People’s Emotional Responses to a Plant’s Emotional Expression

Abstract
In this paper we investigate how people emotionally respond to the emotional expression of a plant when external stimuli were given to the plant. For this purpose we built a simple LED emoticon-based device as an emotional proxy for delivering inner states of a plant, assuming the inner states of a plant can be changed depending on either positive or negative external stimuli. Our pilot study suggests that people’s attitude on plants can be influenced by observing the emotional expressions of a plant.

Author Keywords
People-plants interaction; Emotion expression of plants; Emoticons

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

General Terms
Experimentation.

Introduction
The relationship between humans and plants is vital. Plants make positive effects on people in many ways. They provide people with clean oxygen and food as well as making spaces for leisure. Psychologically people
can make themselves feel better and stable with plants [1].

While plants are beneficial to people in various ways as described above, people tend to treat plants with less care compared to dealing with other living things such as animals. It is mainly because plants, unlike animals, cannot express themselves in an explicit way. Suppose plants are able to scream or shed tears when they get hurt. People's attitude to plants will be not exactly the same way that people currently do to plants.

In this paper we are not claiming that plants have emotions. It is beyond the scope of our paper. Our research question is rather about people's emotional responses when they observe a plant's emotional expression in accordance with external stimuli. We hypothesized that people's emotional attachment to a plant would increase when the plant expressed its emotions in real time, though the expression was made simply using emoticons.

**Related Work**

The interaction between people and plants are two-fold. People observe, nurture, and grow plants. Some people often have a strong empathy with their plants in the process of plant-growing. Plants’ impacts on people, meanwhile, are enormous (in a positive manner). As described in the previous section, plants supply us with oxygen, food, life resources, and living environments as well as influencing our sentiments (or feelings) and bodily functions [10]. Indoor plants also contribute to enhancing our pleasantness by alleviating people's tension and anxiety level [2]. More psycho-physiological benefits from plants include visual fatigue alleviation from looking at plants [9], stress reduction [3], and air purification through the absorption and adsorption of harmful gases indoors [11].

Compared to the studies on the positive effects of plants on people, there has been relatively less research on how people affect plants. According to studies, a weak electric current can be measured in plants and it can be changed accordingly to external stimuli [4]. Specifically when negatively physical stimuli such as cutting leaves, hitting with a plastic bar, and touching with a hot object were applied, it was found that the ampere meter was changed rapidly [8].

Just with the studies by [4] and [8] above, we cannot argue that plants have emotions. We may say, however, that plants can respond to external stimuli rather in a way that we hardly recognize. For this reason, our study aims to visualize a plant's responses to external stimuli in such a way that we can easily recognize, that is, in an emotional way using (LED) emoticons. Emoticons have been considered as an effective method of expressing basic emotions such as joy and sorrow [6]. Particularly in Instant Messaging (IM) area, it is known that the use of emoticons can enhance the communication quality [7] and contribute to expressing sympathy [5].

**Experimental Study**

As a way of investigating the relationship between people and plants, we built a simple emotional proxy for a plant and conducted an experimental pilot study with 11 participants.

*Material: A plant's proxy device*

As a proxy for delivering the emotional expressions of a plant, we built a simple visualizing device consisting of
an Arduino UNO board (main board), 3 Arduino sensors (input devices), and an LED and a buzzer (output devices).

LED, as an output device, was designed to express visually three different states (joy, neutral, sadness/anger). In order to indicate that they are the emotional expressions of a plant, flower-looking petals are added. Joy was represented as a green emoticon of a smiling face. Neutral was coloured in orange with an expressionless face. Sadness/anger was characterized by a red angry face with a buzzer making an alarming sound. [Figure 1] shows the prototype of the output expressing the plant’s responses to external stimuli in an emotional way.

As input measuring devices we employed three different sensors – temperature, humidity, and sound detection. The temperature sensor was programmed to express three distinct LED states for ranges 20–25°C, was also programmed to express three different LED states for humidity ranging lower than 300, 300–600, and higher than 600. The values for the base temperature and base humidity were accordingly set for a plant to be tested, which can be easily changed in case different plants are employed in the study. The sound sensor was programmed so that the plant can respond with the LED as if it is humming to the sound of music.

In addition to the three input sensors described above, we programmed the Arduino main board to control the LED states by detecting a weak electric current change as a way of simulating a plant’s expression to external physical threat. It is basically similar to galvanic skin response-based lie detectors. When a person gets tense, the resistance of the skin is lowered, and a lie detector detects a lie based on the change in the resistance. Inspired by the lie detectors and the fact that plants respond electrically to external stimuli, we connected two pins from the Arduino board to a plant and set the threshold of change in the current flowing between the two. If the current exceeds the threshold value, the LED state is changed. We used this for the change of emoticon as Wizard of Oz approach when the participants exerted physically threatening or damaging actions to our plant.

Figure 1: The prototype as a proxy for the emotional expressions of a plant

Material: A real plant
We employed a plant called 'Pepper Face' (scientific name: Peperomia obtusifolia A.Dietr; See Figure 1) as our study material. The best growing conditions for Pepper Face are between 20 and 25°C temperature, without direct sunlight, and less watering (only once in 1-2 weeks). In other words, excessive heating and watering are very unfavorable conditions for Pepper Face.
**Participants:**
In total 11 graduate students (7 males, 4 females; age range between 25 and 32) were recruited as study participants. Among the 11 participants, 9 participants had an experience of growing at least one plant in recent two years and 8 out of the 9 participants had an experience of the death of the plant that they were growing.

**Methods and Procedure:**
The study was conducted through the survey questionnaires based on each participant’s self-report.

Before conducting our study, we first checked the participants’ attitudes to plants by showing them pictures of plants in severely bad conditions – such as a badly damaged cactus by people or a dying plant out of water. After watching the four pictures each participant answered how painful he or she felt in 5-point Likert scale (1: Not painful at all; 5: Extremely painful).

Our study consists of four experiments with different external stimuli (three negative stimuli and one positive stimulus). For each experiment two types of survey were conducted. The first survey was done with only explanation and no direct actions applying to the plant (Before). In the second survey participants exerted direct actions on the plant and observed the plant’s proxy device expressing the plant’s inner states through the LED emoticons. The three negative stimuli include applying physically threatening actions (hitting or tearing out the leaves), applying hot wind to the plant using a hair drier, and watering excessively. Finally we chose playing bright mood music to the plant as a positive stimulus. Before conducting the two surveys, each participant was told that the plant is very sensitive to heat and humidity in a negative way and is fond of listening to music. Figure 2 illustrates applying the four external stimuli to the plant and the plant’s responses through its emotional proxy. After the four experiments were done, each participant was asked whether their emotional connection to plants was increased through the experiments.

**Results and Discussion**
In the pre-survey on the participants’ attitude to the plants with the pictures of damaged or dying plants, the participants answered that they felt painful more than medium (m=3.82; sd=.874). It seems reasonable considering the fact that most of participants (9 out of 11) had an experience of growing plants.

In the four main experiments, participants’ average mean ratings over the first three negative stimuli were 3.36 (sd=1.036) after only hearing the explanation.
without watching the LED emoticon-based proxy device’s emotional expression, 4.18 (sd=0.718) after applying direct actions on the plant with watching the change of emoticons. As for the positive stimuli in the fourth experiment (i.e., playing bright-mood music to the plant), the average mean rating was 3.0 (sd=1.095) and 4.0 (sd=.894) respectively. Overall the people’s average rating of their emotional connection to the plant was slightly higher with regard to negative stimuli than with regard to positive stimuli, though the difference was not statistically significant.

Performing Fisher’s exact test on the collected data suggests that there is a significant difference between the two means in the third experiment (watering excessively to a water-sensitive plant; p=0.0004423). We suspect that the continued negative actions with the first and second experiments may affect the third experiment. There were no statistically significant differences in the other three experiments. Overall the participants’ average mean ratings over the four experiments were 3.27 (sd=1.051) before applying actions and 4.14 (.762) after applying actions with the LED emoticon (Refer to Table 1 and Figure 3).

For the question of whether the participant’s emotional connection to plants was increased through these experiments, the participants’ mean rating was 4.45 (sd=.688) in the 5-point Likert scale (1: Not at all, 3 : Medium, 5 : Extremely).

In general, the participants showed high curiosity and positive responses to our study on the relationship between people and plants. They also suggested that this idea would be useful particularly when growing plants that are sensitive to their surrounding environments such as sunlight, temperature, and water.

Table 1. Participants’ mean (and standard deviation) of their ratings in the four main experiments, where E1: Applying negative physical stimuli; E2: Applying hot wind as negative stimulus; E3: Excessive watering as negative stimulus; E4: Playing bright-mood music as positive stimulus

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<th>After only hearing the explanation without watching emoticons</th>
<th>After applying actions with watching emoticons</th>
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<tr>
<td>E1</td>
<td>3.55 (1.036)</td>
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<td>E2</td>
<td>3.45 (1.128)</td>
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<td>E3</td>
<td><strong>3.09 (.944)</strong></td>
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<td>E4</td>
<td>3.0 (1.095)</td>
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<td>Avg</td>
<td>3.27 (1.051)</td>
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**Figure 3:** Four experiment results: (A) Applying physical action, (B) Applying hot wind, (C) Watering excessively, and (D) Playing bright-mood music. One only with explanation without direct actions applying to the plant (Before) and the other with direct actions to the plant and observation of the LED emoticon change (After).

**Conclusion and Future Work**

In this paper we described our effort to investigate the emotional relationship between people and plants. For this purpose we designed and built a simple flower-shaped, LED-based emoticon device using an Arduino board and three sensors (temperature, humidity, and sound detection) as a proxy for emotional expressions of a plant. In our pilot study we let the participants apply four external stimuli (three negative stimuli and one positive stimulus) to a plant and observed their emotional responses through survey questions and discussion.

We believe our research will be beneficial to enhancing our general attitude to plants. Our current research, however, has some limitations. First, we limited the modality of a plant’s emotional expression to a simple visual expression through three different types of LED emoticons. Detailed visual expression or inclusion of
other modalities (e.g., short text messages) could be more appealing. Interaction through social network systems would be also an interesting research. We leave these as a future work of ours. Second, in our study, we chose four external stimuli to a plant as instantly applying ones. In reality, however, the relationship between a human user and a plant often requires some periods of time, which was not easy to test in a lab environment due to several practical reasons. Moreover, as too many experiments on the same plants could be an abuse to the plants, we had to limit the number of experiments. In our next study we plan to explore the interactive relationship between a human user and a plant over a span of time. Particularly we expect that our system can be beneficial for children to develop their empathic capabilities through the interaction with plants.

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