves. In this light, the 13% figure (the percentage of posts focused on nature) could be seen as quite large. Our exploratory analysis of the 4th quartile group (who posted at least 22 times) suggested that the more a user's conversations were about nature, the more likely it was that the user talked about nature within the Telegarden versus nature beyond the Telegarden. This latter analysis suggests that at least some active users (those drawn most to nature in general) sustained their interaction with nature as embodied within the Telegarden.

To put these findings in perspective, imagine living back in 1926, and watching "nature movies" for the first time using John Baird's television that operated with 30 lines of resolution at 5 frames per second. Presumably, our mediated experience with nature would be quite limited compared to today's standard. Thus there is reason to believe that as the telerobotic technology advances, the connection to people and place – and natural places – will become increasingly compelling.

Kahn, Friedman and their colleagues [4, 11, 17, 20] have shown that while children and adults recognize that the robotic dog AIBO is a piece of technology, that people also conceive of AIBO in certain ways as biological (as if it is alive), mental (as if it has intentions and desires), social (as if it were a friend), and moral (as if it could be a recipient of harm). In the present study, we incorporated similar measures into our coding manual of the chat dialog. Results showed no evidence that people conceived of the telerobotic installation (e.g., the robotic arm itself) in biological, mental, social, or moral terms. Thus, taken together these studies provide empirical support for the proposition that people clearly distinguish in their robotic interactions between mechanical artifacts and robotic others [10, 15].

Social interaction is one of at least three main ontological categories of interaction essential to human living. The other two are artifactual and natural. The field of Human-Robotic Interaction has largely focused on social and artifactual interactions. For example, "social robots" [2, 3, 5, 9] are being used in a variety of social settings, as peer

tutors [18], to help engage autistic children [7, 8], and as companions for the elderly [4]. Other types of robots have emphasized the human interaction with our own human-made artifacts, as in industrial robots on an assembly line [1]. But humans also have strong desires, indeed needs, rooted in thousands of years of evolution, for contact with rich and varied natural forms and natural environments [29]. Thus the present study shows the emerging possibilities in human-robotic interaction of using telerobotics to help foster healthy relationships with the larger natural world.

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