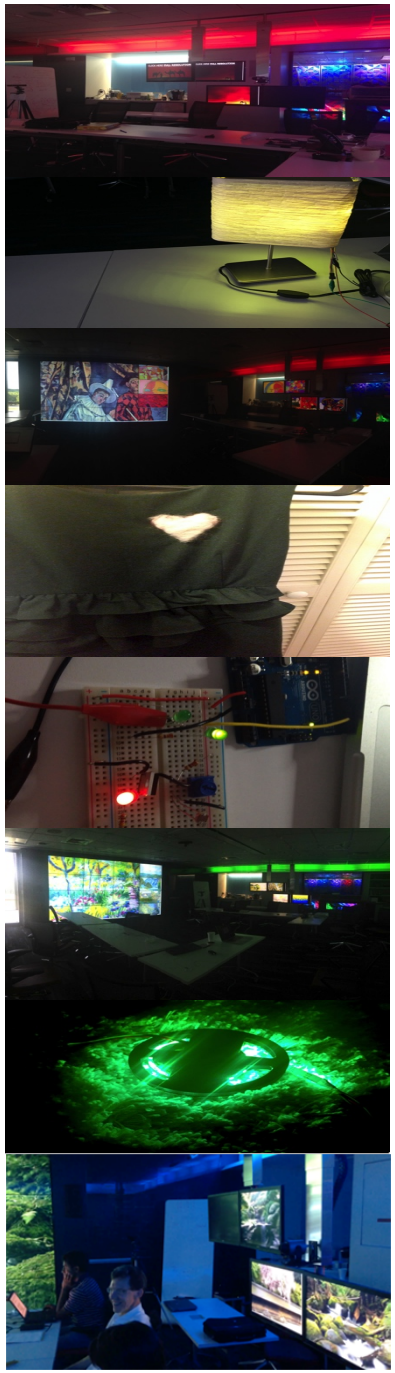


Creating the Mood: Design for a Cognitive Meeting Room

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Abstract
Mood affects the decisions we make and our attitudes toward work and the people with whom we work. The availability of peripheral and focal information also affects the quality and speed of decision-making processes. We are exploring ways to use ambient lighting, music, and images over the course of group meetings in order to understand how these ambient elements affect the quality of meetings, people's attitudes, and the decisions made.

Author Keywords
Cognitive Environments; emotions; mood; cognitive furniture; Internet of Things

Introduction
The environment in which we work affects our mood, which in turn affects the decisions we make, our attitudes toward work, and how we interact with others. At IBM Research, we are designing a Cognitive Environment to enable teams such as business managers, emergency planners, and executives to make more effective strategic decisions. An aspect of this research is to explore how qualities of the environment influence a decision-maker's moods and the impact this has on strategic decision-making.

Mood affects the way we see things and how we think about things [4]. When we feel positive, the scope of our field of vision increases, allowing us to take in more

of the information at the periphery of our visual field; negative feelings have the opposite effect, causing a reduced field of vision and decreasing peoples' awareness of peripheral information [9]. Mood also moderates the scope of our attention on the conceptual level. It has been shown to influence the breadth of activation of stored mental representations in long-term memory [1], and whether we tend to categorize composite visual figures on the basis of their global form or their local components[5]. For older adults, positive feelings have been shown to facilitate working memory and complex decision-making processes [2].

The ambience of the environment also affects the speed and depth of thought. For example, qualities of the casino environment such as red lighting, ambient money-themed sounds, and the presence of a competitor can diminish the time gamblers spend reflecting and thinking before acting after losses [10].

Ambience is a topic that has a long history in HCI [8]. Early work such as the MIT ambientRoom [3] explored many different types of audio and visual ambient techniques, focusing on how to provide information at the periphery of a person's attention and thus increase the information someone could be aware without being distracted from their main task. More recent work such as Breakaway [7] investigates the use of ambient displays to change people's behavior. Clearly, understanding the relationship between environment, mood, and decision-making behavior is important.

To facilitate our research, we are developing a research infrastructure called the Cognitive Environments Laboratory (CEL) in which we develop and refine the building blocks of Cognitive Environments. The CEL is an exploratory space where we can implement design experiments and in so doing learn about the characteristics that best facilitate a group decision-making process. In this paper, we describe a few preliminary design explorations that investigate the impact of ambient lighting, sound, and images on peoples' mood during group meetings. We present our anecdotal findings and outline plans for a more rigorous investigation into how we can manipulate environmental characteristics to change peoples' mood in order to improve the quality and speed of a group decision-making process.

Cognitive Meeting Room Design Explorations

We have created a number of design explorations for our cognitive meeting room environment to understand how the room can provide both informational and affective support to occupants across a variety of meeting, working, and social situations. These designs manipulate different environmental characteristics of the room, such as the intensity and coloring of ambient lighting, the content displayed across a multitude of screens situated around the room, and even the character of objects contained within the room. In our current implementation, these ambient features are activated through voice interaction with a cognitive agent. The agent triggers an environmental state based on the request of the user. In future work, we expect this agent to automatically trigger different environmental states based on sensing the moods and states of the occupants; then deciding whether to enhance that mood state or do something to try to change their mood. For example, we can measure the vocal stress and ambient loudness of room occupants to infer a tense situation, and diffuse that situation with by manipulating the room state using our Zen Garden.

Zen Garden: an exploration in altering mood
John walks into the cognitive environment after a long, stressful meeting. Jane, a software agent that manages the cognitive environment, detects that John is feeling stressed because his heartbeat is significantly higher than normal, as measured by his smart watch. Jane asks John how he is feeling, and he responds by saying, "Not well, I could use a moment to relax." Jane dims the lights, plays soothing music, and displays pictures of a relaxing Zen Garden on the walls. After a few minutes, John feels much better and Jane, the cognitive agent, returns the room to it's normal working state.

Figure 1 shows our cognitive environment in the Zen Garden mode. Informally, we have found that people working in this room enjoy the Zen Garden and have triggered the garden mostly toward the end of the day.

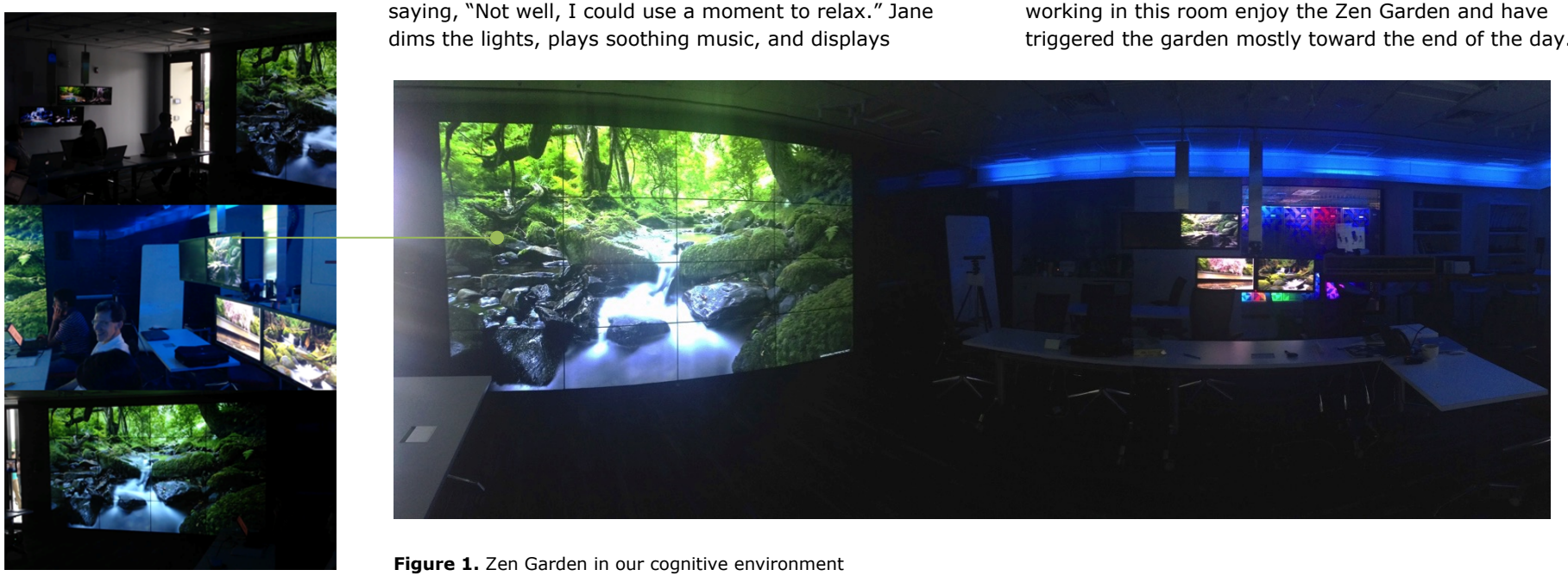


Figure 1. Zen Garden in our cognitive environment

Inspiration: facilitating creativity with thematic images
A group of designers is working together in the cognitive environment. Their task is to create a logo for their new mobile app. They are discussing the few concepts they have created but they aren't feeling strongly about the visual design. They ask Jane, a software agent, to provide some inspiration to broaden their thinking. Jane asks, "What would you like to be inspired by?" One member of the team thinks that fractals may be an interesting path to explore, and asks for 'fractals'. Suddenly, the lights dim and huge, colorful pictures of fractals start appearing everywhere around the room. One of the designers sees a fractal

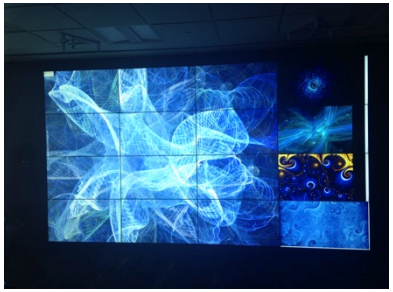


Figure 2. Inspiration mode – the room's ambient color is changed to reflect the dominant color of the retrieved images.



Figure 3. The Cognitive Lamp shows the status of the ever-present cognitive agent.



Figure 4. The cognitive lamp glows solid red to indicate that there is a problem with the background services. User can ask the room agent to provide more information via speech.

with many vibrant shades of blue and this inspires him to explore a blue palette for the app icon.

Figure 2 shows our cognitive environment in Inspiration mode. Occupants of the room can ask to be inspired via a speech interface. The room uses public APIs (Google Images, Flickr) to search for relevant images and display them across the screens in the room. In addition, the images are analyzed for their dominant color. The colored LED lighting in the room changes to this dominant color in order to provide an accent to the room to match the color theme of the results.

Informally, we have found that displaying images across the various displays in our room has a calming effect similar to that of the Zen Garden. Both modes take occupants out of their "work" mindset for a few, brief moments to show them something that is aesthetically and/or aurally pleasing. In the case of Inspiration, our goal is to provide a service that may also be useful for work tasks, such as that described in our scenario.

Cognitive Lamp: embodying room state in an object

Our CEL environment contains an always-on, always-listening software agent to provide occupants with a speech-based user interface for interacting with room services. However, the state of this agent was not always clear to room occupants; sometimes, people would attempt to address the agent when it wasn't running or after it had crashed, causing people to become frustrated with the agent. We felt that embodying the agent's status in a piece of smart furniture would provide an easy, ambient way for occupants to understand the running state of the room's software agent.

Our cognitive lamp uses four colors to represent the different states of the software agent.

- Pulsing green indicates that all services in the room are up and running and the agent is actively listening to a speech command.
- Pulsing yellow indicates that the agent has some further information relevant to the meeting in progress, but doesn't want to interrupt the discussion; the agent may be queried for this information when room occupants desire (Figure 3).
- Flashing red indicates that there is a problem with the services in the room that require human attention (Figure 4).
- Slow pulsing blue indicates that the room agent is idle.

For the implementation of the lamp, we used an array of 30 addressable LEDs that are controlled by an Arduino Uno. We used XBEE modules for communication with the lamp server, so the lamp is wireless and can be placed anywhere in the room. The lamp server was written in Node.js and is subscribed to the speech engine to detect when someone is speaking in the room. For the lamp itself, we chose a small IKEA lamp with a neutral-colored shade in order for the color of the LEDs to shine through and produce an ambient glow. The colored glow is clearly visible to room occupants under normal lightning conditions. The specific mapping of color to room state (e.g. "green" means "up and running") was chosen to reflect typical color conventions (e.g. a "green" traffic signal means "go"). Slow pulsing and fast flashing are used as another means of capturing attention, such as when the room agent has additional information to tell occupants but does not want to interrupt auditorily.



Figure 5. Cognitive dress that senses body temperature and pulse. The dress flashes LEDs when these signals exceed a threshold value, alerting others of the wearer's state.

Cognitive Clothing: sensing peoples' moods
One requirement for the success of our cognitive environments is in their ability to infer the mood of room occupants. If the room can't detect when people are calmly working versus engaged in a heated debate, it cannot provide the right informational or environmental support it needs to facilitate the meeting. There are two primary ways we can infer the mood of room occupants, by using ambient sensors (e.g. room microphones and cameras) and by using on-body sensors (e.g. a pulse sensor). Ideally, data would be captured via both methods and fused in order to provide a more accurate representation of an individual's mood.

In order to capture data from on-body sensors, we designed some pieces of clothing to measure biometric information such as heartbeat and body temperature. Figure 5 shows a dress that lights up in response to elevated heart rate or temperature.

The lights are used to communicate to other room occupants that the wearer is experiencing higher levels of psychological arousal. The dress operates wirelessly using XBEE radios to communicate with a back-end service. Figure 6 shows the architecture of the Arduino circuit on the dress. We note that not all room occupants would be interested in wearing a dress to capture biometric information, and we have designed wearable devices with other form factors, such as a gender-neutral felt armband (Figure 7).

Informally, people expressed interest in monitoring their biometrics during a meeting but raised several privacy concerns over displaying that information publically to other meeting participants. Rather, they expressed a preference for a private signal, like a buzzer that provides tactile feedback, over a public signal from an LED. Private feedback can be used as a reminder to the wearer that they are becoming overly excited and should calm down.

Evaluation

We have implemented the design experiments described above in our Cognitive Environments Laboratory and gathered informal feedback from our team on the utility of these designs. We plan to continuously iterate on our designs as we receive more feedback from our team, especially as we introduce these technologies into our day-to-day working practice. As we evaluate these technologies, as well as develop new ones, we feel that it is important to evaluate them "in situ" so that they are being used in as realistic a situation as possible. However, in-situ evaluations of ambient technologies are difficult because of the Hawthorne effect (people alter their behavior when they know they are subjects of a study), novelty effects, and difficulties in measuring peripheral awareness without changing the focus of people's attention [6].

We plan to take a participatory and Darwinian approach [6] to our evaluation; Darwinian in the sense that as we develop and introduce these technologies into our Cognitive Environments Laboratory, we will see which ones survive over time and which ones die out from lack of use; and participatory in the sense that we will have groups of strategic decision makers use the CEL for their regular meetings and we will engage them in discussions to discover the kinds of information of which they need to be peripherally aware, and how we might best present this information and to which sense

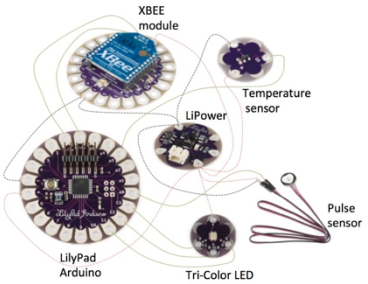


Figure 6. Circuit design for the cognitive dress.

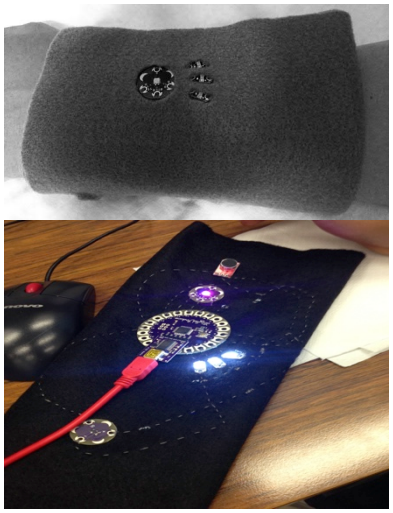


Figure 7. Wearable devices such as this armband can be used to capture biometric data from the wearer and the wearer's environment.

(vision, auditory, touch, etc.) so it is minimally intrusive on their focused activities. Finally, after declaring success or failure for a particular design experiment, we will engage in design critiques and analysis aiming to articulate why it succeeded or failed.

Conclusions

We are in the early stages of research into how environmental manipulations can alter the mood of a group and understanding what impact they will have on the speed and quality of a group decision-making process. We have designed a number of technologies that measure and alter mood through a combination of biometric sensors, LED lights, images, videos, and sounds. Informal results suggest that our designs do have a positive impact on mood, and our future work will focus on more rigorously quantifying these effects.

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