Expected User Acceptance of an Augmented Reality Service for a Smart City

Francisco Rebelo[1,2(✉)], Paulo Noriega[1,2], Tiago Oliveira[2], Daniela Santos[2], and Sabrina Oliveira[3]

[1] CIAUD, Universidade de Lisboa, Rua Sá Nogueira | Pólo Universitário | Alto da Ajuda, 1349-063 Lisboa, Portugal
fsrebelo@gmail.com
[2] Laboratório de Ergonomia, Faculdade de Motricidade Humana, Universidade de Lisboa, Estrada da Costa, Cruz Quebrada, Portugal
[3] Laboratório de Ergonomia e Usabilidade, Universidade Federal do Pará, Curitiba, Brazil

Abstract. Despite the existence of automatic systems for collecting information about events in the city, without information sharing by citizens, smart city services concepts can hardly success. Thus, the problem is not the existence of technology solutions for smart cities concepts, but how to develop services that will involve citizens to share information about the events in the city. Social psychology theories point out that sense of bellowing, perceived enjoyment, perceived reciprocal benefits, power of knowledge, outcome expectation and perceived status, provides an involvement for citizens to share information and knowledge. In this paper, we propose to relate those theories, with the intension to use a mobile augmented reality service. We created an online survey, based in a scenario with a video, where the participants visualize a character behavior sharing and getting information in the city, using a mobile augmented reality service. The results confirm that the participants accept and want to use a mobile augmented reality service in a smart city, and have been identify the factors that could be more associated with the intention to use the augmented reality technology in the smart city, namely perceived enjoyment, intention to share experience, intention to get knowledge, perceived value, perceived similarity and perceived reciprocal benefits. Exploring those constructs inside gamification solutions in this mobile augmented reality service, is discussed in the conclusion.

Keywords: Smart city · Technology acceptance · Augmented reality

1 Introduction

This paper outlines a research project, funded under the Portugal 2020 Program, which involves the conceptualization, design and implementation of an information technology platform where the wealth of data collected by citizens (volume, variety and detail), is aggregated with data collected by a variety of other existing sensors in the city, giving in real time, a clearer and more vivid vision of the global "pulse" of the city. The platform will also create an adequate environment (physical and virtual) for cooperation between citizens and city authorities enabling that the information added

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by one part to be available to all stakeholders. This objective proposes an approach to the concept of Smart Cities that puts the citizen as the focal point of the data collection and information sharing process. The citizen is the most relevant element in this process of sharing information, because humans have the most notably sensory and processing capabilities that allow them to create criteria about city status. Thus, allowing people to be more than a passive information receiver but an active contributor to healthy smart city pulse. Hence, is fundamental that the citizen can be engaged in a virtual community, to consult and share information. Virtual communities (VCs) play an important role in this subject, affecting the way that the citizen uses and share the information in the smart cities.

In this context, it is fundamental that the citizen can share the information and knowledge associated with the events in the city. Some studies have emphasized the importance of knowledge sharing in VCs, to identify the aspects that facilitate the knowledge sharing behavior [1–3].

A good example of sharing knowledge is the *Tripadvisor* application, where users share their experiences about their travels with other potential travelers. Also related with the use of such apps, some studies found that online evaluations of movies or booking might affect the sales [4, 5].

However, in order to people share information in those kind of apps or VCs, first they have to accept technology. In this stud the evaluation of the user acceptance was done according to some social psychology theories: sense of bellowing (familiarity, perceived similarity and trust in other members); perceived and expected reciprocal benefits; perceived value; knowledge power and enjoyment; beside the intension to use a mobile augmented reality service.

Sense of Bellowing

Some researchers studied what factors attract people to the VCs [6]. For those authors, an important factor for the success and survival of a VC is the sense of belonging and participation. According to Hagerty et al. [7], sense of belonging is considered as one specific process of connection between people and an important factor for mental health and social well-being. Sense of bellowing describes an emotional connection of a user to a VC that are related with a sense of identification and membership [8]. Also, sense of bellowing is an important component in online communities [9], contributing to the members' loyalty to VCs [10], and it subsistence [11]. Sense of bellowing can be evaluated with the following variables: familiarity, perceived similarity and trust in other members.

Perceived and Expected Reciprocal Benefits

According to Kankanhalli et al. [12] perceived reciprocal benefit in the context of information sharing is defined as the benefit expectancy of a future request for information being met as a result of current contributions. In this context, in order to the Citizen contribute with information events of the city he must believe that their contribution is worth the effort. Inside the smart city contexts where the Citizen time and energy are limited, by the others stimulus and tasks, they usually unwilling to share scarce resources with others. Earlier research in this area suggested that information sharing in online communities is facilitated by a strong sense of reciprocity [3]. Perceived and expected reciprocal benefits can be evaluated with the intention to share and get information.

Outcome Expectations
Outcome expectations means to the expected consequence of one's own behavior [2, 13], also refer to an individual's belief that activity realization leads to a beneficial outcome [14]. In the smart city context, personal outcome expectation refers to the rewards following the actions of Citizen, who share their information in return for some benefits, such as information that can improve their efficiency. Outcome expectations can be evaluated with the intension to share and to get information.

Knowledge Power
If a person has control over an information that the others need or want, this puts a person in a powerful position. According to Kankanhalli et al. [12], knowledge is considered a source of power and individuals may hide it, because people are afraid that loss of knowledge will cause them to lose their competitive advantage. In this context, people can prefer to retain information than share it. In the same line, Dunford [15] and Grandori and Kogut [16], suggests that some persons have a reluctance do share information due to their insecure feelings, such as the fear to lost career opportunities. In the context of smart city, this power comes when the Citizen is in a position to share or not an important information that can be important for the others.

1.1 Perceived Enjoyment

According to Hsu and Lin [17], perceived enjoyment can be defined as the degree to which an internet user participates in social networks, because the process "yields fun and enjoyment". The authors suggested that enjoyment is a factor that determines the intention of users to participate in social networks. Another complementary definition is proposed by Venkatesh [18], that defined perceived enjoyment as "the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use". From another viewpoint, Kankanhalli et al. [12], defined enjoyment in helping others, as the perception of pleasure obtained from helping others via knowledge contribution. Previous research in the work context, indicated that employees are intrinsically motivated to knowledge contribution because they enjoy helping others [19].

1.2 Intention to Use and Perceived Value

Perceived value refers to the perception that a service would be appropriated for a described situation [20]. Intention to use is influenced by attitudes towards the behavior, subjective norm and perceived behavioral control, that are associated with the technology acceptance model [21]. Both concepts are connected and influences the Citizen decision to use or share information in a particular online platform.

1.3 Objectives

The main objective of this study is to evaluate the expected user acceptance of a mobile augmented reality service for a smart city, using a scenario where a person uses this service. We are also interested to identify the constructs from the previous theories that

are more related with intention to use a mobile augmented reality service and explore the existence of relations between the individual characteristics of the participants and the constructs.

2 Methodology

A questionnaire was designed to elicit the expected participant acceptance of an augmented reality service for a smart city, using the following previously described parameters: sense of bellowing (familiarity, perceived similarity and trust in other members); perceived and expected reciprocal benefits; outcome expectations; perceived enjoyment; knowledge power and perceived value and intention to use.

Considering that the interaction with an augmented reality system could be a new experience for many persons, we create a video with a narrative that enables the comprehension of a potential usage of a mobile augmented reality service. This narrative served as script in the development of the video where a protagonist, a citizen of an intelligent city (Maria), uses her smartphone to share and consult information about the city, in different situations during a day when she must go to a medical appointment. During the course, Maria interacts with a mobile augmented reality service to report a problem for citizens safety (a hole in the sidewalk) and to consult two good practices (an restored building and urban art in a building). After each interaction with the mobile augmented reality, Maria receives a feedback with additional information about the events (i.e. number of persons that already reported the event) and a reward.

The illustrations are made in Adobe Illustrator® and placed on the VideoScribe® application. The video lasted 2 min and 39 s.

2.1 Video Narrative

Maria is at home and receives a notification on her smartphone that she has a medical appointment scheduled in 40 min (Fig. 1). Maria starts her journey to the health center where she will have her appointment, but while she walks she finds a hole in the sidewalk that can be a problem for the people safety. She has the idea of sharing this information in the City's Information Sharing Platform, taking a photo. After this action, Maria receives the information that she was the 10th person to report, the repair is expected soon, and she will have a reward for sharing (Fig. 2).

After the appointment, Maria will walk through the city and receive a mobile notification, that she and another 1000 people reported six months ago, the existence of a ruined building. Now, she can use her mobile augmented reality system, to see the building before the restoration (Fig. 3). Later, Maria is surprised by an intervention of urban art in a building, she receives a notification in her mobile augmented reality system saying that she should point the camera of her smartphone, if she wanted to have more information about this urban art. In addition to using the camera of the mobile phone she still shares the information. After, she received the information that was the first person to share and have earned a reward (Fig. 4).

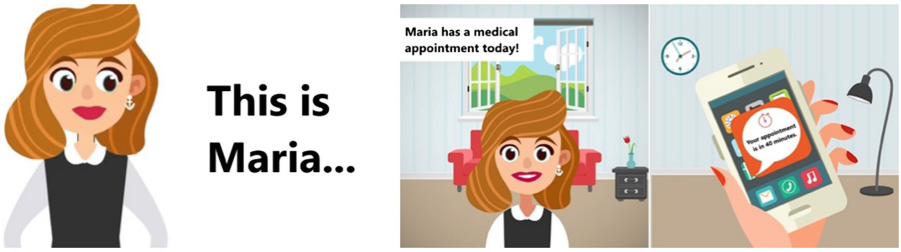

Fig. 1. Maria's presentation, she has a medical appointment in 40 min.

Fig. 2. First situation, Maria finds and reports a hole in the sidewalk.

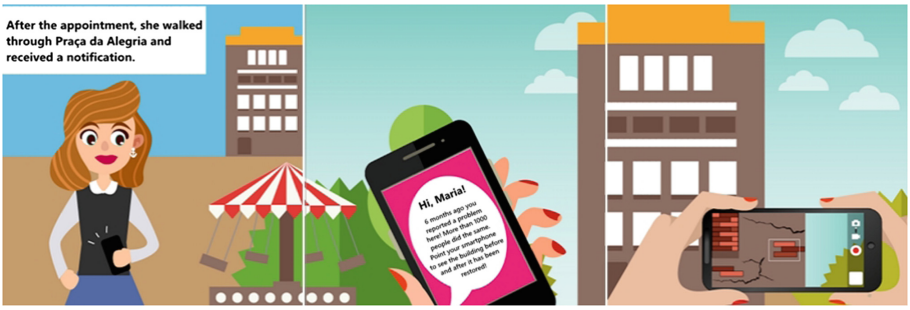

Fig. 3. Second situation, Mary uses RA to visualize the building before restoration.

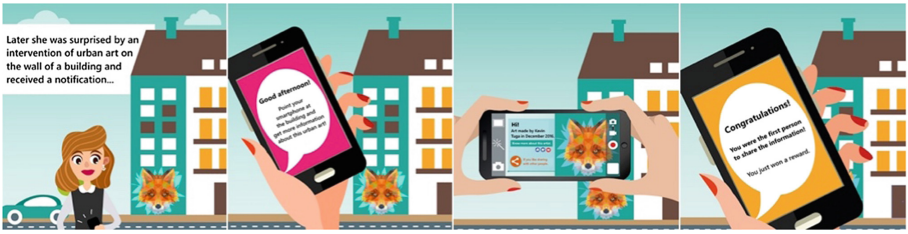

Fig. 4. Third situation, Maria is the first to report the existence of an urban art.

2.2 Sample

In total, 194 questionnaires were collected online for analysis. The gender ratio corresponds to 78 men (59.8%) to 116 women (40.2%). The minimum age was 17 years and the maximum age was 70 years, the average was 33.9, with a median of 28.5 and a standard deviation of 13.6 years.

The nationality with the highest frequency was Portuguese (n = 183, 94.4%) followed by Brazilian (n = 9, 4.62%), Guinean (n = 1, 0.5%) and French (n = 1, 0.5%). For the qualification of the sample 5 participants (2.6%) have basic education, 53 (27.3%) high school, 85 (43.8%) graduation, 44 (22.7%) master's degree and 7 (3.6%) PhD.

Responding to the question "weekend occupation", 56 (28.9%) chose to stay home, 120 (61.9%) get out and 18 (9.3%) indecisive or other response. For the question "place for vacations", 107 participants (55.2%) show interest in spending vacations in a city, while 87 (44.8%) prefer to interact with nature.

Twenty-two participants (11.3%) don't use or rarely use social networks while 172 (88.7%) say they frequently use social networks. Of the 194 participants, 17 (8.8%) don't use social networks, 82 (42.3%) use mainly to see information and 95 (49%) use essentially to share information.

2.3 Survey

Based in the previous described references, we developed a questionnaire in the Google Forms online platform, divided into 4 sections: (1) consent terms; (2) video with the scenario to be studied; (3) 12 questions in a seven-point Likert scale ranging from 1 to 7, where 1 was (completely disagree), 2 (disagree), 3 (disagree partially), 4 (don't agree or disagree), 5 (Partially agree), 6 (Agree) and 7 (completely agree); and (4) demographic data (gender, age, nationality, profession, qualifications, place of residence preference, weekend occupation, frequency of use of social networks and reason for use of social networks).

Following the 12 questions for each questionnaire construct:

Familiarity: I became familiar with Maria's interests and behaviors in the city.
Perceived Similarity: I feel that Maria has interests similar to mine.
Trust in Other Members: Maria will do everything within her capacity to help others.
Sense of Belonging: I feel I am part of the city where Maria lives.
Intention to Get Knowledge: I want to get information, shared in the smart city, about the places in the city where Maria lives.
Intention to Share Experience: If I went to Maria city I would like to share events with other people.
Perceived enjoyment: The process of sharing events in the Maria city's is enjoyable.
Perceived reciprocal benefits: If Maria shares events (problems and good thinks of the city), other citizens will also share events with her.

Knowledge power: Maria feels important and special when sharing the events of the city.
Knowledge sharing: Maria uses her smartphone to keep up-to-date on city events.
Perceived value: The way Maria reported events in the city, could help me achieve my goals in the smart city.
Intention to use: I would like to try this kind of interaction with the city.

2.4 Procedures

Participants were recruited through social networks or contacted by email. All participants responded freely and spontaneously to the questionnaire after reading and agreeing to the consent form. The confidentiality of the data collected and its use for research purposes has been ensured.

Participants start by viewing the video before answer the previously described 12 questions and the demographic data.

The data, was processed with IBM SPSS (*Statistical Package for Social Sciences*) software to perform the statistical analysis.

3 Results and Discussion

Table 1 shows the distribution of scores by percentage of participants (N = 194). The first and second columns shows respectively the sentences and the constructs. The third column, the percentages of participants that: 1 (completely disagree), 2 (disagree), 3 (disagree partially). The fourth column, the percentage of participants that: 4 (don't agree or disagree). The fifth column, the percentage of participants that: 5 (Partially agree), 6 (Agree) and 7 (completely agree). All the agreements are related with the sentences.

Considering our main objective, evaluate the expected user acceptance of a mobile augmented reality service for a smart city, using a scenario where a person uses this service, we verify in the Table 1 a distribution tangentially to the right. On average, 68.4% of the participants identifies with the Maria behaviors and want to try this kind of interaction, although most of them, feel that they are not part of this city. Only 39.2% agrees positively with the sentence "I feel I am part of the city where Maria lives". Probably they did not identify themselves with the city in the movie, since we try to not use familiar elements from any particular city.

In order to identify the minimum number of factors representing relationships between the various items from the questionnaire a factorial analysis was performed. The validity tests of factorial analysis (c.f. Pereira [22]) allow to say that the factorial analysis has validity for the chosen variables. Thus, the Keyser-Meyer-Olkin test had a value of 0.891 revealing that the principal components analysis is good. The Bartlet sphericity test allows to reject the null hypothesis of non-correlation between the initial variables ($\chi = 1146$; $df = 66$; $p < 0.001$).

Table 1. Distribution of scores by participants for each question.

Sentences	Construct	Percentage of responses 1, 2 and 3	Percentage of responses 4	Percentage of responses 5, 6 and 7
I became familiar with Maria's interests and behaviors in the city	Familiarity	16.5%	24.2%	59.3%
I feel that Maria has interests similar to mine	Perceived similarity	18%	26.3%	55.7%
Maria will do everything within her capacity to help others	Trust in other members	4.6%	10.8%	84.6%
I feel I am part of the city where Maria lives	Sense of belonging	45.4%	15.5%	39.2%
I want to get information, shared in the smart city, about the places in the city where Maria lives	Intention to get knowledge	23.2%	17%	59.8%
If I went to Maria city I would like to share events with other people	Intention to share experience	19.1%	16.5%	64.4%
The process of sharing events in the Maria city's is enjoyable	Perceived enjoyment	14.4%	17.0%	68.5%
If Maria shares events (problems and good thinks of the city), other citizens will also share events with her	Perceived reciprocal benefits	10.8%	12.4%	76.8%
Maria feels important and special when sharing the events of the city	Knowledge power	9.3%	16.5%	74.2%
Maria uses her smartphone to keep up-to-date on city events	Knowledge sharing	4.1%	8.2%	87.6%
The way Maria reported events in the city, could help me achieve my goals in the smart city	Perceived value	9.3%	13.4%	77.3%
I would like to try this kind of interaction with the city	Intention to use	13.9%	13.4%	72.7%
Global average		15.7%	15.9%	68.4%

In Table 2, the factor matrix after varimax rotation can be seen. The factor extraction determined three factors. These represent a cumulative percentage of 67% of the variance.

Table 2. Factorial analysis.

Constructs	Factor 1	Factor 2	Factor 3
Evaluated	47.7%	11.6%	7.7%
Intentions to use	**0.85**	0.24	0.11
Perceived enjoyment	**0.77**	0.31	0.13
Intention to share experience	**0.76**	0.17	0.23
Intention to get knowledge	**0.73**	0.13	0.36
Perceived value	**0.64**	0.52	0.20
Perceived similarity	**0.62**	0.06	0.56
Perceived reciprocal benefits	**0.58**	0.51	0.12
Knowledge power	0.00	**0.84**	0.18
Trust in the others	0.28	**0.65**	0.10
Knowledge sharing	0.41	**0.65**	−0.09
Sense of belonging	0.11	0.08	**0.81**
Familiarity	0.25	0.12	**0.77**

The first factor, responsible for 47.7% of the variance, is saturated in descending order by intentions to use, perceived enjoyment, intention to share experience, perceived value, perceived similarity and perceived reciprocal benefits. The second factor, responsible for 11.6% of the variance, is saturated in descendent order by the knowledge power, trust in the others and knowledge sharing. The third factor is saturated by Sense of belonging and familiarity.

Concerning user acceptance off a mobile augmented reality service, the item that is associated with it, is the sentence intention to use this service, that is in the first person, thus ask directly to participants in the study if they would like to try that kind of interaction in the city. Thus, the constructs from the social psychology theories that according to the first factor in the factor analysis are best associated with intention to use are the perceived enjoyment the, intention to share experience, perceived value, perceived similarity and perceived reciprocal benefits.

Related with the other relations between the user acceptance constructs with the individual characteristics of the participants, we used Mann-Whitney U, a non-parametric test for independent samples to analyze the data. We don't found any significant differences between the constructs and the age, gender and habilitation ($p > 0.05$). However, we verified significant differences in the use of networks (people who never, or rarely use social networks, $n = 22$) and (people who use almost always, or always use social networks, $n = 172$) for the following constructs*: perceived similarity ($z = -1.8$; $p < 0.05$); intention to get knowledge ($z = -2.4$; $p < 0.05$); Perceived reciprocal benefits ($z = -2.6$; $p < 0.05$); knowledge sharing ($z = -1,9$; $p < 0.05$ and the intention to use ($z = -2.7$; $p < 0.01$). Chart 1 illustrates the scores for each construct and the sentence. This means that for participants who "never or rarely use social networks", and users who "always or almost always use social networks," don't have an interest to use a mobile augmented reality service to get or share information in a smart city (Fig. 5).

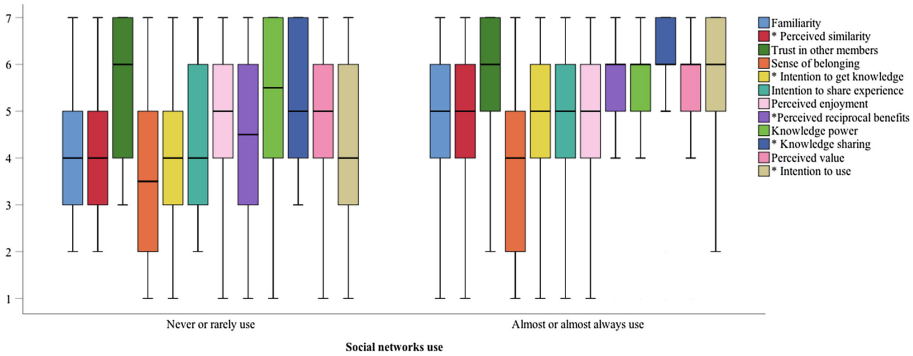

Fig. 5. Scores across constructs by frequency of use of social networks

4 Conclusions

This study reports the result of expected user acceptance evaluation of a mobile augmented reality service for a smart city, using a scenario where a person uses this service. The identification of the acceptance of this kind of technology in an early phase of our project development – Smart City Sense, will be very important to justify the costs involved in the development of a mobile augmented reality service. For this subject we identified that 72.7% of the participants agree with the sentence "I would like to try this kind of interaction with the city". However, 27.3% of the participants disagree (13.9%) or don't have a preference (13.4%) for this kind of interaction. We verify significant differences between the participants that use frequently social networks and the intension to use this kind of technology, particularly to get or share information. In conclusion, those results showed the use of a mobile augment reality service in a smart city is a good option for the participants that have a frequent use of social networks.

In this study we were also interested in identifying the factors that could be more associated with the intention to use the augmented reality technology in the smart city. From factor analysis we can observe that the, perceived enjoyment, intention to share experience, intention to get knowledge, perceived value, perceived similarity and perceived reciprocal benefits, are the factors more associated with the intention to use augmented reality. Exploring those constructs inside gamification solutions in this mobile augmented reality service, could be a good strategy to engage the Citizen in our Smart City Sense Project. In order to citizens use the augmented reality technology in the smart city, the design solutions must include the fun of use, they must allow citizens to share the experience and get knowledge. They must be very well informed and aware of the technology and how the use of technology benefits you and the other members of the community.

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