Assessing Contextual Mood in Public Transport: a Pilot Study

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Abstract
In recent years, the technological developments in mobile and communication networks have paved the way for smart environments, whose final goal is to provide users with enhanced experiences. The measure of user experience satisfaction, or Quality of Experience, may be defined as an affective state in response to a product or service. Thus, an experiment was devised to explore the relationship between users' affective state and their context, for assessing Quality of Experience in public transport services. A pilot study, conducted to evaluate the feasibility and requirements of such an experiment is presented, leading to a large scale field study.

Author Keywords
Quality of User Experience, Affective Computing, Experience Sampling, Smart Systems, Pilot Study

ACM Classification Keywords
H.1.2 [Information Systems]: Models and Principles—*User/Machine Systems*; H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

General Terms
Human Factors; Design; Measurement.

Introduction

In recent years, miniaturisation of computerised devices and ubiquitous communication networks have paved the way for an increasingly pervasive computing environment[18]. Moreover, the advent of the Internet of Things has further increased the number of interconnected devices provided with computing capabilities. This context has caused a shift in the paradigm of Human Computer Interaction, resulting in a number of new opportunities to interact with users[17].

Smart systems emerge as a by-product of this pervasive context and are capable of perceiving an environment in terms of both context and user activity. The final goal of such systems is to act upon the perceived environment for improving users' experience[4].

The measure of user experience satisfaction, also designated as Quality of Experience (QoE), has been defined as an affective state that is the users' emotional reaction to a product or service[20]. Furthermore, a causal relationship was observed between affective state and satisfaction in relation to a product or service in two primary dimensions: utilitarian and hedonic judgement[14]. In the context of smart systems, QoE may be defined as the ability to meet users' tacit and explicit expectations[1, 8].

The measure of emotion, however, is complex and subjective. Extensive research has been developed in the field of Affective Computing (AC) for measuring users' affective state, with the goal of producing more empathic systems[15]. In a smart environment the measure of users' affective state, or mood, enables the delivery of personal services[19], with the potential to enhance users' QoE.

This paper proposes an experiment to explore the relationship between affective state and the environment in the domain of Public Transport (PT). The study aims at acquiring insights for the development of user-centric and affective-aware services with the potential to enhance QoE. Furthermore, the preliminary results obtained from a pilot study, conducted on a small scale, are presented and discussed.

Related Work

Advances in the field of AC have resulted in a number of effective methods to measure emotion through physiological and cognitive methods, ranging from healthcare[12] to education[22, 9]. Some affective devices have reached a commercial status, such as the Q Sensor[1], and are available to the general public. However these methods are intended for semi-controlled environments and its usage in more dynamic contexts, such as urban mobility, is still in early stages of research.

As an alternative, the Experience Sampling Method (ESM) has been used to assess QoE in everyday context, a technique from the field of psychology[3]. The ESM allows for the collection of data in a real-usage context and has been used in a number of domains ranging from Subjective Well-Being (SWB) to mobile privacy. A successful implementation in SWB resulted in the mobile application Mappiness[2]. This application aims at studying users' affective states in relation to their surroundings. It collects reports at random times of the day and a significant association between mood and context was observed[11]. In the domain of mobile privacy an experiment was carried out, based on a hybrid technique involving ESM and contextual interviews[13]. This project aimed at studying the privacy habits and concerns of users

[1] affectiva Q Sensor *http://www.affectiva.com*
[2] Mappiness *http://www.mappiness.org*

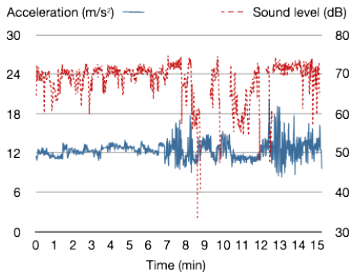

Figure 1: Journey Sample, Acceleration and Sound Level

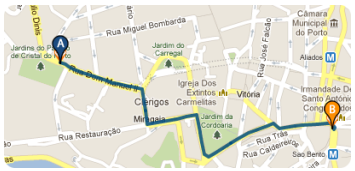

Figure 2: Journey Sample, Route

when using their mobile devices. Users were presented with a feedback form that was later discussed on a semi-structured contextual interview.

Domain of Application
The domain of urban mobility, and Public Transport (PT) in particular, is desirable due to its characteristics and potential benefits. PT provides a rich sensing environment, provided by advanced technological infrastructures and demand for real-time and dynamic information. Moreover the need for advanced information regarding the travelling environment has been identified under Advanced Traveller Information Services (ATIS)[2]. ATIS aim at providing services that offer information beyond the traditional cost and duration, including comfort and convenience. Such services provide relevant information regarding both positive and negative occurrences, that have a significant impact on travellers' satisfaction due to the emotional arousal caused[8].

In addition, the increasing concern with providing more sustainable alternatives for urban mobility is also addressed by PT. However, the perceived poor QoE presents a barrier to PT usage. This barrier may be diminished by providing travellers and commuters with personalised and relevant services.

Contextual Mood in Public Transport

The context of PT raises a number of challenges for collecting and measuring QoE. Thus, an experiment was designed for collecting personal data in-situ and non-intrusively, with the goal of investigating the relationship between affective state and environment. The experiment is based on the usage of an ESM-based prototype followed by a debriefing session. The prototype is divided into two main components: a user-centric mobile application, installable on users' personal devices, and a cloud-based software platform. User interviews are conducted at a later stage, in a debriefing of the overall experiment.

Procedure
The development of a mobile application for participants to use on their own mobile devices has the advantage of integrating seamlessly in their daily habits. In addition to the privileged channel of interaction with users, smartphones are provided with a number of sensors that may be used to sense the surrounding environment[6].

The prototype developed collects environment data using the sensors available on the device (see Figures 1 and 2) and personal data through a short feedback form (see Figure 5). Such data supports the investigation of the relationship between user and the travelling environment in different dimensions. Some of the dimensions to explore include: the relationship between user mood and environmental context; the variability of reported conditions in relation to sensed ones; or even the identification individual profiles with common needs and preferences.

Service providers were contacted during the preparation of this study, whom have shown interest and were willing to collaborate. Even though PT infrastructures are continuously improving, it was not possible to provide the environmental data required to describe vehicle environment at the time.

Mobile Application
The mobile application was developed for the Android[3] platform and enables users to record and report their daily

[3]Android *http://www.android.com*

journeys. In order to guarantee individual privacy the data collected is anonymised. Furthermore, a secure cloud-based platform stores the collected data, taking advantage of the ubiquitous connectivity and protection against unauthorised access.

Environment sensing occurs in-vehicle, throughout the journey, and samples the sensors available on the device. The application supports an extensive list, including ambient sensors (air temperature, pressure and relative humidity), motion (accelerometer and gyroscope), position (orientation and proximity), geolocation and microphone.

The application was subjected to usability testing sessions with positive results. The tests demonstrated that users were able to successfully use the application as intended. Moreover, the feedback form used to collect personal and environment data proved to be intelligible, relevant and a convenient solution overall[6].

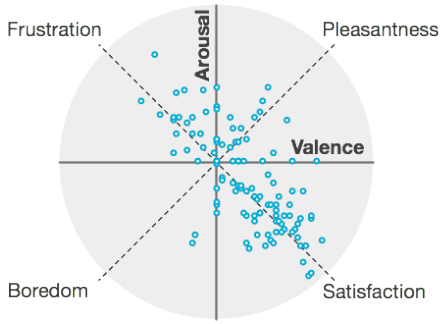

Figure 3: Participants' Travelling Mood, based on Russell's Circumplex of Emotion[16]

The feedback form is divided into affective state and environment perception. However, due to the complexity of human emotion, the expression of affective states is supported by a simple model. This model is based on Russell's Circumplex of Emotion (see Figure 3) and is divided into two dimensions: cognitive valence and physical arousal[16].

In addition to an open text entry for additional comments, the feedback form requests users for an evaluation of their journeys using continuous ordinal scales, in both utilitarian and hedonic dimensions:

- MOOD: user's affective state (see Fig. 3);
  - Valence: cognitive dimension;
  - Arousal: physical dimension;
- CONTEXT: in-vehicle environment;
  - Noise: sound level;
  - Saturation: quantity of passengers;
  - Smoothness: driving quality;
  - Ambience: environment impression;
  - Speed: speed of journey;
  - Reliability: reliability of service;

Ordinal scales facilitate rank ordering as subjective evaluations across journeys. The wording on the form presented to users assumes a colloquial tone to facilitate interaction and comprehension.

Cloud-based Platform

The collection of data is supported by a cloud-based software platform, Cloud2Bubble, which allows for the collection and processing of multiple sources of data. Moreover, this platform aims at leveraging the affective loop of interaction to measure and enhance QoE in smart systems[5].

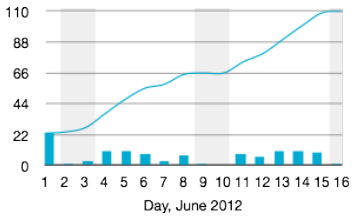

Figure 4: Cumulative Journey Reports

Pilot Study

A pilot study was conducted to evaluate the feasibility of the experiment on a small scale, including statistical variability and design, prior to a more extensive one. The study was therefore conducted in the city of Porto, Portugal with a small group of users.

Participants

Participants were selected through social networking and mailing lists. The selection was based on a short survey composed of two main sections: mobile device usage and travelling habits.

The survey was completed by a total of 172 respondents, who also contributed with improvement suggestions. The results obtained at this stage suggest a great potential to improve users' journeys through a personalised empathic service, with 42% of the suggestions being related with comfort, real-time information or dynamic trip planning.

The criteria for selecting participants include: being a frequent PT passenger, travelling within the area covered by PT providers in greater Porto and owning an Android-based device. This resulted in a diversified set of 10 subjects aged between 19 and 33 years old ($\bar{n} = 24.1; \sigma = 4.7$); 6 male / 4 female; 3 professionals / 7 students.

Setting

The study was performed in the city of Porto, Portugal between the 1st and 16th June 2012 (see Figure 4). The application was made available on the Android platform, through the dedicated application distribution channel[4]. The participants were provided with detailed instructions about the application and asked to install it on their personal devices. All journeys were then recorded and reported for a period of two weeks.

All data was collected anonymously and stored securely, ensuring participants' privacy. During the debriefing session however, with the participants' consent and cooperation, some individual journey reports were discussed.

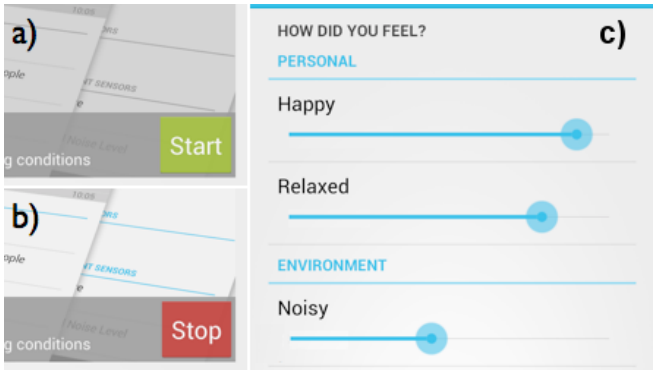

Figure 5: Mobile Application Detail: a) Start button; b) Stop button; c) Feedback form

All users were instructed to start recording their individual journeys when inside the vehicle by pressing *Start*, and correspondingly to press *Stop* before leaving the vehicle. The application then requests for users to fill out the feedback form (see Figure 5). For the purpose of this study, one journey consists of one vehicle only; a journey involving transfers generates multiple reports.

The period of data collection was followed by individual debriefing sessions with the users in the following week. The goal of the interviews was to explore users' perspectives on the experiment, including ease of interaction with the mobile application, suitability to

[4] Google Play Store *http://play.google.com*

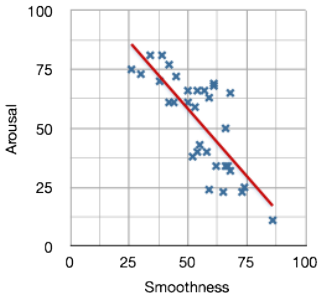

Figure 6: Smoothness-Arousal Correlation, Subject C ($r = -0.77; p < 0.01$)

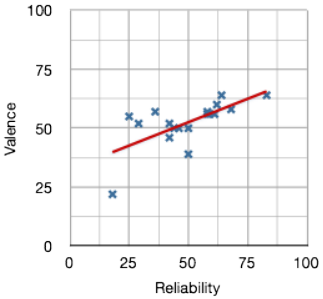

Figure 7: Reliability-Valence Correlation, Subject E ($r = 0.67; p < 0.01$)

describe the travelling context and convenience in relation to their daily habits.

Data Collection
A total of 135 journeys were reported, 25 of which were excluded for being too short (under 1 minute), or for having unanswered feedback. In some cases the journeys were only partially recorded, and the participants indicated this fact using the text field as instructed. This field was also used to provide comments and suggestions.

The participants were asked to operate their devices as usual, as it is a goal of this study to assess the reliability of such devices for sampling the surrounding environment. However, the prolonged usage of the application increased battery consumption significantly in some cases, causing users to refrain from reporting journeys as often as desirable. Furthermore, most devices were not provided with the full range of sensors supported by the application, with the exception of microphone, geolocation and motion sensors.

Results

The experiment ran for a period of two weeks and resulted in 110 valid journeys reported from 7 different subjects. Even though 10 subjects were initially selected to take part in the experiment, 3 of them reported a low number of journeys or were unable to commit to the entire two week period. The reported journeys originated over 26 hours of data, with durations varying between 1 and 60 minutes approximately. The distribution of reports per subject is presented in Table 1, and correlation examples in Figures 6 and 7.

Application Usage
Two different versions of the Android OS (2.2; 4.0) and devices (HTC Magic / Dream; Samsung Galaxy Nexus) were used to develop and test the mobile application. The Android ecosystem is, however, pervaded by a number of different software and hardware versions. Thus, some users experienced unexpected errors and corrupted data when the application was released.

All technical issues were addressed rapidly, enabling users to actively participate in the study. However, the difficulties resulted in some data loss in the first two days of the experiment.

Subject	**Journeys,** n	**Duration,** $\bar{n}$	**Duration,** σ
A	8	25:51	22:04
B	7	27:24	14:37
C	45	6:29	3:05
D	15	25:13	14:40
E	18	13:36	6:19
F	8	17:34	8:12
G	9	15:33	6:40
TOTAL	110	14:11	12:18

Table 1: Distribution of Journey Reports

Nevertheless, users proved to be satisfied with the flow of interaction with the application. They reported ease of use and convenience in participating using their own personal phones. However, route selection was limited to bus and metro stops operated by PT providers. In some areas, private companies operate similar services using different stops. Thus, some flexibility was requested for specifying the route, which will be implemented in a newer version of the mobile application. The collection and storage of data was performed as expected and monitored daily.

The extensive usage of sensors by the prototype revealed some difficulties. Firstly, most active devices used by the participants were not provided with all the sensors.

Second, some of the available sensors, when running for a extensive period of time, increase battery consumption considerably. These will be limited to the microphone and motion sensors in newer versions of the application. However, this may be complemented with other sources, such as weather and traffic feeds or data from PT providers.

Debriefing Session
The interviews were performed after the data collection period via telephone and were recorded with the knowledge and consent of participants. The purpose of the interviews was to explore users' perspectives on the study.

The first section was focused on the interaction with the mobile application. None of the users reported difficulties with installing or using the application throughout the course of the experiment, apart from the initial technical difficulties that were rapidly corrected. The users pointed out the ease of use and convenience, as well as the ability to describe the travelling context with the feedback form provided. However, two of the users felt that the feedback became too cumbersome to answer in the final days:

> *"I use the same bus everyday, we already know each other. There's not much difference."* (Subject A)

The users reported most of their journeys, a small number in some cases due to the combined usage of private transport or changes in travelling routines. There were also concerns regarding battery consumption, contributing to a lower number of reports.

The second stage of the interviews focused on the travelling context. There was an overall agreement that having to report journeys had the effect of making users more aware of their surroundings. However it did not seem to have a significant effect on the journey report. Some difficulties arose in expressing the relationship between mood and context and the opinions were illustrated with such examples as:

> *"There are some situations that have a strong effect. For example, when I'm very tired and I don't have a place to seat it really annoys me."* (Subject G)
> *"When it's very noisy in the morning I get a strong headache."* (Subject B)

The complexity of reporting mood was also expressed in relation to the activity. All the subjects, except for subject E, reported their inability to think of their mood in relation to a single activity and therefore reported their overall mood. Subject E, however, tried to report mood in relation to the journey exclusively.

> *"I reported my mood in absolute terms, I don't think it's possible to dissociate [mood]."* (Subject F)
> *"It wasn't very easy, but I always tried to report my mood for the journey only"* (Subject E)

Finally, the last section of the interview focused on security and privacy. None of the users felt uncomfortable or expressed any concerns in relation to the collection or usage of data. All of the subjects would continue using the application if they were offered a service with the discussed characteristics.

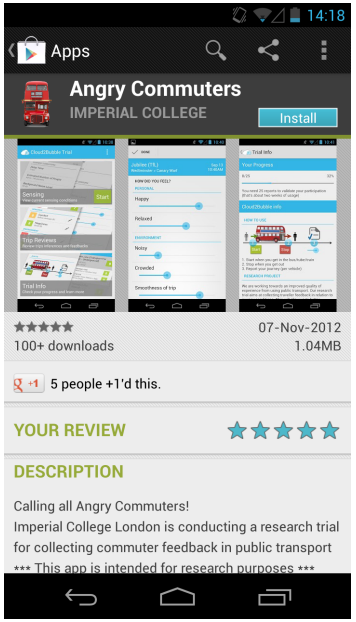

Figure 8: Mobile Application, Store

> *"I don't feel it's intrusive at all, after all we are used to share our lives online."* (Subject B)

Discussion
The realisation of this pilot study enabled the assessment of the experiment feasibility and requirements. The results obtained provide valuable insights, but were insufficient to perform a full analysis. However, a preliminary analysis was performed to explore different possibilities.

The overall response of the participants to the pilot study supports the proposed approach for investigating quality of user experience in PT. The technical solution proved to be effective throughout the experiment, enabling collection of both personal and environmental data.

The experiment design benefited from a number of improvements, unveiled during this stage, including user interaction design and quality of collected data. Such improvements include more flexible input methods and optimisation of device usage.

An analysis across travellers does not identify a common set of factors with a direct impact on their experience. Thus, there seems to be no common travelling preference for a diverse group of users, even though there are levels of comfort in relation to the environment. In contrast, when considering individual users, their experience seems to be directly related with distinct factors. Moreover, this factors differ between users, suggesting individual user profiles. Such profiles may be shared across users with comparable needs, preferences or demographics and inform the development of personalised services.

Most participants reported having difficulties with dissociating emotion in relation to a single activity. The affective state acquired in naturalistic settings, either by participatory or automated sensing, is not a direct measure of a particular experience. This latent effect must therefore be taken into consideration in future studies.

Emotional state seems to be affected by different contextual elements. The preliminary results suggest that the cognitive component tends to be more closely related with the travelling means, *eg:* mode of transport and condition of vehicles. The arousal component, in contrast, seems to be associated with specific characteristics of a single journey, *eg:* saturation and reliability.

The preliminary findings open up a number of opportunities for empathic systems in the context of urban mobility and smart environments in general. In the context of PT, there are two main possible avenues. Firstly, to facilitate service providers in managing their resources and planning the development of transportation networks. Second, to provide users with a personalised empathic system with the potential to enhance their QoE.

Future Work

The pilot study presented leads to a large scale field study in London, UK. The findings obtained at this stage are used to improve the overall design of the experiment and prototype, as well as to determine user and environment data requirements. The preliminary findings obtained will be used as a guidance for further investigation of the relationship between mood and context.

The improved experiment is being conducted in the last quarter of 2012 in London, UK. With the goal of recruiting a large number of users, the call for participants was open to the general public and distributed through social networking platforms, mailing lists and authors' contacts. The study was also featured in widely known publications, such as The Guardian[7], Stuff magazine[21]

Figure 9: Mobile Application, Trial Info Screen

and The Next Web[10], reaching a larger and more diversified audience.

Field Study

The participation is limited to commuters living in greater London, frequent PT users and provided with an Android device. The application was made publicly available (see Figure 8) as well as a supporting website containing information about the experiment and detailed instructions.

A set of additional features were also implemented in the application to facilitate user participation. These features include a demographics profile, a personal goal to achieve a valid contribution and simple instructions on how to report journeys (see Figure 9).

Conclusion

This paper presents an experiment devised to investigate the relationship between affective state and environment conditions in the domain of public transport. This research aims at facilitating the convergence of affective-aware technology and smart environments towards QoE enhancing systems.

A pilot study was conducted with a small group of users, in preparation for a more extensive one, to assess the experiment feasibility and requirements. This study resulted in a number of improvements of the overall experiment design and contributed to a more robust technical solution. Moreover, the limitations uncovered at this early stage were addressed prior to the main field study. A preliminary analysis also made possible to explore some aspects of the relationship between user and environment. A more extensive field experiment takes place informed by the results obtained from the pilot study.

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