The Japanese Garden: Task Awareness for Collaborative Multitasking

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ABSTRACT
Most technical support for multi-tasking considers multi-tasking as a single-user activity. We consider multi-tasking instead as a collaborative activity and in this paper, we report on a prototype designed to help people manage interruptions by broadcasting to colleagues their availability for interruptions for specific projects. The prototype is designed as a tangible interface, a desktop "Japanese Garden" where rocks represent a person's projects. We first performed ethnographic observations of the prototype in a natural work environment and found that users used the prototype easily to signal work on their current task-at-hand. However, we found that social agreements are needed as well as a technical solution. We then conducted an experiment to test the use of the prototype compared to using a chat system alone to signal availability for interruptions. Our results showed that with our prototype, task performance results did not differ, but collaborating partners sent significantly fewer coordination messages, fewer inappropriate messages, and produced fewer interruptions. We discuss future design ideas using tangible interfaces to manage multi-tasking.

Categories and Subject Descriptors
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous. K.4.3 [Computers and Society]: Organizational Impacts – Computer-supported cooperative work.

General Terms
Design, Experimentation, Human Factors

Keywords
Multitasking, collaboration, interruptions, tangible interface, empirical study

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1. INTRODUCTION
As more digital devices are being developed and adopted in the workplace, this also creates the potential for faster and more access to information and people. This in turn leads to the challenge of managing more interactions, often in the form of interruptions. In recent years, the problem of managing interruptions and multiple tasks has begun to receive much attention, e.g. [2, 7, 8, 11, 13]. Though many of these studies have focused on individual work, we feel that multi-tasking can better be characterized as a collaborative effort since switching tasks often affects interdependencies with other teammates. Interactions and interruptions from other colleagues is a major factor in explaining why people switch tasks [18].

Managing interruptions can involve social or technical solutions. Social solutions such as "email-free Fridays" [1] have been attempted but involve collective buy-in for them to work. On the other hand, purely technical solutions such as sensors for determining appropriate points for interruption are good for detecting movement or computer actions but miss contextual information [9]. We are concerned with designing a technical solution to support social cooperation to enable information workers to have more control over when they can be interrupted by others.

Studies of information workers have revealed that they experience high levels of multi-tasking and interruptions [11, 18] which has been associated with high levels of stress [25]. Interruptions can be distracting and lead users to forget their main task focus [5]. In fact, task switching can cause the delay of task resumption up to 15 minutes, attributed to change of context [14]. Together, these results suggest that the timing, amount, and context of interruptions affect people and may even be detrimental to work.

2. MULTI-TASKING AS A COLLABORATIVE ACTIVITY
We view multi-tasking as a collaborative activity. Switching tasks often affects interdependencies with other teammates. How tasks are prioritized, and whether to interrupt or respond to a colleague involves negotiations between collaborating partners whose work might be interdependent. For example, a colleague might interrupt another to ask for information about a collaborative project proposal. The interrupted person may have been working on a different project (in collaboration with a different set of individuals) and after discussing the collaborative proposal, the person is faced with having to reorient back to the interrupted task. Research shows that it takes on average over 23 minutes to resume

work on an interrupted task [18]. Thus, collaborative work can affect interruptions which leads to additional consequences involved in resuming work.

Interruptions may be from colleagues who are physically collocated and thus have awareness of opportune times to interrupt (e.g. when hearing a colleague in the next cubicle hang up the phone). Interruptions may also be from colleagues who are at a distance and who may be working on a different task. In this case, distributed colleagues may lack awareness of when there is a natural breaking point or when it might be convenient for their colleague to handle an interruption [2]. While interruptions from other people can be beneficial, e.g. in gaining relevant information [13], they can also be distractions if they cause people to switch contexts or if they happen at an inappropriate time [11, 18]. Researchers in CSCW have been concerned with understanding how interruptions can be less invasive [2, 3, 9].

Our project is concerned with the notion that it is common for information workers to be involved in multiple collaborations. Each collaboration may involve a unique project with an associated set of people, timelines, and resources. People generally have different responsibilities on projects and different styles of working. People are thus not often synchronized in their tasks. One collaborating partner may seek information on project A from a colleague when in fact that person may be immersed in project B. Even if distributed partners can learn that their colleagues are busy (e.g. through the use of an awareness system) there is currently no system to our knowledge that can inform partners on exactly which task (or set of tasks) they are actively involved in.

Technical solutions to support multi-tasking have not considered this collaborative aspect, viewing multi-tasking instead as a single-user activity. Over two decades ago, the Rooms system [4], designed to support task-switching on the desktop interface, was based on the property of creating low user-overhead. Other single-user approaches have followed a similar design principle, supporting the resumption of interrupted tasks [10, 22] and management of multiple tasks [17, 21, 24].

Designing systems to support multi-tasking involves a delicate balance of considerations. First, multi-tasking involves the rapid switching of tasks. Empirical studies show that people switch tasks about every three minutes [11]. Providing awareness information about collaborating partners' current tasks-at-hand could be beneficial in helping partners align their tasks and interactions. On the other hand, such information might introduce additional overhead especially during times of fast task switching.

We maintain that it is less burdensome for the user to be interrupted on a task that they are already currently working on because the interruption would match the current task context. If the user needs to switch tasks to handle an interruption on a different task, then not only does this introduce a cognitive shift in context, but the user also then needs to keep track of the interrupted task to resume it later. In fact, interruptions are often nested [18]. Thus, not only is the timing of incoming messages important to consider in technical support but also the association between the contexts of the current task-at-hand and the interruption.

Off-the-desktop solutions may offer critical advantages for supporting multi-tasking. Solutions have explored off-the-desktop solutions for managing interruptions or displaying colleagues' availability in distributed groups [12]. The physical environment has also been utilized in the form of a physical door of an office as an interruption gateway [21] and in displaying the "ins and outs" of colleagues both on physical walls and online [20].

Tangible interfaces in particular may offer advantages for supporting multi-tasking. First, workplace studies of multi-tasking revealed that users mostly used tangible artifacts to keep track of their interrupted work, such as post-it notes or email printouts [11]. Second, the design of tangible interfaces utilizes a different sensory channel for the user other than the visual 2D information from the GUI. Much research in psychology shows that there is independence among different sensory channels and people can multi-task better using input from different modalities [e.g. 26]. Third, tangible interfaces have been argued as being intuitive to use [15], which may be critical for reducing physical and mental workload especially during periods of high task-switching. It is especially important to not introduce extra overhead to the user [4]. Thus, we feel that tangible interfaces provide a promising research direction to explore.

3. THE JAPANESE GARDEN: A TANGIBLE INTERFACE

We use a sociotechnical approach to support multitasking. Such an approach assumes that social interaction in conjunction with technical support together can help people manage multitasking. Our goal is to provide users with an intuitive tangible interface to support the collaborative aspect of multitasking by enabling users to easily notify colleagues of their current task-at-hand. The motivation for our system design is based on the idea that users should be in control of what interruptions they choose to receive, when, and from whom. For example, if one is working to create an agenda for an upcoming meeting and a colleague stops by to notify her that some colleagues will not attend, then this could be an opportune time to be interrupted. The interruption allows the person to change the agenda while all the task concerns are still fresh in her mind. We therefore expect that giving a user control of notifying others of what tasks they are available for interruption could be beneficial. First, it enables users to control when they want to be interrupted and for which topic. It is a way to help people manage stress. Second, a user can control their privacy. They can direct the broadcast of their current task context to those who they choose. Third, it may invite productive feedback about their current tasks-at-hand.

Our prototype consists of two parts, 1) a tangible interface for users to arrange and broadcast availability of each project for interruptions and 2) a GUI that displays one's current project context to distributed colleagues. Given that empirical studies have shown that multi-tasking is associated with stress [19], we were motivated to design an interface that could connote a tranquil space. The tangible interface is inspired by a Japanese rock garden design, a "*tranquil sanctuary that allows individuals to escape from the stresses of daily life*".[1]

Japanese rock gardens, or Karesansui in Japanese, consist of raked white sand to help people recall waves or rippling water, and are designed to evoke feelings of tranquility [16]. The action of raking white sand allows people to focus their concentration. Creating a Japanese garden involves arranging rocks, and the positions of rocks evoke contemplation. One of the most famous Japanese gardens is located at Ryoan-ji in Kyoto, Japan, where 15 irregular shaped rocks are arranged on white raked sand. Interestingly,

[1] http://en.wikipedia.org/wiki/Japanese_garden.

people can see only 14 out of 15 rocks from whatever position they are at in the garden. One interpretation is that no one can see perfection. Figure 1 shows an image of this rock garden.

The interface is designed as a miniature Japanese garden, a small sandbox with colored rocks, each rock representing a different project of a user (Figure 2). While we would hope that our Japanese garden prototype would connote tranquility, our intention is to provide an intuitive and tangible interface for managing multiple projects. As people switch tasks at a rapid rate, we reasoned that moving small rocks on a desktop interface would be fast and very intuitive. We also felt that a miniature setting of a desktop Japanese garden could also be “playful” for users and that tangible icons in the form of rocks would serve as personal visual placeholders for the status of projects.

Figure 1. A rock garden by the temple of Ryoanji in Kyoto, Japan.

Figure 2. The Japanese Garden prototype system

This prototype has three components: color recognition, a server, and a GUI, written in Visual C#. Color recognition is employed to identify each different colored rock in the sandbox, each representing a user’s different project. The color recognition component reads thresholds from a setting file in a client computer, and then identifies each different color in an image recorded every second by an overhead camera. The data detected by color recognition is sent to a server, and these data include time, the color names, and the rock locations, as well as a user name and project names that a user chooses. Users can replace their own names and project names when changing the information in a setting file. The server component combines these data from all clients and sends it to all clients. Data is designated as either ‘private’ or ‘public’ status based on the quadrant in which the rock is placed, in the interface. Four types of statuses correspond to the four quadrants (see Figure 3): public/active (upper right), public/inactive (lower right), private/active (upper left), and private/inactive (lower left).

If the data is private (based on the rock’s position in one of the private quadrants) then it is only displayed to the user. Otherwise, if the data is recognized as public, based on the rock’s position in a public quadrant, then the project name is displayed in a task window on a GUI to all users who subscribe to this information (Figure 4). The GUI display shows each user’s own project status of public or private, active or inactive. The status on private projects is not shown to other users.

Figure 3. The Japanese Garden interface with four quadrants: public/active (upper right), public/inactive (lower right), private/active (upper left), and private/inactive (lower left).

Thus, if a user begins to work on a project and decides that she wants to be available to others to discuss that project while she is working on it, then she places a rock (representing that project) in the public/active quadrant of the sandbox. This communicates to those who subscribe to that information (and who the user accepts as subscribers) that she is available to be interrupted about that project. For example, if Joan places her blue “grant proposal” rock in the public/active quadrant, then Bill, who has subscribed to Joan’s information (with her consent), sees on his display that Joan is currently working on their joint project. She is signaling that she is open to interruptions about that proposal. Bill might then decide to phone Joan to discuss the proposal.

Multiple rocks can be placed in the public/active quadrant, indicating that the user can be interrupted concerning any of those projects. The private/active quadrant is for the users’ personal task management. This information is not broadcast to other users. Public/inactive and private/inactive statuses serve as personal visual “reminders” to the user that these projects are currently pending. They might be projects that have been interrupted and need to be resumed or may be other projects that need to be managed for which the user wants a visual reminder.

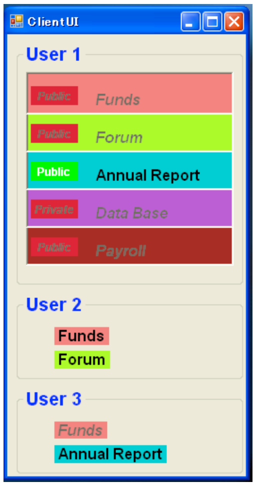

Fig. 4. Task availability window

4. OBSERVATIONS OF THE PROTOTYPE USE IN REAL WORK SETTINGS

We first examined our prototype by observing users working with the interface in their real work settings. In a user's natural work environment we can better understand how the prototype would be used under real multi-tasking conditions. We were specifically interested in 1) how intuitive the interface would be, 2) whether users would use the tangible rock icons to indicate their availability for interruptions, and 3) how this affects the timing of external interruptions. We tested our prototype with pairs of colleagues who worked as staff in a large research university. All participants were information workers with multiple projects who multi-tasked. They were asked to perform their work in their usual way while using the Japanese Garden prototype.

Three pairs of participants were observed, with work roles of accountant, financial officer, program director, software engineer, and technical assistants. These pairs collaborated together on multiple projects. These colleagues sat in different offices, usually in the same hallway. Each person in the pair was given a Japanese Garden prototype installed on a laptop computer. All participants sat in their own office. The laptop computer served as a second display providing peripheral awareness of the colleague's tasks.

Each participant was asked to assign a different colored rock to represent a different project of theirs and we asked that the participants assigned rocks to represent their collaborative projects. Participants were asked to work naturally while moving the tangible icons (i.e. rocks) if they chose to change their availability to colleagues for interruptions on a project. Each pair used the system for two days and on one of those days an observer shadowed the user for the entire day by sitting next to the user in their office. Positions of rocks, color names, and time of movement were logged on the computer. Users were interviewed about their experience with the prototype using a semi-structured interview after the observations were completed.

4.1 Results of Observations

Participants were observed for a total of 27.2 hours over six days. Each user used the prototype for an average of 4.53 hours per day. Users averaged 4.8 (sd=0.75) individual projects and 2.3 (sd=1.37) common projects with his/her colleague.

Our observations revealed several interesting points. First, users tended to utilize a physical feature of a rock icon in order to express a feature of each project. For example, three users assigned a large or important project to a large or a red colored rock which was more noticeable than the other rocks.

In the same way that a large-scale Japanese garden often provides a personal experience for a visitor, we also found that the users personalized the use of the prototype. Users often commented on how the rocks reminded them of certain attributes of a project. One user, for example, chose a brown rock (reminding her of a chunk of chocolate, her favorite food) to represent her favorite project.

We found that some informants had difficulty assigning tasks to categories (i.e. different rocks), required of the prototype. Also, different colleagues working on the same project divided up their same collaborative projects at different levels of granularity. For example, one user assigned one rock to an accounting project whereas their collaborating partner divided the project up into two rocks to indicate different aspects of the project. One informant stated that she has a number of projects which are complicated, and that she is at different stages in these projects. For this reason, it is somewhat difficult for her to categorize each project and assign it to a tangible icon. The observations along with the interviews suggest that it can be difficult for users to figure out the granularity of the project that they want to represent. One informant explained that if she categorized projects at a small unit, then she might have to manipulate the rock icons every minute, and she cannot afford to do that in real work. Thus, assigning projects to the rock icons may require time in use of the interface until informants work out the right level of granularity. The fact that collaborating partners understood different levels of granularity for projects suggests that it is important for collaborating partners to define their projects together.

There was also variability in when a rock was used to signal availability. Some informants did not always move a tangible icon when small deviations from a current project occurred, such as checking email or browsing a schedule list associated with the email. From interviews, users explained they tended to move the rocks only when they felt that they had really switched projects and were thus ready and available to be interrupted on a different project.

Some icons were moved quite often while others were hardly touched at all. The rock icons that were not touched tended to be in the inactive area. This observation indicates that though people have multiple projects some remain in the "background". In interviews, informants described that these rocks served as a reminder or visualization of their personal projects. One reason for not moving the icons might also be related to how users categorized their projects. On the other hand, some icons were moved often by users in order to control interruptions from their partner when they switched projects, left their office for some errands, or interacted with colleagues who came to their offices.

Some informants frequently moved the tangible icons and switched to another project when they felt "stuck" on a current project. They reported that when they were near completion of a project and intended not to resume it for a while, they wanted to change their mood and did this by moving the icon. Moving the icon was a way for them to keep track that they were setting the project aside for a period, and yet it remained visual as a reminder that the project needed to be resumed.

Some informants kept multiple tangible icons in the public/active quadrant simultaneously. In the post interview, these informants stated that those projects were associated with each other, so that even though they were dealing with only one current task at-hand, they were available and ready to manage interruptions on the related projects as well.

In sum, during our observation period users actively used the prototype to signal their availability for interruptions. In interviews, our informants reported that the tangible interface was easy to use and they even felt relaxed using it. One informant reported that she enjoyed playing with the rocks in the garden. Thus, our observations suggest that such a tangible interface would not create too much extra overhead in the context of multi-tasking. Our observations also suggest that social agreements are also needed (e.g. agreeing on how to define common projects) for the technical system to work in a collaborative context.

However, despite the fact that users seemed to enjoy working with the tangible interface, we reasoned that there are other technical methods for signaling availability, most commonly Instant Messaging (IM). Though notifications from IM have been reported as disruptive [6], many information workers keep chat windows open. Thus, a tangible interface would involve learning a new system for the user. So why introduce a new system if users could use an already adopted technology and simply use it to broadcast their availability? Following Rogers [23], the value of new technologies is related to whether they offer a relative advantage to the technology that is currently used.

IM is somewhat different than the Japanese Garden system, but our goal was not to conduct a study that examines the effect of specific features of the Japanese Garden but rather to contrast the Japanese Garden with what is currently adopted and commonly used in practice to signal availability. IM is commonly used for showing availability and shares broadcasting features with the Japanese Garden. We chose IM as a contrasting condition to explore: why introduce a new system when IM is already widely adopted and can perform the similar function of broadcasting (task) availability? In experimental drug trials, new drugs are pitted against those drugs already adopted. One major difference between our prototype and IM is that with the Japanese Garden, one can broadcast multiple projects for which one is interruptible, and one can easily change the combinations of projects for which one is interruptible.

We decided to examine whether our prototype would contain advantages for the user compared to using IM to signal their availability for interruptions. We therefore decided to test this experimentally. We present our hypotheses next.

4.2 Hypotheses

Based on our observations we came up with the following hypotheses to test possible advantages for using our prototype, the Japanese Garden, over IM, to signal availability for interruptions.

H_1: Using the prototype to broadcast the specific task that one is working on will require less messages concerning coordination compared to using Instant Messaging.

IM differs from our prototype in that it is difficult with IM to signal complex combinations of availability on multiple projects at one time (i.e. that one can be interrupted on projects A, B, or C but not on projects D or E). We therefore expect that indicating which task one is working on will require less communication involving coordination with the prototype system. On the other hand, we expected that there would be more coordination messages about a task when one is using IM compared to our prototype.

H_2: Using the prototype to broadcast specific tasks that one is working on will lead to fewer interruptions compared to using Instant Messaging.

We expect if users have the opportunity to broadcast a specific task that they are working on currently, and which consequently also indicates that they are *not* available for other specific tasks, then colleagues will be less likely to interrupt them on a different topic. Thus, there should be fewer interruptions. Colleagues might be willing to wait until they see that their colleague is working on the same project so as to not lead their colleague to shift contexts.

H_3: Interruptees will perceive that it is easier to change their availability for interruptions using a tangible interface compared to using Instant Messaging.

We expect that users will perceive the action of moving a rock in the desktop garden prototype to be easier than changing the status on an IM client. While most IM clients allow users to easily show whether their status is available or not, it is more complex to type in free text combinations of task availability (i.e. available on Task A or B, but not C). One can show these task combinations easier with the prototype by simply moving the rock icons.

H_4: Interrupters will perceive that it is easier to be aware of their partner's availability using a Japanese Garden interface compared to using Instant Messaging.

We expect that interrupters will also perceive benefits in using the prototype as they will be aware not only of the partners' availability but also of the specific tasks that their partner is working on. We expect that this additional awareness information would be perceived as a benefit for the interrupter.

5. EXPERIMENT

Our goal in the experiment was to simulate a multi-tasking environment by asking subjects to work on multiple tasks. We compared the use of our prototype system with Google Talk, an Instant Messaging client, to compare how these systems affect the participants' task performance, awareness of the partner's work, and interruption behavior. We used two experimental conditions as follows.

Japanese Garden prototype. In this condition subjects worked on tasks using the Japanese Garden prototype to signal their availability for interruptions, along with using Google Talk for chat communication about the task. Users could change their availability for working on a task by moving the rock icons on the Japanese Garden interface.

Google Talk Alone. In this condition subjects worked on the same tasks using Google Talk without the prototype. When users changed their availability in Google Talk, they changed their current status using the pull-down list on the interface: the Interruptee selected a green bar in the menu that indicated they were free for interruptions concerning the task and a red bar indicated they were not available. Informal observations of IM suggest that these two types of status are used most often as opposed to specific task status.

Thirty people participated in the experiment working in pairs, for a total of 15 pairs. Participants were undergraduate students at a large U.S. west coast university. All had experience with computers and the use of IM systems. Subjects received either extra credit in a course or $10 for their participation.

We used a within-subjects experimental design. Working in pairs, subjects performed a set of tasks, with either the Japanese Garden prototype or Google Talk alone. They then performed the same set of tasks using the other system. The order in which the conditions were assigned was counterbalanced. Each session lasted for 18 minutes. The entire experiment including an instruction and a practice session lasted for about one hour.

Subjects entered the experimental room, were greeted by the experimenter, and the experiment was explained to them. After training, subjects then conducted two sessions of the experiment working on the tasks (using the Japanese Garden or Google Talk alone, counterbalanced). At the end of each session subjects filled out a questionnaire.

Participants sat in the same experimental room with a divider between them. Participants were instructed not to talk with each other but to communicate only using chat. One person in the pair was randomly designated the "Interruptee" and the other person in the pair was designated the "Interrupter".

5.1 Experimental Tasks

Both partners in the pair needed to multitask as they were asked to solve three crossword puzzles. The Interruptee was given an answer key of 15 answers (out of about 64 questions) for each puzzle in advance. The Interrupter was told that the Interruptee had puzzle answers. In addition, the Interruptee was also asked to play the TETRIS game as well as work on the three crossword puzzles. TETRIS is a video game that involves matching up block shapes as they fall vertically down the computer screen in order to create a horizontal line of shapes without spaces. TETRIS requires continual concentration on the game in order to match up the block shapes because the shapes are moving continuously across the screen. Subjects were told to perform as best as they could on the tasks. During the experimental session, the Interruptee played TETRIS for two minutes, and then the experimenter indicated to the subject that they needed to switch tasks to work on a crossword puzzle. After four minutes, the Interruptee was then instructed by the experimenter to resume playing TETRIS. Because there was a divider between the two subjects in the pair, the Interrupter did not see the experimenter indicate task changes (nonverbally) to the Interruptee. The process repeated for the rest of the experimental session. Interruptees were not told the amount of time they had to play TETRIS or the crossword puzzles. The Interrupter only worked on crossword puzzles and could work on any puzzle he or she chose.

Thus, the Interrupter was not aware of what task the Interruptee was working on, i.e. either TETRIS or a crossword puzzle, and was not aware which puzzle the Interruptee was currently working on. Subjects were told to perform as best as they could on the tasks. Subjects were not instructed to work collaboratively. However, the Interrupter was told they could ask the Interruptee questions about the answer keys. This involved interrupting the partner. From the Interruptee's perspective, it would not be a good time to be interrupted while playing TETRIS as this game demands continual attention. In this case, interruptions would likely be disruptive. Also, when the Interruptee is working on crossword puzzle #1, a question from the Interrupter about an answer for crossword puzzle #3 could also be disruptive. The reason is because the Interruptee would then have to switch concentration from puzzle #1 to #3. Subjects were told to perform on the tasks as well as they could.

5.2 Experimental Measures

We measured the following items to compare our prototype with Google Talk alone.

• TETRIS scores of Interruptees
• Crossword puzzle scores of Interruptees
• Crossword puzzle scores of Interrupters
• The number of interruptions from Interrupters (Subjects were not instructed to work collaboratively, but the Interrupter was told that they could ask the Interruptee for puzzle answers. Therefore, we consider all chat messages sent from the Interrupter to the Interruptee to be interruptions.)
• The number of chat messages from Interruptees to Interrupters (as measured by the number of chat messages that the Interruptee sent to the Interrupter.)

In addition we measured message content in two categories: messages concerning "coordination" and "inappropriate" messages. Details of these measurements are described later.

6. RESULTS

6.1 Overview of experiment

During training, we felt that the participants spent enough time before the experiment to become accustomed to using our prototype as well as Google Talk during their tasks of playing TETRIS and solving the crossword puzzles. We intentionally made the experiment simple as our aim was to focus on how the prototype affected interruptions. The participants reported that they had no difficulties in using either our prototype or Google Talk. A t-test showed no differences were found in the results of subjects who received extra credit or payment ((TETRIS scores with prototype: $p<.933$, and with Google Talk $p<.301$; Puzzle scores of Interruptees with the Japanese Garden $p<.240$, and with Google Talk $p=.589$; Puzzle scores of Interrupters with a Japanese Garden $p<.623$, and with Google Talk $p<.396$)).

Sometimes there was confusion on which task the partner was working on. For example, when Interrupter John was working on puzzle #1, he sent to his partner Nancy that "#36 across was HERO, and #37 was GREW." He did not mention to her which puzzle he was working on. However, Nancy was working on puzzle #2 at that time. Both John and Nancy believed that they were working on the same puzzle, but the number of letters which John sent to Nancy didn't match with her puzzle #2. Then, Nancy asked John: "#36 isn't wrong?" and John replied "Which puzzle are you working on?" Nancy answered "2" and John said "Oh, that was for puzzle #1. Ummmmm". Finally, they realized they were working on a different puzzle, coordinated which puzzle they needed to work on, and John switched from puzzle #1 to #2.

Here is another example of chat in Google Talk Alone:

```
I have owe
for 6 down?
yes
for puzzle #1?
lol
I have puzzle #2
Oh
lol. No wonder it don't make any sense
```

These miscommunications happened nine times during just the condition of Google Talk Alone in the experiment.

6.2 Quantitative results

Table1 shows the means and standard deviations of the scores for TETRIS and crossword puzzles (of Interrupters and Interrupters) and the average number of coded chat messages (described in the previous section). Although the average scores of TETRIS and crossword puzzles using the Japanese Garden were higher than the scores using Google Talk Alone, a paired t-test showed the results did not reach a significant difference (for TETRIS: p<.66, puzzle for Interruptees, p<.55, puzzle score for Interrupters, p<.78.

A paired t-test showed that the average number of interruptions from Interrupters using the Japanese Garden (mean=21.7, sd=6.6) was significantly *less* than the number of the interruptions using Google Talk alone (mean=26.2, sd=9.6, t(14)=2.22, p<.05).

	A Japanese Garden (Avg.(sd))	**GoogleTalk (Avg.(sd))**	**p value**
TETRIS score (of Interruptees)	7371.6 (7004.4)	6634.5 (4135.8)	.655
Puzzle score (of Interruptees)	16.8 (9.9)	15.67 (6.2)	.550
Puzzle score (of Interrupters)	34.0 (17.0)	32.8 (15.2)	.779
Interruptions from Interrupters	21.7 (6.8)	26.2 (9.6)	.046 *
Messages sent from Interruptees	18.7 (5.6)	21.3 (6.3)	.107

Table 1. Results of TETRIS score, puzzles score, and the number of interruptions. N=15 Interrupters, 15 Interruptees.

However, a paired t-test showed that the average number of messages from Interruptees was not significantly different using the Japanese Garden (mean=18.5, sd=5.6) and Google Talk alone (mean=21.3, sd=6.3, t(14) =1.80, p<.11).

6.2.1 Questionnaire results

Table 2 shows the questionnaire results. A paired t-test showed that Interruptees reported that they felt it was significantly easier to change their availability using the Japanese Garden (mean=3.8, sd=1.0) compared to Google Talk Alone (mean=2.7, sd=1.1, t(14)=3.67, p<.003). Interruptees responded that they felt 'the system was useful in enabling interruptions to occur at a good time', significantly more for the Japanese Garden (mean=3.8, sd=1.3) compared to using Google Talk alone (mean=2.6, sd=1.3, t(14)=2.69, p<.02). The Interrupters reported that they believed that the Interruptees replied to their messages significantly quicker when utilizing the Japanese Garden (mean=3.7, sd=0.8) compared to Google Talk Alone (mean=3.2, sd=0.9, t(14)=2.45, p<.03). The Interrupters also reported that the Japanese Garden (mean=4.5, sd=0.7) was significantly more useful in showing awareness of when it was a good time to interrupt their partner than GoogleTalk Alone (mean=3.7, sd=1.0, t(14), p<.03).

	Questionnaire items	Japanese Garden (Avg. (sd))	GoogleTalk (Avg. (sd))	p value
Interruptee	It was easy to change my availability.	3.8 (1.0)	2.7 (1.1)	.003 **
	The system was useful in enabling interruptions to occur at a good time.	3.8 (1.3)	2.6 (1.3)	.017 *
Interrupter	It was easy to be aware of my partner's availability.	4.6 (0.6)	3.9 (1.0)	.044 *
	My partner replied to my messages immediately.	3.7 (0.8)	3.2 (0.9)	.029 *
	The system was useful in showing awareness of a good time to interrupt my partner.	4.5 (0.7)	3.7 (1.0)	.028 *

Table 2. Results of questionnaires with 5 point scale, 1=low, 5=high (*=p<.05, **=p<.01).

Table 3. shows the results of a questionnaire using a nominal 5-point scale to compare the systems, where 1 meant 'definitely agree for Google Talk', and 5 meant 'definitely agree for Japanese Garden'. A score closer to '5' on the scale to answer the question "Which was better at informing your availability?" meant they agreed more that the Japanese Garden was better at informing their status and a score closer to '1' indicates they agreed more that Google Talk was better for that item.

The results show that all Interruptees felt that the Japanese Garden was more fun to use than Google Talk (mean = 5, sd=0.0) and Interrupters also agreed the Japanese Garden was more fun to use (mean = 3.9, sd=1.4) even though they only viewed the GUI display. Both Interrupter and Interruptee viewed the Japanese Garden as less disruptive than Google Talk Alone. Both subjects in the pair favored the Japanese Garden for awareness and both reported they preferred the Japanese Garden for their daily work.

	Questionnaire Items	Japanese Garden = 5 Google Talk = 1
Interruptee	Which system was better at informing about your availability?	3.6(SD=1.4)
	Which system was less disruptive?	4.1(SD=1.1)
	Which system would you prefer to use in your daily work?	3.7(SD=1.4)
	Which system was more fun to use?	5 (SD=0.0)
Interrupter	Which system was easier to show awareness of your partner's availability?	3.7(SD=1.3)
	Which system was less disruptive?	3.6(SD=1.4)
	Which system would you prefer to use in your daily work?	3.7(SD=1.0)
	Which system was more fun to use?	3.9(SD=1.4)

Table 3. Questionnaire results where '5'= definitely agree with the Japanese Garden while '1' = definitely agree with Google Talk. Average scores and sd shown.

6.2.2 Message content

We also analyzed the contents of the chat messages to understand how our system changed participants' collaboration behavior. We developed codes of "coordination" and "inappropriate" messages.

Messages were coded as involving *coordination*. Examples include if the subjects confirmed what they were working on currently, if a subject asked their partner which puzzle they were working on, or if a subject mentioned which puzzle they were working on.

Messages were coded as *inappropriate* if the Interrupter sent a message about the crossword puzzle while the Interruptee was working on TETRIS. This is a special case of interruption. It would presumably be a more annoying type of interruption because in both conditions, the Interruptee signaled during TETRIS that they were not available for interruptions.

Chat messages were saved using screen recording software. One coder coded all chat messages. A second coder independently coded the messages for inter-rater reliability**.** Kappa statistics were: .91 for 'coordination' and .76 for 'inappropriate', which show very good agreement. Table 4 shows the results of the coding.

	Japanese Garden (Avg. (sd))	Google Talk (Avg. (sd))	p value
Coordination messages	2.8 (2.6)	6.2 (3.7)	.004 **
Inappropriate messages	3.5 (3.8)	5.5 (5.0)	.015 *

Table 4. Results of coded messages (*=p<.05, **=p<.01).

Coordination messages: Google Talk Alone subjects sent significantly more messages coded as involving coordination (mean=6.2, sd=3.7) compared to subjects using the Japanese Garden (mean=2.8, sd=2.6, t(14)=3.61, p<.004).

Inappropriate messages: Google Talk Alone subjects sent significantly more messages coded as inappropriate (mean=5.5, sd=5.0), compared to Japanese garden messages (mean=3.5, sd=3.8), t(14)=2.84, p<.02.

7. DISCUSSION

In this paper we presented a tangible interface to help support the handling of interruptions and multi-tasking. We view multi-tasking as a collaborative activity, a joint production of work among collaborating partners. Our view was that partners should be able to inform each other of their availability to be interrupted on particular sets of tasks. In this sense, it should help give users more control over when they can be interrupted, by whom, and on what topic.

We found support for Hypothesis 1, where fewer messages concerning coordination were sent with the Japanese garden. This suggests that the Japanese Garden did communicate enough about coordination, such that, it reduced the amount of coordination done via chat.

Hypothesis 2 was also supported, which stated that there should be fewer interruptions using the Japanese Garden. Further, in examining what we expect to be more annoying interruptions (interruptions during TETRIS, which were coded as "inappropriate"), we also found significantly more of these types of interruptions with Google Talk Alone. One might question whether it is a good or bad thing to receive fewer interruptions. After all, interruptions can be beneficial, especially when informing people about relevant ideas. Interruptions can also have a social benefit, e.g. as a relief from work. We argue that it depends on context. In the *context* of our experiment, where the TETRIS game required continual attention, interruptions would not have been desirable. However, it is important to keep in mind that despite more interruptions, task performance was unaffected with TETRIS. However, since the Japanese Garden prototype was rated higher on several dimensions we argue that in the case of this experiment, fewer interruptions was a good thing. Certainly interruptions have been shown to induce stress [19]. It is possible that had we measured stress, it may have been rated higher with Google Talk Alone, since there were more interruptions. We would speculate that more interruptions during TETRIS would lead to higher stress since the game requires continual concentration.

Hypothesis 3 was also supported, where subjects reported that the Japanese Garden was easier to use than Google Talk alone. Similarly, Hypothesis 4 also received support; subjects reported that it was easier to both inform, and to be informed of, a partner's availability using the Japanese Garden. The Interrupters also reported on average that the Interruptees replied to messages more immediately when using the Japanese Garden. If people are using chat for multiple conversation threads, then we would maintain that it would be more difficult to be aware of a partner's specific project use amidst other conversation threads. Our results suggest that in the context of our experimental tasks, the Japanese Garden prototype helped inform participants of the opportune time to exchange task messages.

While there were fewer messages about coordination and inappropriate messages with the Japanese Garden than with Google Talk, no significant differences between all task scores were found for the two systems. It is possible that our tasks were too easy, or perhaps we did not introduce enough tasks to model a typical information workers' environment. Further research is needed to see how well the system functions with more tasks and more complex work.

We argue that the Japanese Garden provides benefits for the Interrupter as well as the Interruptee. The benefit for the Interruptee is that it provides a degree of social control by enabling them to control the amount and target of interruptions. Our reasoning was that users would signal to collaborating partners their current tasks-at-hand so that their colleagues can gear interruptions to match that context. Our observations did show that users did regularly use the tangible interface to signal their availability. However, we also maintain that our prototype provides a benefit for interrupters as well. Interrupting a colleague while a task is fresh in their mind could provide better and more relevant information for the interrupter.

We feel that our system can perhaps best have potential as a means for negotiating interruption of time between collaborating partners. Certainly there are time-sensitive issues when one must immediately get information from a colleague. A system such as the Japanese Garden informs that person that their colleague has deliberately broadcast that they are available for interruptions on particular tasks. Though an interrupter may override this information and interrupt anyway, at least it is an interruption with knowledge about their colleague's immediate context. Of course such deliberate interruptions can lead to interesting social dilemmas and future research should examine this.

Perhaps the biggest benefit of such a task awareness system is that it informs collaborating partners specifically which task their partner is working on. There may be indirect benefits that could be further explored such as social facilitation, where partners may be motivated to perform knowing that their colleagues are making headway on a task. Another potential benefit is that colleagues can be reminded on work needed for collaborative tasks as they become aware of what their partners are working on. Again, this could be further investigated.

Our observations revealed that social agreements are needed to best use the technical system. Informants sometimes used different levels of granularity to define their tasks which suggests that it is critical for users of the system to collaboratively define how to symbolize their tasks. We learned that different people parse up tasks in different ways. For example, to one person an entire proposal could be a single project whereas to their collaborating partner, the narrative and budget could each be defined as separate projects. The work of collaboratively defining how tasks are parsed could have a hidden benefit in making collaborating partners more aware of how their partners view and conduct work on tasks.

Perhaps an important benefit is that the system is perceived by subjects as fun to use. In our observations users reported that they enjoyed having the desktop garden and some found it evoked a feeling of relaxation, perhaps thinking of a full scale Japanese Garden. Subjects reported that they wanted to use the Japanese Garden in their daily work. In the stressful work life of information workers, an interface that is not perceived as disruptive but rather fun could be an undervalued benefit. Of course this could be a novelty effect, and a longer study *in situ* would be needed for a deeper examination of the role that a "fun" interface plays in supporting work and collaboration.

To our knowledge, the Japanese Garden is the only collaborative task management system with which users can indicate their receptivity to interruptions related to a specific task, and to multiple tasks they are working on. Certainly, the custom set "away" messages in many IM systems could be adapted to indicate availability/unavailability for a single topic, but not for multiple topics simultaneously. We believe that the novelty of the Japanese Garden is that users can easily broadcast their availability for interruptions on combinations of projects, as well as indicating projects for which they are not available for interruptions. Displaying such complex availability in a task-switching environment would be far harder with IM even though people can type in free text. Our informal observations suggest that users rarely type in their current task-at-hand in IM but rather use generic "busy" and "available" statuses. Our prototype also is different than other systems which only show person status for availability, irrespective of the project [2, 9, 12].

7.1 Design for multi-tasking

We feel that there are more ways that the tangible interface could be exploited to give users additional information that they could use to manage projects. Project details such as due date could be tied to the tangible icons through means other than on the GUI interface. For example, the tangible icons could be instead objects that contain lights inside to indicate reminders or "hotness" of the due date. A flashing rock could indicate for the user that a task is pending or that a deadline for that project is near. We feel that there are more ways to experiment with the icons themselves, such as using icons that change color, or using flexible forms that change shape to convey project information. Tangible icons could also be constructed so that the names of projects are programmed to appear inside the rock, i.e. through digital means. The rocks themselves can be sensors that can provide the user information, e.g. of the heat of their hand, how strong they grip the rock, or the speed of placement.

Another direction to explore is a collaborative interface not involving a GUI, where when one partner moves their icon representing a common project, the icon on the partner's display moves correspondingly. We can also envision games involving the tangible interface and projects, e.g. to see which partner can finish their work on a project first, reflected by their icon moving first on the two displays.

We also feel that the tangible display could provide more information to the user. For example, the computer could remind one if a project is pending too long, i.e. if it is in the private/inactive space too long. Users can even set a time frame for how long they want an icon to remain inactive, e.g. "5 days for the tangible icon paper". Users can then receive a reminder after five days.

8. CONCLUSION AND FUTURE WORK

In this paper, we reported on a prototype modeled after a Japanese Garden which enables users to signal to others their availability for interruptions based on their current work context. We feel this is a first step in enabling users to gain more control over their interruptions. Although our observation and experiment were just first steps to understand how users utilize our prototype, these results indicate some future research directions for exploring how tangible interfaces can support multitasking. First, this tool can be used to study social and collaborative aspects of interruptions such as negotiations. We also envision a cost structure build into the tool so that collaborating partners can allocate their time with others as a limited resource. We will also explore how we might help users define the granularity of common projects, and how we might better exploit the interface for personal task management.

The Japanese Garden is a first step in examining how task management systems can support collaborative work on multiple tasks. It is not clear how scalable such a system might be. Empirical studies show that people average working on 11 different tasks [18]. We feel that this seems to be a reasonable number of tasks that this prototype could support with daily use. However, if people define tasks at a much finer level of granularity, then this creates a challenge for scalability and needs to be further explored.

9. REFERENCES

1. ABC News, Fridays go from casual to email free. http://abcnews.go.com/Business/CareerManagement/story?id=3693216&page=1, Oct. 5, 2007.
2. Begole, J.B., Matsakis, N.E., and Tang, J.C. Lilsys (2004). Sensing unavailability, *Proceedings of CSCW 2004*, ACM Press, 511-514.
3. Begole, J. B., and Tang, J. C. (2007). Incorporating human and machine interpretation of unavailability and rhythm awareness into the design of collaborative applications, *Human-Computer Interaction*, 22 (1), 7-45.
4. Card, S.K. & Henderson, A.H. (1987). A multiple, virtual-workspace interface to support user task switching. In *Proceedings of the CHI/GI'87*, 53-59.
5. Cutrell, E., Czerwinski, M. and Horvitz, E. (2001). Notification, disruption, and memory: Effects of messaging interruptions on memory and performance. *INTERACT '01*, 263-269.
6. Czerwinski M., Cutrell E. & Horvitz E. (2000). Instant messaging and interruption: Influence of task type on performance, *Proceedings of OZCHI'00*, 356-361.
7. Czerwinski, M., Horvitz, E. and Wilhite, S. (2004). A Diary Study of Task Switching and Interruptions. *Proceedings of CHI'04*, ACM Press, 175-182.
8. Dabbish, L. and Kraut, R. (2004). Controlling interruptions: awareness displays and social motivation for coordination. *Proceedings of CSCW'04*. 182-191.
9. Fogarty, J. Lai, J., and Christensen, J. (2004). Presence versus availability: the design and evaluation of a context-aware communication client, *International Journal of Human-Computer Studies*, 61 (3), 299-317.
10. Franke, J.L., Daniels, J.J. and McFarlane, D.C. (2002). Recovering context after interruption. *CogSci 2002*, 310-315,
11. Gonzalez, V. and Mark, G. (2004). "Constant, Constant, Multi-tasking Craziness": Managing Multiple Working Spheres. *Proceedings of CHI'04*, 2004, 113-120.
12. Greenberg, S. and Kuzuoka, H. (2000). Using Digital but Physical Surrogates to Mediate Awareness, Communication and Privacy in Media Spaces. *Personal Technologies*, 4(1), 182-198.
13. Hudson, J.M., Christensen, J., Kellogg, W.A. and Erickson, T. "I'd be overwhelmed, but it's just one more thing to do:" Availability and interruption in research management. *Proceedings of CHI'02*, 97-104, 2002.
14. Iqbal, S.T. and Horvitz, E. (2007). Conversations Admist Computing: A Study of Interruptions and Recovery of Task Activity. *Proceedings of User Modeling '07*, 360-364.
15. Ishii, H. and Ullmer, B. (1997). Tangible Bits: Towards Seamless Interface between People, Bits, and Atoms. In *Proceedings of CHI '97*.
16. Japanese Rock Garden. http://en.wikipedia.org/wiki/Japanese_rock_garden
17. Kaptelinin, V. (2003). UMEA: translating interaction histories into project contexts. *Proceedings of CHI'03*, 353-360.
18. Mark, G., Gonzalez, V., and Harris, J. (2005). No Task Left Behind? Examining the Nature of Fragmented Work. *Proceedings of CHI'05*, 321-330.
19. Mark, G., Hausstein, D., and Kloecke, U. (2008). The cost of interrupted work: More speed, more stress. *Proceedings of CHI'08*, 107-110.
20. Moran, T., Saund, E., Van Melle, W., Gujar, A.,Fishkin, K., and Harrison, G. (1999) . Design and technology for collaborage: collaborative collages of information on physical walls. *Proceedings of CHI'99*, 197- 206.
21. Nichols, J., et al., (2002). Mediator and medium: Doors as interruption gateways and aesthetic displays. *Proceedings of DIS'02*, 379-386.
22. Robertson, G., van Dantzich, M., Robbins, D., Czerwinski, M., Hinckley, K., Risden, K., Thiel, D., and Gorokhovsky, V., (2000). The task gallery: a 3D window manager. *Proceedings of CHI'00*, 494-501.
23. Rogers, E. M. (1995). *Diffusion of innovations* (Fourth ed.). New York: The Free Press.
24. Smith, G., Baudisch, P., Robertson, G., Czerwinski, M., Meyers, B., Robbins, D., and Andrews, D. (2003). GroupBar: The TaskBar evolved. *Proceedings of OZCHI'03*, 34-43.
25. Su, N. and Mark, G. Communication chains and multi-tasking. *Proceedings of CHI'08,* ACM Press (2008), 83-92.
26. Wickens, C. D. (1980). *The Structure of Attentional Resources. Attention and Performance*. Hillsdale, NJ: Erlbaum.