Emotionscape: Mediating Spatial Experience for Emotion Awareness and Sharing

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Abstract
We bring the concepts of emotional self-awareness and emotion sharing to the problem space of Mixed Reality and by adding our observations on the influence of the physical space on emotions, we speculate whether we can mediate the spatial experiences of collocated people to increase their emotional self-awareness and ease emotion sharing between them. Our study is structured around a conceptual system we designed, one that mediates the spatial attributes of the surroundings according to the user's and collocated people's emotional states. After the initial ideation of the concept, we built a prototype application for HoloLens. We then conducted a 2-legged user study with 12 participants; first we gathered data using an online survey, followed by a study with thinking aloud protocol using the prototype. We believe that the results and discussion we provide in this paper will be useful in development of emotionally aware Mixed Reality systems.

ACM Classification Keywords
H.5.1 [Information Interfaces and Presentation (e.g. HCI)]: Multimedia Information Systems - Artificial, augmented, and virtual realities; H.5.2 [Information Interfaces and Presentation (e.g. HCI)]: User Interfaces - Prototyping; User-centered design

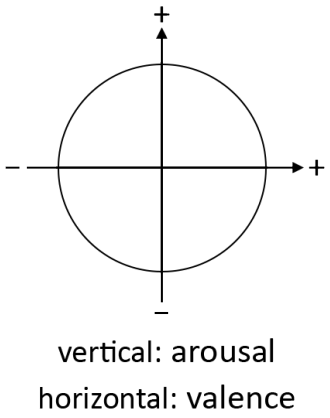

Figure 1: An example diagram illustrating Russel's circumplex model. In this model there are two dimensions: valence and arousal. The leftmost point of the circle on the valence axis represents unpleasant, whereas the rightmost point represents plaeasant. Similarly the top point of the circle on the arousal axis represents high and the bottom point represents low. Any emotion is characterized by the combination of a valence and an arousal value [9].

Author Keywords
Mixed reality; augmented reality; affective computing; space-emotion relationship; emotion representation

Introduction
Designing for emotion awareness, sharing and regulation has been of interest to HCI community recently [1, 3]. It is shown that the ability to stabilize and control one's emotional state is important for a person's mental well-being [2], which falls under the term emotion regulation. In order to regulate emotions, awareness is necessary [2] and sharing is helpful [8]. In this paper we share our early-stage experiences in designing a system to improve emotion awareness and sharing.

Understanding the nature of emotions and the interactions that shape a person's emotional state is important when designing for emotion awareness and sharing. Our research and observations on this topic led us to one interaction that we found interesting, the interaction between the space (a bounded 3 dimensional area) and the emotional states of the people within it.

We think that this existing interaction can be strengthened by an intelligent system that makes it possible for the space to respond to people's emotional states; this way the properties of the space would be able to influence people's emotional states systematically and people would be able to actually sense the differences in the space according to how they feel. We tackle the design of such a system from a Mixed Reality perspective. Although it would also be interesting to speculate on a space that physically changes, we think that speculating on making a space responsive through Mixed Reality technologies is preferable as it offers us the additional opportunity of studying how these technologies will become integrated with our lives.

In this paper, we share with you our conceptual design of a system, Emotionscape, that mediates the spatial perception of its users with a yet-to-come more immersive and unobtrusive Mixed Reality technology, to improve emotion awareness and sharing. To get feedback on this concept that we cannot currently realize, we developed a prototype with Microsoft's Augmented Reality glass, HoloLens. We then conducted a 2-legged user study with 12 participants; first we gathered data using an online survey, then we conducted a prototype experience study.

We contribute to the existing literature by sharing our speculations on the use cases and affordances that will be offered by natural interfaces developed for emotion awareness and sharing; and how Mixed Reality technologies, in this case HoloLens, can be used to explore these speculations. Our experience may inform and inspire researchers working on affective interfaces and space-emotion relationship, especially within Mixed Reality context.

Related Work
Emotion Models
In order to work with emotions, we needed a model to describe them. Our review of the literature showed that there are two dominant classes of emotion models, categorical and dimensional. Categorical classification model represents emotions with labels such as anger, sadness, happiness; whereas, in a dimensional model an emotion is represented by a value in each defined dimension [5]. An example of a popular dimensional model, Russel's circumplex model, can be seen in Figure 1; it might make what a dimensional model is more clear. In our study we chose to use a dimensional model because it provides a broader and continuous representation of emotions.



Figure 2: Sketch of the three modes of Emotionscape

Space and Emotion

Previous work in HCI show that making emotions more tangible increases emotional awareness both for individuals and groups [3, 6, 10, 11] and helps communication of emotions [3, 6, 7]. There are different emotion representation approaches in the literature; however, due to space limitation we will only discuss two examples that use spatial attributes [4, 7]. Huang, Wu and Liu chose to manipulate the texture of the walls, lighting and sound in order to have the space respond to the user's emotional state and actions as part of a smart space design [4]. Li and Jiantig discuss the idea of mediating similar spatial attributes -lighting, colors, music and projected images - for remote communication of emotions [7]. They propose coupling two spaces and mediating each of them with respect to the emotional state of the person in the other space. The spatial attributes manipulated by our prototype overlap with those used in these two works.

Conceptualizing the Emotionscape Idea

We identified 3 user needs related to the idea of an emotionally responsive space and our goal of enhancing emotion awareness and sharing: (a) allowing the user to perceive their own emotional state, (b) allowing the user to perceive collocated people's emotional states, (c) allowing the user to experience an emotional state they choose. Our system, Emotionscape, responds to these three needs with three modes as illustrated in Figure 2:

(a) real reflection: spatial attributes are mediated to represent the user's emotional state in real time. This mode is mainly for raising the emotional awareness of the user.

(b) transferred reflection: spatial attributes are mediated to represent a collocated person's emotional state or the overall emotional state of everyone who is present. This mode is designed for enhancing emotion sharing.

(c) desired reflection: spatial attributes are mediated to represent any emotion selected by the user.

An important concept related to this idea is adaptability. The way people experience their emotions and perceive the space are both very subjective. This translates into the relation people form between the spatial attributes and their emotional states. For this system to be successful in mediating the space in a way that the user can perceive the reflected emotion, it must take into consideration how each user associates spatial attributes with emotions and how this association changes over time.

Feedback: Prototype and User Studies

We designed a user study with 2 parts to assess the Emotionscape concept. The first part of the study is an online survey and the second part is an on-site prototype experience study. Participants were recruited by announcements on social networking platforms and word-of-the-mouth. 12 participants completed both stages of the study (6 female, 6 male, M=24.33, SD=4.64).

Online Survey

The aim of the survey was to collect data on how people associate spatial attributes with emotions, to be used for the customization of the prototype application for each participant. There were 21 questions out of which 17 included an image and 4 included a textual description of a situation. Based on either the image or the description, participants were asked to provide two ratings based on the emotion they associate with it. Both ratings were from 1-5, one for how pleasant the emotion is (valence) and the other for how active the emotion is (arousal).

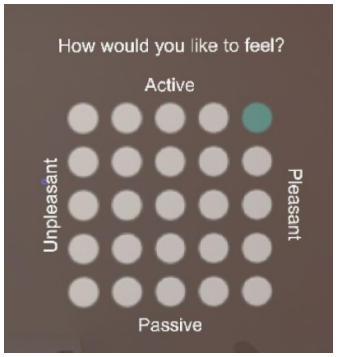

Figure 3: A screenshot from the prototype application showing 25 point valence-arousal grid

Size	67%
Shape	42%
Color	67%
Light	92%
Surface Properties	75%
Visual Crowd	100 %

Table 1: Percentage of participants who answered positive for wanting to be able to modify the given spatial attributes

We chose to work with 1-5 scales, because with 5 different values in both arousal and valence dimensions we get a 25 point valence-arousal grid. We thought that having 25 points distributed like this gives us a good balance between having a enough resolution for testing purposes and being easy to work with. The grid constructed for the application can be seen in Figure 3.

Prototype

The prototype was built with Unity to be run on HoloLens. The application scans the room, detects wall and table surfaces and creates planes to be laid on them. It's main functionality is modifying the wall planes' color, reflectivity and position, the table planes' color, reflectivity and texture scale according to a chosen emotion. Figure 4 shows screenshots from the application during the scanning process and after modification. The emotion choice is made out of 25 points on the valence-arousal grid. To ensure that each user gets a personal experience we configured the color, reflectivity, scale and size attributes separately for each user according to their responses to the online survey.

The application flow is as follows: user scans the room for 20 seconds, after scanning is complete a user panel is shown for the user select the participant number corresponding to themselves. When the user panel is closed the mode panel is made visible with three check boxes corresponding to three modes of the Emotionscape concept. When modes one and three are selected a 25 point valence arousal grid is displayed for the user to select an emotion and when mode two is selected an emotion text randomly selected from 'neutral', 'happy', 'sad' states is displayed. The planes are modified for each emotion selected in modes one and three and the randomly assigned emotion in mode two. The mode panel and the 25-point grid can be seen in Figure 3.

Procedure

After someone responded to the user study announcement, we sent the online survey link to them. Upon the completion of the survey, we invited them to the on-site prototype experience study to be scheduled within a week. Before the arrival of each participant, we made sure their answers to the online survey were processed and integrated in the application. During the study, the participant was given the prototype and was asked to explore it with the guidance of the facilitator when necessary. After the participant was done exploring the prototype, they were shown a video of a pre-recorded use of the application in order to give them a better idea of the intended experience; considering that sometimes the spatial scan is not as good, the participants don't explore all the modes fully and the vision of the holograms from the computer screen is clearer. Both before and after the prototype experience, participants were asked to fill paper-based questionnaires. The questions in the questionnaires were to assess the participants' thoughts on the appeal of the concept, its potential in improving emotion awareness and sharing and to gather their ideas on suitable use cases.

Results and Discussion

Quantitative

Both the questionnaire distributed before and after the prototype experience contained the same 6 quantitative questions with 5 point Likert-scale answer choices. The scale was defined as 1-strongly disagree, 2-disagree, 3-neither agree or disagree, 4-agree, 5-strongly agree.

In order to compare the pre and post prototype experience questionnaire results we ran a paired-sample-t-test for all six Likert-scale questions and found a significant increase between the score of pre test (M=4.28, SD=0.35) and the score of post test (M=4.43, SD=0.40); $t(11)$=2.30, p=0.04.

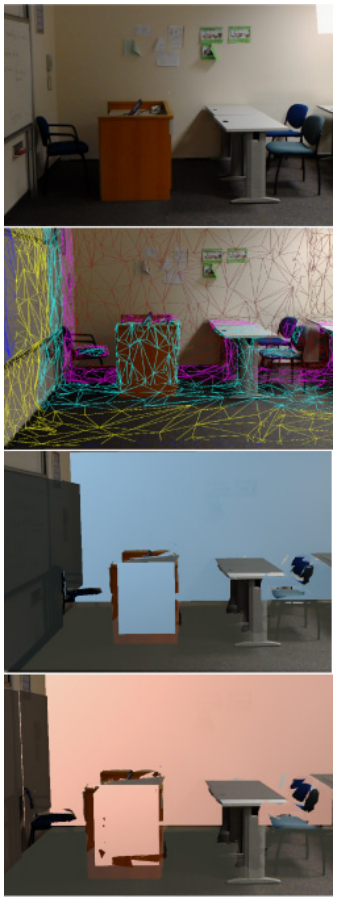

Figure 4: The scanning and modification process of a room

We observed that, for all questions (in both questionnaires) means of the responses were greater than 4, showing that the feedback we received is positive, regarding the use of Emotionscape system in general, for emotion awareness and emotion sharing. It is worthy to note that the lowest answer given overall was 3-neither agree or disagree.

In the post questionnaire, we asked the participants whether they would like to be able to modify the size, shape, color, light, surface properties and visual crowd of the space. The majority of the participants answered positive for all attributes but shape. All participants answered positive for visual crowd. For more specific information, you can refer to Table 1.

Qualitative

We analyzed the open ended questions in the questionnaires and the observational notes taken during the user studies by identifying similar answers and grouping them into categories.

The most frequent use case was communication, and there were several contexts specified for it. These contexts were: business related interactions, encouragement to socialize and psychologist-patient interaction. After communication, the most frequent use case identified was interior design, followed by gaming and education. Communication being the most frequent use case in the results backs our expectation on Emotionscape's usefulness for emotion sharing.

We also asked if the participants saw any problems with the conceptual system. Only 4 participants responded to this question. Two of them indicated concern about privacy issues and the threat of being emotionally manipulated by unwanted third-parties, one participant was concerned with the technological constraints, and the remaining participant thought that the system might not function so well in different types of places. We think that the privacy concern should be taken into consideration; however, it is currently not a primary concern for Emotionscape, since the future technology and societal constructs are currently unknown. Similarly, we currently don't know and are not concerned with the technological limitations in the future.

Finally, we collected suggestions both as answers to the post-experience questionnaire and verbally during discussions. The suggestions can be summarized as: Dynamism in emotion reflection (for a given emotion), adaptability to different types of places, inclusion of familiar objects, making the attribute changes subtle, modifying attributes that correspond to other senses, especially those related to sound and odor. We find these worth exploring and will consider integrating them into our future studies. Among these, adaptability to places is an important design consideration to take into account. Tracking and keeping different preferences for different types of places (public areas, workplaces, home) or limiting the use of the system to one type of place could make this system more usable.

Further Directions

One of the major limitations of our study was the technical capability of HoloLens. We experienced difficulty with the quality of the holograms produced and the limited field of view. When producing spatial holograms, field of view decreases the immersion level of the application as all of the modifications are not visible to the user at a given time. In order to overcome this, we are planning to either redesign the spatial manipulations to be more local, conduct longer user studies to let the participants observe the manipulations in more depth or work with other prototyping methods to simulate the spatial responses. We also want to integrate a multimodal emotion recognition system, even if not fully functional, to have our participants experience responses

to their actual (approximate) emotional states. Narrowing down the use of Emotionscape to a specific use case could be another direction to take; which would also relate to and possibly solve the difficulties posed by the use of the system in a broad range of places.

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