Feel Connected with Social Actors in Public Spaces

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Abstract. Public spaces changed in the last couple of years: abundant use of smart phones and other digitally connecting devices draw peoples' attention away from physical neighbors to virtual peer groups. So, will masses of isolated people be the desired future? We think that current technology involving new display technology and, therein, new interaction possibilities hint at a different future vision. Social connectedness and bonding are important aspects of public interaction that are often overlooked, but can be initiated and supported by technology. This paper reports on research investigating how a publicly displayed application can improve social connectedness by acting in a socially accepted way. Blobulous is a novel interactive installation that interacts with participants through projected avatars, which react to the participants' movement and body signals. A functional prototype was implemented and evaluated.

Keywords: System Design Social Connectedness, User Experience, Interactive Displays, System Design, Avatars, Computers as Social Actors

1 Introduction

Public displays in public spaces have been means in addressing multiple people and the same time in aiming at engaging bystanders, people passing by and others for a certain cause. While the use for advertisements, entertainment and promotion is quite far-spread and has been around for decades already, the usual modus operandi of a single display is to engage people as a single person in a dedicated 1:1 message. A second drawback is the limited interaction space for people "using" a public display: messages are mostly unidirectional and there is a little that a person can actually do to be engaged in a richer interaction than simple information broadcast. At the same time, people are currently more and more "distracted" by smart phones, mp3 players and other personal devices in their immediate environment, that are (1) open for bi-directional interaction with direction manipulation, (2) offer personalized content and functionality, and (3) allow users to pursue activities of their interest.

How can public display compete with this? One possibility is to leverage the social situation in the public space, the unique set of people, who potentially follow a shared interest (which might have brought them to the location). While individual, personalized devices tend to isolate people in their dedicated spheres of personal activities and

content, public displays can inspire connectedness and support social bonding between people in the same space.

To achieve this the public installation has to act as a mediating entity, a social actor that addresses multiple people at the same time and increases the level of social connectedness among them. The main challenge is how to realize an interactive installation, which can act in a socially acceptable way and participate in a social multi-user setting. Partly, the motivation of this research is also to investigate whether computers (controlling the public installation) can indeed act as a social actor and improve social connectedness. The concept "social actor", in general ICT uses, was developed into a conceptualization model through a series of empirical studies. There are five dimensions in the conceptualization of a social actor [1]:

- Affiliations: organizational and professional relationships that connect an organization member to industry, national and international networks.
- Environments: regulated practices, associations and locations that define organizational actions.
- Interactions: information resources and media exchange that organization members mobilize as they engage with members of affiliated organizations.
- Identities: representation of the "self" and profiles of organization members as individual and collective entities.
- Temporalities: socially constructed segments of time that elicit and shape the interactions of an individual in response to the expected affiliates.

Social actorship in the context of HCI is an indicator of computers in participating in social activities with humans. These activities focus on social connection and bonding, between humans and computers during socially interactive sessions. It covers from one-one to many-many relations. Social actorship can be represented through elevating levels:

- Attention and awareness
- Information
- Social acceptance
- Social bonding
- Social behavior

Some examples of social interactive sessions are:

- Visiting or passing by a public place,
- Well-being persuasion,
- Supporting elderly,
- Social engaging with children with autism.

In order to apply this definition in designing social actors, design guidelines were derived from the definition of social actorship. Later, the design of the prototype will follow these design guidelines:

1. Users' awareness and attention are considered to be the first level relationship between humans and computers. Factors can be used to attract attention: attractiveness, suddenness, surprise, and confusion.

2. Users need to be provided with information depending on the contexts of use. Information can be presented at concrete or abstract levels. The context is important

for maintaining the connection between computers and humans otherwise they will lose interest in the design.

3. Interactive sessions between users need to be supported by the design in order to gain social acceptance from the users. Users need to understand that the artifacts of the design are connected with the in-context activities.

4. Social bonding between humans and humans, and between humans and computers, should be stimulated after being socially accepted.

5. Stimulating social behaviors can be achieved after going through the above four guidelines.

2 Related Work

Social connectedness also stands out to be a very important psychological feeling that links to personal health and well-being [2].

In the field of HCI, computers are considered to be able to handle social tasks and tend to be treated like humans [3]. There is a growing community around public projection and large-scale installations, and social interaction of their users, which is picked up by user-dedicated devices such as RFID tags and mobile phones [4-6]. In the case of *Blobulous*, an interactive installation to be introduced in the next section, the large (possibly public) projection of abstract avatars is combined with bio-signals, i.e., the heart rate, which other research also consider as a reliable and effective means of communication between people [7, 8]. With the system we explore the possibilities in utilizing related technologies to collect information from wearable objects for social interaction in public spaces [9].

This work is an extended version of a paper for the CHI'13 workshop on Experiencing Interactivity in Public Spaces [10].

3 Blobulous System

Blobulous is a novel interactive installation (see **Fig. 1** for example settings and **Fig. 2** for system overview) that interacts with participants through projected avatars in public spaces, which react to the participants' movement and body signals. Blobulous uses a large projection to show abstract avatars, blobs of dots – therefore the name "Blobulous" – one for each participant and moving around slowly. The movement of the avatars is connected to the participant's movement in the space in front of the projection. The second mapping involved in the installation is from a participant's heart rate to the color of his or her avatar. The mapped colors range from blue (cold, low engagement) to red (warm, high engagement).

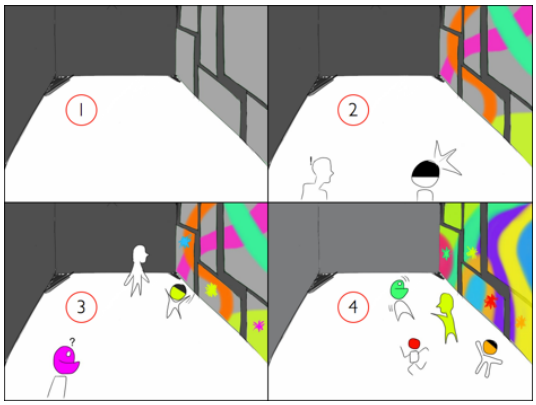

Fig. 1. Example space for using Blobulous

Blobulous is designed considering the proposed definition of social actorship in the context of HCI. Blobulous aims at stimulating physical and mental connections between humans in order to influence social connectedness by using physiological data from users. The concept is designed for all ages as long as they are having activities in a shared space. It is about creating a visualization system shown on a public display, which generates visuals according to the users' biological data and movements. The concept aims to serve three user groups:

- Visitors of exhibitions
- People sharing a public space
- Employees of a company

Biosignals are proposed to integrate in the design of Blobulous to enhance its social actorship. So a physiological model needs to be designed to help improve the feeling of social connectedness between people. Considering a list of design guidelines for social actors, some design assumptions or goals of the prototype were made:

- Blobulous has the ability to draw great attention from people.
- Blobulous raise curiosity to people and trigger discussion or communications, and interaction accordingly.
- Systems with a physiological connection between human and system may improve social connectedness.

With abstract visuals (avatars) and avatars' behaviors, the system aims to improve social connectedness among people in the same space. It provides a bird-eye view of the context to help people be aware of the current social situation unobtrusively.

Heart rate (HR) and heart rate variability (HRV) can indicate people's moods, emotions and activities [8]. At a prototype level, it is feasible to collect HR data not HRV data. Even short-term HRV data analysis requires a five-minute recording in a steady-state physiological condition. In this concept, people have their normal activities in a public space. So it would be very rare that someone would rest or stand still for 5 minutes to provide accurate HRV data to the prototype. Therefore, we use only HR data for the prototype and its evaluation in an explorative study.

An abstract representation is chosen to be the avatars that act as social actors. It is designed to make users believe they are social actors and act accordingly. They mimic users' movements and change colors according to their heart rate. Their shapes and movements depend on people's ways of movement, speeds of movement and heart rate. In other words, they are influenced by the way people move and behave in the current context. Particles' colors, a spectrum from shades of green, red or blue, is mapped with a healthy heart rate range of the target group, from 60 to 150 BPM. Fig. 2 shows an example of the visuals in the upper part, which are unique depending people and context of use.

The final version of the Blobulous system consists of four parts:

(1) Wireless heart rate sensors capture and send heart rate data from users to a central instance. Three of these sensors can be seen at the bottom left of figure 2 on a charging board. The sensors are custom-made 3D-printed enclosures that can be worn on a necklace (see mid bottom of Figure 2), and which provide the housing for an Arduino nano with a Zigbee[1] unit. Through the necklace, a HR sensor is guided towards the ear of the participant. This ensures correct placement as well as certain robustness in case the participant decides to dance or otherwise move rapidly.

(2) A central instance, including a receiver and a visual program, receives data from users' sensors and, after processing this data, it derives avatar behaviors represented as visuals on the projected screen. The instance is realized as a Processing sketch (a program written in Processing, a Java based programming language and environment) that is running in Presentation (full screen) mode.

(3) A projector connected to the central instance will simply project the screen contents on a large display.

(4) A Zigbee network handles the communication between sensors and the central instance.

This system allows for several rapidly moving users and an arbitrarily large display. The setup is also quite independent from the display system, as the interaction between the social actor, Blobulous, and the users will be controlled entirely by their position and HR sensor data. This makes the system quite portable and will hopefully allow for more future evaluations in real-life settings.

[1] http://www.zigbee.org/

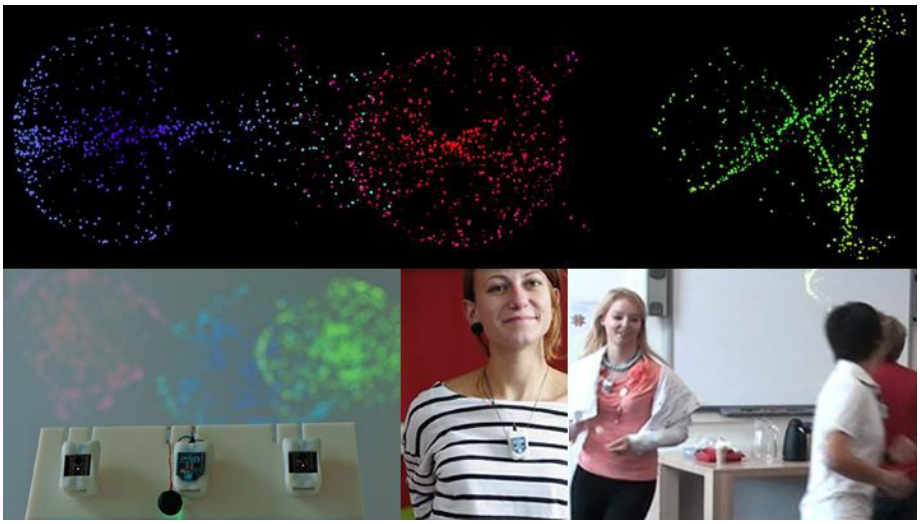

Fig. 2. Overview of system components

4 Evaluation

The objective of evaluating the Blobulous system is to show an improvement of social connectedness among participants and the attractiveness of the installation. In this work the social connectedness will be in the focus. The study was planned to take place in a living lab environment to yield most reliable and realistic results. The results about attractiveness have been evaluated and reported in [11]: 21 participants (14 male, 7 female) in 7 randomly selected groups were asked to experience and interact with the Blobulous system and, later on, they were asked to use the AttrakDiff [12] instrument for rating the system. With the help of pairs of opposite adjectives, they could indicate their perception of the system. The installation was rated as fairly "self-oriented". It provides the user with identification and is generally considered attractive by the participants, although they were aware that they were evaluating a prototypical system. Attractiveness is certainly an important aspect of a system aimed at inducing social connectedness among its users. Although systems are imaginable that operate as a "common enemy" with low attractiveness and thus united its users, this was not an option for this line of research.

Social connectedness is measured by means of a questionnaire that has been derived from Social Connectedness Scale Revised (SCS_R) questionnaire [13]. The two research hypotheses are:

- Hypothesis
    - Blobulous has the effect on an individual of feeling socially connected to others (H1a).
    - Blobulous improves the feeling of social connectedness of people (H1b).

- Null Hypothesis:
  - Blobulous has no effect on an individual of feeling social connectedness to the others (H0a).
  - There is no improvement on the feeling of social connectedness of people from Blobulous (H0b).

4.1 Experiment Setup

In order to evaluate the feeling of social connectedness of people while interacting with each other, it is better to include a group dynamics factor in the evaluation. 21 (14 male, 7 female) participants were recruited online and randomly divided into 7 groups according to their time preference, taking into account the balance of gender, age, and background. So, in most of the groups, participants did not know each other before the experiment. Users' backgrounds were distributed to Industrial Design (7), Electrical Engineering (4), Computer Science (3), Automotive/Logistics (3), Biomedical (2), Architecture (1), and Business (1).

Before coming to the experiment, participants were requested to answer the questionnaire to measure their initial level of social connectedness. During the experiment, this measure is repeated at the end of sessions 1 and 2. In the experiment, participants as a group were asked to perform three sessions: the first two sessions were planned to study social connectedness, the final one is to see how people can interact with Blobulous. Experiments were carried out following the two protocols shown in Table 1 to avoid a direction effect in the evaluation.

Table 1. Evaluation protocols

	Protocol 1	Protocol 2
Session 1	A	B
Session 2	B	A
Session 3	Brainstorm & Demo	

A: Random Blobulous
B: Interactive Blobulous

In both conditions A and B (Tab. 1), participants were asked to watch and explore the visuals projected on the wall (Fig. 3a) while wearing the sensor (Fig. 3b) and then have a short discussion about what they perceive from the visuals. Heart rate data was streaming automatically by the prototype while movement data was manually controlled via an Apple iPad using touchOSC [14] (Wizard of Oz) (Fig. 3c).

Only afterwards, in the demo session, participants were explained details about the functionality of *Blobulous,* and then asked to come up with some ideas and try to demonstrate the ideas together with *Blobulous*. All sessions were recorded for later video analysis. The experiment room was prepared with a large display on the wall,

an interaction space in front of the display, and an experiment control area (depicted at the bottom of Fig. 3).

Fig. 3. Experiment room with a) projection screen, b) heart rate sensors, and c) central control.

4.2 Methodology

A video analysis was proposed to follow up the social connectedness test. The video analysis was to investigate and capture social behaviors that might link to social connectedness but could not be captured by questionnaires. Therefore, the evaluation was carried out in two steps:

Firstly, the Social Connectedness Scale Revised (SCS_R) questionnaire [13] was chosen to evaluate the level of social connectedness of participants in this study. SCS-R consists of 20 items (10 positive and 10 negative). The negatively worded items are reverse scored and summed with the positively worded items to create a scale score with a possible range from 20 to 120. Then, the mean score with a possible range from 1 to 6 is calculated by dividing the total scale score by 20 (or 20 scale items). A higher score on the SCS-R indicates a stronger feeling of social connectedness.

Secondly, the video analysis was carried out to check the feeling of social connectedness in conditions A and B. An observation scheme with behaviors and scores was developed to compare between conditions A and B.

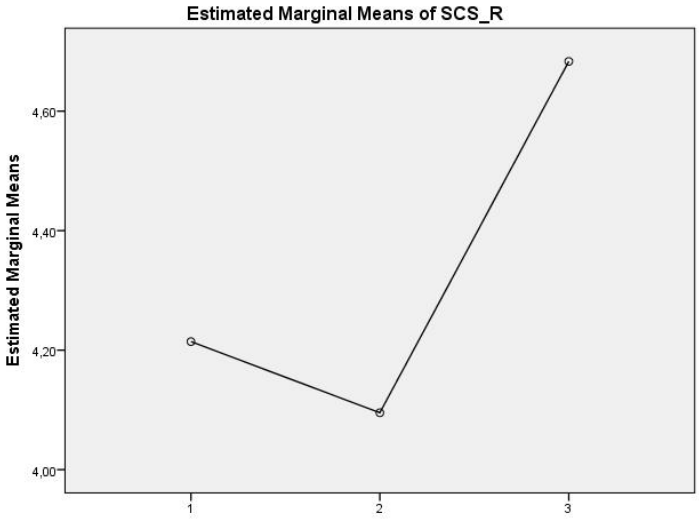

Fig. 4. ANOVA repeated measures (SPSS). 1. Before the experiment; 2. After random Blobulous; 3. After interactive Blobulous

4.3 Results

SCS-R was used to study if there is an improvement or difference in the feeling of social connectedness of participants while interacting with the system. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that the mean SCS_R score differed statistically significantly between different conditions ($F(1.484, 8.107) = 3.791$, $p < 0.046$). Post hoc tests using the Bonferroni correction revealed that there is a slight reduction in the SCS_R score when bringing people from their own setting to a social setting or testing environment ($M = 4.21$ vs. $M = 4.09$, respectively), which was not statistically significant ($p = 1$). However, the SCS_R score had been improved after the interactive session with *Blobulous* ($M = 4.68$), which was statistically significantly different to the random session without *Blobulous* ($p = 0.002$) (see Fig. 4 and Table 2). Therefore, it can be concluded that the *Blobulous* prototype elicits a statistically significant improvement in SCS_R score or the feeling of social connectedness of people but only in certain social contexts.

The internal reliabilities on the SCS_R questionnaire from pre-test, random and interactive condition had been found to be good ($\alpha = 0.936, 0.756, 0.751$, respectively). Strangely, there were slight drops in the alpha values between the testing and pre-test conditions. This can have resulted from the fact that the pre-test participants were at their own places while answering the SCS_R questionnaire, but during the test they were in a controlled room.

Table 2. Pairwise comparison of SCS_R scores between the three conditions (1. *Before* the experiment; 2. After *random* Blobulous; 3. After *interactive* Blobulous).

		Mean Difference	Std. Error	Sig.
before	random	,119	,264	1,000
	interactive	-,469	,249	,223
random	before	-,119	,264	1,000
	interactive	-,588*	,146	,002
interactive	before	,469	,249	,223
	random	,588*	,146	,002

The video analysis consists of seven steps:

1. Conduct qualitative study based on demo videos to categorize users' behaviors while interacting with the system (not shown)
2. Divide the SCS-R questionnaire into groups of behaviors (see Table 3):

Table 3. Predicted behaviors from SCS_R questionnaire

Negative	Positive	General	Context	Behaviors
I catch myself losing a sense of connectedness with society.	I fit in well in new situations.	world	room with Blobulous	Interact with Blobulous
I feel like an outsider.	I feel comfortable in the presence of strangers.			Make sound
I feel disconnected from the world around me.	I am in tune with the world.			
I feel distant from people.	I feel close to people.	people	other participants	Turn head to someone
I don't feel related to most people.	I see people as friendly as approachable.			Staring at someone
I see myself as a loner.	I am able to connect with other people.			Reach to someone
I have little sense of togetherness with my peers.	I am able to relate to my peers.	friend	participants with	Walk to someone
I don't feel I participate with anyone or any group.	I find myself actively involved in people's lives.		same sex	Talk to someone
Even around people I know, I don't feel that I really belong.	I feel understood by the people that I know.		similar occupation	
Even among my friends, there is no sense of brother/sisterhood.	My friends feel like family.		similar education	

3. Combine 1 and 2 to derive an observation scheme for video observation (see Table 4):

Table 4. Combination of observed behaviors and predicted behaviors

Category (react to)	Behavior
Blobulous	Interact with Blobulous
	Make sound
People	Turn head to someone
	Lean toward someone
	Reach to someone
	Staring at someone
	Follow someone
	Mimick someone
	Stand next to someone
	Touch someone
	Walk to someone
	Talk to someone
	Do something with someone
	Tell someone to do something

4. Conduct two pilot observation sessions to revise and finalize the observation scheme (see Table 5):

Table 5. Observation scheme for the level of social connectedness in a social setting

Category	Behavior	Score
Individual	Turns head to someone	1
	Goes and stands next to someone	2
	Touches someone	3
Group	Does something with someone	2
	Talks	2
	Laughs	2
	Moderates an activity	3

5. Observe one random participant (first one on the left) in each video: 5 participants and 10 observation sessions.
6. For participants, a higher score means a higher feeling of social connectedness.
7. Compare random and interactive conditions to see if there is an improvement in the feeling of social connectedness.

The paired t-test is used to check whether the scores derived from observed social connectedness scale (SCS_O) are significantly different from random settings to in-

teractive settings. Normality test was conducted to check the assumption of the t-test that both variables are normally distributed. The results shows that the observed data of individuals is normally distributed ($p = 0.619$ and 0.807, respectively). In the t-test, $t(4) = -4.214$ and $p = 0.014$ (mean = -1.09; standard deviation = 0.58, standard err = 0.26)), which means there is a significant difference between the SCO score of random setting and interactive setting.

Considering results from both statistical tests, a repeated measure ANOVA and a paired t-test, there is a significant difference between the feelings of social connectedness, in general, between the two controlled settings (random and interactive).

5 Conclusions and Future Work

The *Blobulous* prototype was designed to act as a social actor, specifically to improve social connectedness between people. *Blobulous* draws great attention from users due to its colorful appearances and lively movements. It also raises social awareness between people while they are together and informs them about individuals' and the group's condition. With those effects, *Blobulous* makes people talk about it, about each other and sometimes they try to understand *Blobulous* and interact with it. As a system with a physiological connection between humans and computers, *Blobulous* has more impact on social interaction than one without physiological connection: The experiment results showed a significant difference in the level of social connectedness between the two testing conditions (random avatars and interactive, mapped avatars).

Most importantly, the study showed that while *Blobulous* was mediating social activities, peoples' feelings of social connectedness were improved significantly ($P = 0.002$ – one way ANOVA).

The system needs to be further developed with the ability to act independently but not only mimicking to do so, which was a pragmatic design choice in this study.

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