Personalized interactive urban maps for autism: an innovative approach involving persons with Level 1 autism spectrum disorder to user-centered design

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PERSONALIZED INTERACTIVE URBAN MAPS FOR AUTISM: AN INNOVATIVE APPROACH INVOLVING PERSONS WITH LEVEL 1 AUTISM SPECTRUM DISORDER TO USER-CENTERED DESIGN

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ABSTRACT

Purpose: Because of social interaction difficulties, cognitive characteristics and sensory sensitivity, people with Autism Spectrum Disorder may struggle with independence and active participation in urban contexts. Through understanding how people with Autism Spectrum Disorders experience and perceive urban spaces, the PIUMA (Personalized Interactive Urban Maps for Autism) project' purpose is to create a useful platform to support persons with ASD in their movements in the city, helping them in managing their daily lives, promoting their autonomy and active participation in urban contexts, taking in to account their direct point of view.

Design/methodology/approach: We involved researchers with different backgrounds applying mixed research techniques such as semi-structured qualitative interviews, Participatory Design, exploiting user-adapted systems techniques, Human-Computer Interaction (HCI) techniques and interviews. We involved PWA from the beginning of the project to gain user requirements, as well as to assess the acceptability and effectiveness of our solution in the final stage. In specific phases of the project, we involved a group of parents of PWA and a group of neurotypical individuals as a control group.

Findings: We collected various data and created an App taking into account people with autism needs, suggestions and points of view.

Research limitations/implications: Choosing different methodologies in order to allow participants to express their point of view, their needs and suggestions, we limited the quantitative data collected. The male-to-female ratio in the study, along with the sample size and participants' age, can also be considered limitations.

Practical implications: We collected information about how autistic people move in urban contexts, represent the space of their cities, move independently and use technological devices. The data we collected also provides suggestions about how to improve computer systems designed for them.

Social implications: Our results suggest how to improve computer systems designed for autistic people and how to encourage their full participation in community life according to their cognitive and sensory characteristics.

Originality/value: The PIUMA project takes into account the direct input of people with autism in all the different stages from conception and design to deployment of the device in a human-centered design approach.

1. Introduction

Autism Spectrum Disorders (ASD) are characterized by communicational and social interaction difficulties in different contexts and patterns of restricted and repetitive behavior, interests, or activities. All of these symptoms cannot be explained by a generic Intellectual Disability (ID); they are present in early childhood but may not fully manifest until daily functioning is significantly impaired in social context, family, school or work (APA, 2013). The occurrence of Autism Spectrum Disorders is about 1% of the general population (Maenner et al., 2020; Keller et al., 2020). The most recent estimates for the United States are 1:44 with 23 children per 1000 and a male-to-female prevalence ratio of 4.2 (Maenner et al., 2020a), up to 1:36 in recent dara (Maenner et al., 2020b) even though there are some concerns about these findings.

The DSM 5 distinguishes 3 Levels of support for Autism Spectrum Disorders based on difficulties in communication and social reciprocity and the interaction and patterns of restricted and repetitive interest and behaviors (APA, 2013). The level of support required varies with Level 1 requiring support, Level 2 requiring substantial support, and Level 3 requiring very significant support (APA, 2013).

Some people with autism (PWA) show intellectual disabilities and/or low- or mid-language abilities; other PWA can have an intelligence profile on average or above average (Brighenti et al., 2018). PWA may have difficulties in social-emotional reciprocity, nonverbal communicative behaviors or show stereotyped or repetitive speech, and fixed and highly restricted interests (APA, 2013).

PWA may struggle in communication and with sensory sensitivity (APA. 2013): they may have unusual interest or preference in certain sensory aspects of the environment or tend to avoid other types of sensory stimulation. PWA may show sensory reactivity that influences the way they perceive and process information (Tavassoli et al, 2014, Talay-Ongan et al, 2000) and enjoy their living-environments: they can be either hyper-sensitive (over-reactive) or hypo-sensitive (under-reactive). PWA can be overwhelmed by sensory stimulation (Robertson and Baron-Cohen, 2017, Robertson and Simmons, 2013.) and this can result in sensory avoidance. At the same time, PWA experiences sensory seeking (Tavassoli et al., 2014), pursuing sensory stimulation across various modalities such as touch, sight, taste, hearing, proprioception and interoception.

Difficulties may arise in processing multiple stimuli at the same time and in the synthesis of information from the different sensory components (Happè, 1999).
From a neuropsychological point of view (Brighenti et al., 2018-2019), there may be difficulties in attentional shifting or in managing multiple things at the same time. Difficulties in sustained attention may occur due to fatigue or increased sensory overload. In addition, peculiarities in the executive functioning of PWA have been highlighted (Hill, 2004) namely the preference for routines, the low tolerance for unexpected changes and interruptions, the need for predictability and difficulties in generalization and planning (see Brighenti et al., 2018-2019).
As results, in everyday life, PWA may express experiences of anxiety and/or loneliness (Umagami, et al., 2022 for a review) concerning social interaction difficulties, cognitive characteristics and sensory sensitivity and as a result, their participation in social or aggregative events may be limited (Müller et al., 2008).
Information and Communication Technology (ICT) supports the lives of PWA by enhancing social connection and aiding in the organization of their daily activities (Putnam and Chong, 2008, Gallardo Montes et al., 2021) and generally, PWA show a positive mindset toward computer technologies (Valencia et al., 2019).
Scientists have begun gathering input on how to create and improve smart systems that can help persons with autism (Putnam et al., 2019) and, in recent years, many mobile Apps have been created (Gallardo Montes et al., 2021).
Usually, ICT-based solutions try to help PWA with social difficulties. Most of the research about autism focuses on kids and not grown-ups (Goldsmiths, 2004). Some works try to help ASD children in reading and speaking using different methods like playing educational games (Arciuli et al., 2019; Khowaja et al., 2019) while others use Augmented Reality to help PWA in various social situations (Romero Pazmiño et al., 2020).
Some studies have begun to concentrate on ASD teenagers' or adults' demands, creating technology that will increase their independence in daily activities (Graetz, 2010; Gerhardt, 2011). For instance, (Caria et al., 2018) created a web-based program to assist teenagers with ASD in comprehending the notion of money in real-world scenarios.
However, only a few ICT solutions are customized for each person's specific needs, mostly used in education (for example see Judy et al., 2012; Costa et al., 2017; Milne et al., 2018; Ng and Pera, 2018).
Few technologies help people with autism in spatial exploration. Most of the services in this field are websites that give you information or provide suggestions for traveling. For instance, Autistic Globetrotting (autisticglobetrotting.com) and Toerisme voor Autisme

(https://www.toerismevoorautisme.be/) provide tips for families dealing with autism. They demonstrate how to pack bags and assess tourist spots, explaining what visitors can anticipate there. Other approaches involve creating tourist websites that are easy for PWA to use. Examples of such websites can be found in studies conducted by Dattolo and colleagues in 2016 and in 2017 (Dattolo et al., 2016; Dattolo and Luccio 2017).

Virtual Reality (VR) technology is also used in the tourism industry to simulate the feeling of being somewhere else and to help people learn skills necessary for travelling. For instance, the study by Bernardes et al., (2015) introduces a game that uses virtual reality (VR) to teach PWA how to ride public buses. VR technology can be used for simulation of novel city design modality (Globa et al., 2019).

Mobility in urban settings is influenced by sight, hearing, and smell, and people's emotions are severely impacted by high sensory stimulation. The temperature, openness, and population density of a place are additional crucial environmental factors that might affect people's perceptions of safety.

Such peculiar sensory processing may cause PWA anxiety, exhaustion, disgust, a feeling of oppression, or distraction, to name a few: numerous research revealed that PWA deliberately avoids environments that can impair their senses as a result of sensory sensitivity and overload (Golan et al., 2010; Robertson and Simmons, 2013; Rapp et al., 2018).

This means that technology should be able to help autistic people in managing sensory overload. The focus should be on addressing their dislikes or avoidances related to their heightened sensitivity to sensory stimulation. In simpler terms, it is important to customize solutions because sensitivity to sensory experiences is different for each person with autism. This means that what may be comforting for one person may not be for another. So, it is crucial to take into account each person's individual needs and preferences.

In the literature, there is evidence regarding the peculiarities in spatial exploration of PWA, which is evident in both virtual environments and everyday contexts (see Smith, 2015), but the data from the literature require further investigation. Through understanding how PWA perceived and experience urban spaces, our project, named Personalized Interactive Urban Maps for Autism (PIUMA), finds its main objective in creating a useful map-based[1] platform to support PWA in their movements in the city, helping them in the management of their daily lives, promoting their autonomy and active

[1] We used the open source Open Street Map (https://www.openstreetmap.org/). OpenStreetMap (OSM) is a collaborative, open-source project that creates and provides free geographic data and maps to anyone who needs them. OpenStreetMap is built by a community of volunteers who contribute and maintain data about roads, trails, cafes, railway stations, and much more, all over the world.

participation in urban contexts. This can be framed into the wider context of *sensory urbanism*[2], an interdisciplinary field that explores how people perceive their built environment to create cities that appeal to all people's senses (Howes, 2022). Its main objective is to create not only an aesthetically pleasing environment that appeals to the five known senses, for example modulating the quality of sound. Davidson and Henderson (2016) demonstrate how a detailed understanding of the affective and sensory aspects of people's engagements with the city could be incorporated into design practices to improve access not only for ASD people but a wider urban population.

The main objective of the project is the conception and design of a new device using a Human-Centered design approach (Boyd et al 2017, Maun et al., 2023) that takes into account the direct input of people with ASD at all stages.

2. Research process

To gain the goals of the project, we created a network of researchers with different backgrounds: human-computer interaction (HCI) researchers, cognitive scientists, psychologists, neuropsychologists and psychiatrists for gathering the user requirements and evaluating the project outcomes, HCI designers and geographers for designing the interactive maps, computer scientists for the development. This was necessary due to the complexity of the domain and of the target audience, which requires different skills and expertise.

3. Methods

The design of the solution followed a user-centered design approach (Boyd et al., 2017), involving PWA from the beginning of the project to gain user requirements, as well as to assess the acceptability and effectiveness of our solution in the final stage.

In the *1st phase*, neuropsychologist conducts semi-structured individual interviews with autistic people: subjects were interviewed for approximately 45-50 minutes for each one. We also used Participatory Design (PD) techniques, involving end users in the design of new technology-based services, which is increasingly employed in the field of technology for autism. Although the communication problems commonly related to PWA may suggest that PD is counter-indicated, various techniques have been developed for engaging autistic people in design (Good et al., 2016).

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[2]https://parametric-architecture.com/the-ultimate-guide-to-understanding-sensory-urbanism/
https://www.technologyreview.com/2022/06/14/1053771/sounds-smells-vital-to-cities-as-sights/

PWA were involved in the design of the interactive maps, confronting our design decisions with their needs, and incorporating their feedback in the design.
In addition, in this phase, we involved some parents of adults with autism to understand how their sons/daughters learned to move in urban contexts through semi-structured individual interviews.

In the *2nd phase,* we designed and developed the solution exploiting user-adapted systems techniques (Brusilovsky, 2001). These are Artificial Intelligence (AI) methods that allow automatically creating a user profile with user features and then using this model to adapt the content to the specific user. In particular, we collected user preferences for items category of places and user aversions for sensory features of places and then selected the item to propose to the user trying to satisfy both requirements. In doing so, we adopted a content-based recommender approach (Lops et al., 2011). A content-based recommender system is a type of recommendation system that suggests items to users based on the characteristics or features of the items themselves. It relies on analyzing the content or attributes of the items and matching them with the user's preferences.

In the *3rd and 4th phases*, we employed HCI different methods like task experiments, field study and online surveys to evaluate the solution. The prototype has been developed through iterative cycles of design-evaluation-redesign. PWA's suggestions were compared to a control group of neurotypical adults.
Assessments were conducted in real-life contexts of use to ensure the acceptability, usability and effectiveness of the technology. The participants filled in a final designed questionnaire based on an Italian-translated version of the System Usability Scale (SUS- Brooke, 1996), a questionnaire that provides a reliable tool for measuring the usability of a system.
A final field trial of 6 weeks, where PWA used the interactive maps in their daily movements around the city, will provide an ecological assessment of the solution (that is, one based on real activities in real contexts and not in artificial laboratories). Observation and inquiry techniques will be employed to gain data about the usability and acceptability of the maps.

Participants

A total of 35 PWA adults were involved in all four different phases of the project. All the people had a diagnosis of Level 1 Autism Spectrum Disorder according to DSM5 criteria (APA 2013) made by a multi-professional team specialized in autism in adulthood according to the Multistep Network Model (Keller et al., 2020). All participants were verbal. We selected participants through an open call among those who were in the care of the Adult Autism Center and had received a level

1 diagnosis of autism. We did not select based on pre-established criteria such as age or gender but asked participants to join voluntarily.

All the subjects signed a privacy and informed consensus according to the General Data Protection Regulation (GDPR). For participation in the study, no rewards have been provided.

Table I summarizes ages, years of education and scores on the WAIS-IV (Wechsler, 2008) Full Scale Intellectual Quotient (FSIQ) for all autistic participants.

We also involved a small group of 9 parents and 12 neurotypical users as a control group: in Table III and IV we summarized parents' and neurotypical users' demographic characteristics.

Parents were recruited from the parents of the people in the care of the Adult Autism Center and volunteered through an open call. The neurotypical users are volunteers.

Table I. ASD participants' demographic characteristics and FSIQ mean scores

4. Results

Phase 1

20 individual interviews were conducted aimed to obtain useful information about how PWA perceive, experience and cognitive represent urban spaces, with a focus on sensory characteristics (sensory seeking and avoiding), habits, and social aspects related to urban navigation and community participation. We also ask them about their use of Apps, social media, and other devices for urban navigation and to seek information about places.

Here we summarized results in terms of their perception of the city and spaces, planning skills and strategies, how they manage changes and unexpected events, sensory sensitivity, communication habits and social media use and their suggestions about the device.

City and spaces

Subjects mainly go out to carry out commitments or meet friends. To reach meeting points and points of interest they often make their own arrangements, sometimes asking family members for help.

To reach familiar and interesting places they use public transportation. Trains, subway, and buses are used. Buses are the most frequently used but they are not considered pleasant due to sensory overload and social perspective (too many people, fear of pickpocketing, people shouting, people talking too loudly on phones).

> "[Regarding public transportation]... *sometimes I can't stand the noise in general... but usually, on the bus, I always put on my headphones so I can focus only on the music…*" Participant n° 4, Male 20 years old

Among those who do not have a driver's license, fear of not being sufficiently focused and difficulty in attention emerged: this fear for some of the subjects consists of an obstacle in getting a driving license.

> "[Why she doesn't like driving]... *it gives me too much stimulation, there are too many stimuli. So, right after getting my license at 18 years, I didn't drive until I came here. All the stimuli – the mirrors, people honking, pedestrians jumping into the street, bicycles – all of it together causes me great anxiety. I've learned to control it by planning the route in advance and having a good sense of direction. I don't have much trouble changing the route suddenly, but I try to prepare everything beforehand, adjusting all the mirrors and everything.*" Participant n° 3, Female, 29 years old

Interviewed subjects tend to schedule their daily activities within their home urban context independently, almost in all cases (or otherwise with parents/educators when there are new activities to be done); conversely, in places outside their own city, they tend to delegate such scheduling to those traveling with them.

Planning

To plan trips, if computer support is used, Google Maps from PC is used before moving, and more rarely Google Street View. Not all subjects use Google Maps while moving (mainly due to data consumption). When used, different modalities (visual and audit, visual-writing only, audio only, route-map only) are utilized.

To orient themselves in the city, subjects tend to take landmarks (such as stores, and signs...) rather than using street names to orient themselves.

> *“[What kind of landmarks do you notice about the environment?] Well, for example, I look at... if I’m in Turin, in a city, maybe the buildings around, the shops, anyway. Maybe I say, 'Oh, there's that shop over there, so I need to turn that way afterwards” Participant n°16, Male, 24 years old*

Changes and unexpected events

Changes in scheduled appointments and unexpected events are perceived by all respondents as annoying events. Such annoyance is accompanied by anxiety, upset, agitation, feelings of sadness and anger. The main strategies to make such changes more bearable and to remedy them consist of asking family members for help, seeking alternative solutions or postponing their appointments.

In case of unforeseen events related to traffic and travel by public transportation, most subjects consult information on bus stop bollards or consult Google Maps when they get lost. Some prefer to call family members.

> “*When there are changes, I feel really awful, just really bad. Now, with the self-awareness I've gained, I try to manage it a bit, but generally, I don't like it when plans are changed. Even just going to a different place instead of the planned one doesn't sit well with me, and this greatly affects my behavior*.” Participant n°3 Female, 29 years old

> *"I get a bit anxious and say, 'It's fine... we'll do this another time.' At first, my pessimistic side kicks in, saying, 'That's it, I don't want to do anything anymore.' But then, after a while, when I'm calming down and my parents tell*

me to calm down... I say, 'Alright then…" Participant n° 4 , Male, 20 years old

Sensory sensitivity

Most of the subjects say they do not tolerate places too crowded, where there is confusion (meaning noise, hubbub, din) and too many people. They seem to pay attention to the social and auditory aspects of places. Subjects prefer large, cozy, open-air places with few people, with non-annoying brightness (dim light).

> "[What should a good environment be like for you?] *It shouldn't be too noisy; it shouldn't be a place where everyone gradually raises their voices to the point where you can't hear yourself. So, places frequented by older people who are less likely to raise their voices are preferable. The ideal environment has neutral lighting that is neither too strong nor too weak, because even dim light bothers me after a while…*" Participant n°3 Female, 29 years old

Communication and Social Media

Subjects use WhatsApp to communicate with family and friends, organize trips and schedule activities even with group conversations. Not all use social networks such as Facebook. TripAdvisor is known to almost all respondents; however, it is not used as a primary source for seeking information about places because of a distrust of other online users' reviews. In contrast, subjects share information about pleasant places they know with friends and trust the suggestions given by friends.

> [Do you take into account the reviews you see online when choosing where to spend an evening?] *Yes, honestly, I do, because, let's say, if I like a place but I read that many people say it's a nice place, that it's welcoming and everything... then I trust it even more because it means that this place is worth it. However, if I start having doubts after seeing the reviews, if I see that many people didn't*

> *like it, regarding various costs, the staff, and everything, then…*[He doesn't' go there], Participant n° 18, Male, 23 years old

What device?

PWA respondents suggested creating an App with a custom map. Through the map, users should have the ability to review places, receive suggestions for custom routes and sensory pleasant places, display a personal agenda, request personalized support in case of emergency and trace and remember places they have already visited and liked.

> [How could it be useful?] *It could be helpful at least for getting to know places better. In my opinion, there should be some reviews or short descriptions of the places worth visiting.* Participant n°7, Male 28 years old

Moreover, in this phase, we involved a small group of parents in interviews regarding their sons and daughters (see Table III for details) too.

The topics probed the following areas of interest:

- Habits and level of autonomy in relation to daily movements;
- Coping strategies and resources acquired to cope with unexpected events;
- Digital habits and approach to new technologies;
- Opinions and specific suggestions on the application concerned.

The overall picture obtained from parents' interviews is relatively heterogeneous in some aspects and homogeneous in others. Many parents report that their sons/daughters go out mainly for school or work reasons and very few parents report that their sons/daughters go out with groups of friends or, more generally, peers.

The level of autonomy acquired seems sufficient, even if often limited to well-known and routine places; there is a difference due to growth and experience.

Four of the parents that their sons and daughters are able to orient themselves and sometimes they guide their parents. In case of difficulties, however, the most common strategy is to call a family member.

As for technology, it is used regularly, at least for the classic functions of texting, navigation and entertainment. The Apps specifically mentioned were different, but Google Maps in the first place.

According to parents, having a quick function in case of emergency and customization of the application seems to be a priority for the new device.

Table II. Users' requirements and the system's functionalities

Table III. Parents' demographic characteristics.

Phase 2

In this phase, we design the mobile App according to the requirements gathered from the users in a user-centered design mode in the previous phases (see Table II).

The mobile app allows one to explore places, in the following Points of Interest (PoIs), in different modalities:

Navigation of the map. The user can use the map to find new locations. In addition, if the user wants to look at a different part of the map he/she can either use his/her fingers or the search bar at the top to find a specific address. Figure 1 represents a screenshot of the map used in the App, an instance of Open Street Map.

Figure 1. A screenshot of the map used in our App

Filters. Users can search for PoIs by exploiting the filter, which allows them to find only places with specific sensory features (e.g. high brightness, low crowdedness…) or belong to a specific category (e.g. only restaurants or only parks…). Users can use multiple filters at the same time. For example, at the same time, they can search for restaurants or museums that are not very bright and are wide.

Recommendations. The system suggests a list of suitable places for the users. We enhanced the mobile guide with a content-based recommender algorithm (Lops et al., 2011) that gives the user individualized suggestions about specific PoI to see. They choose the places by considering both what the users like and what the users don't like, particularly concerning the user's sensory

preferences and aversions. After the sign-up, up to create a profile, users are asked to answer a few simple questions about the types of places they like to visit and how much certain sensory things bother them. This step is not compulsory.
Moreover, the App shows some crowd-mapping functionality, i.e. allows people (both PWA and neurotypical ones) to contribute to the knowledge of the systems by adding comments, reviews, and evaluations to existing places, or adding new places on the map. That is particularly suitable for gathering sensory information about PoIs that are not easily available with other modalities (Mauro et al., 2022).

Phase 3

After designing the app, participants attend a Usability Test.
During Usability Tests, we follow the eGLU LG46-47, 2018.1 version Protocol.
In detail, we ask them to: Register on the site and fill in the user profile; Go to a Square in the City Center and then reach the main Station; Add a place on the map; Edit a place by filling in the available fields; Evaluate of the place inserted; Find the feature that allow to edit the entered data and run the revision; Consult reviews and give an interpretation; Delete the inserted place.
For this phase, a group of neurotypical individuals was used as a control group (see Table III for details).

Table IV. Neurotypical group' demographic characteristics for Usability Test

PWA participants evaluated the design, usability and customization of the first version of the App. We also monitored specific issues shown by the PWA group in navigating the map, reading symbols and icons, and finding functions.
They provide suggestions that can greatly contribute to cognitive overload reduction.
From their point of view, customization should concern not only the layout but also colors, type of language, images, icons and related labels, number of information elements displayed, fonts and graphics.
In addition, they gave feedback concerning the orientation on the map: for example, they need to have as reference the bus lines, their stops and the indication of the cardinal points. Finally, a certain difficulty in interpreting others' reviews emerged as well as some critical issues related mainly to graphic layout that have confused or led the user to error.

Compared to the control group, the PWA group is very uneven and behaviors emerge in the map navigation. For example, some users move on the map as if they knew by heart the streets and their significant elements, others move on paper mentally along the bus lines, and others, finally, do not read the map commenting that it is confusing for them. In the control group, on the contrary, the differences in navigating the map and using the App are mainly related to the greater or lesser IT competence.

Phase 4

In the last part of the project, we tested the App with PWA in a field study. In particular, we conducted a study to understand how people use our App in real-life contexts.

We used different methods like task experiments, field study and online surveys.

We wanted to find out whether:

1. Showing sensory information affects whether someone decides to go to a certain place;
2. How people use the crowd-mapping feature;
3. How do PWA use the App to navigate.

In the task experiment, the participants were asked to use the app. First, they had to fill out the form on the App to gather information about their preferences for different types of places and their preference or avoidance of sensory stimuli. Then, they were told to look at a list of places the App suggested and rate them: in particular, we asked them to assess their willingness to go there using a scale from 1 (minimum) to 5 (maximum). They could only see the category of a place (like restaurants, parks, museums, etc.), where it was on the map, and the average rating from users (from 1 to 5). The name of the place was taken out to avoid affecting the users' judgment if they were already familiar with it. Next, individuals were asked to examine the sensory characteristics of each location and determine if this information would influence their previous evaluation of the place. They were also asked to explain how and why their evaluation would change. Each person had to do the task for about 20 minutes.

Then, the same people were asked to participate in a *field study*, where they had to freely use the App for 6 weeks, while we logged their actions (to add a place, to evaluate a place, to use the map, to see the details of a place, to use the sensory filters, to use the category filters, to see the recommended items, etc) on a database. In this way, we can observe and measure how really the user uses the App and what are the most appreciated functionalities. Among the participants in this phase, 15 downloaded the system and used it for six weeks. This is due to the nature of the field study: we invited all the 20 participants of the first phase to continue with the second phase, but not all of them followed our invitation. Due to privacy reasons, we were not able to link the log files to the participant's identity, thus we can not have age and gender data.

At the end of the sixth week of the field study, the participants filled in a final designed questionnaire based on an Italian-translated version of the System Usability Scale (SUS- Brooke, 1996). In the end, we asked them some questions that they could answer freely about the App and their movements within the city with the app.

In general, analyzing data from the app's usage, we find that PWA consider the sensory aspects of a place when deciding whether or not to visit it, thus the sensory information affects how PWA makes decisions regarding the exploration of a place. In fact, in the task experiment emerged that sensory features caused the fact that users have changed or not their ratings.

Analyzing how PWA navigate the mobile App we found that most people like to use maps to find information about places navigating across it with respect to using textual menus.

PWA use the App to search for sensory information and thus this confirms how important sensory information is for them. Moreover, crowd-mapping could be a useful way to gather these characteristics, but it should be combined with other approaches, since people tend to be passive fruiters of crowdsourced information, but do not contribute a lot by adding new reviews, evaluations or new places on the system.

Regarding the usability of the app, analyzing data from our designed questionnaire, some problems in the user experience emerged. The questionnaire showed a high appreciation for knowing the sensory characteristics of places, and for using a map to find information, and less interest in being actively involved in the provision of information (even if many users declared in principle to like doing this, in contrast to what they really did using the app).

5. Discussion

Through our PIUMA Project, we had the opportunity to collect the direct contribution of PWA in creating a dedicated device. During all the previously mentioned phases, we collected information about how autistic people move in urban contexts, represent the space of their cities, move independently and use technological devices.

In addition, we considered the point of view of families and gathered their experiences in order to design an inclusive tool that was not "set from above" but designed with end users.

The collected data also suggest different ways of information processing by people with autism and provide valuable suggestions about how to improve computer systems designed for them. From our point of view, taking into account these data is also important to encourage full participation in community life according to their cognitive and sensory characteristics.

One of the major limitations that we identified is the use of a mixed methodology that also included semi-structured interviews. We choose this methodology in order to allow participants to express their point of view, their needs, and impressions and to gather their suggestions more freely. At the same time, this may have limited the amount of quantitative data collected. Other limitations are related to the usability problems there are in the App, and that could prevent the usage of the system.

Another limitation of the study could be the small dimension of the sample that may not be representative of PWA. Male-to-female ratio in the study, the age of the participants and the sample size can be viewed as limitations that may impact the generalizability of our findings. The results should be further examined by incorporating a larger representation of females and individuals across a wider age range.

In addition, our results must be improved and deepened taking into account different target users including in the sample those with more necessity of support (ASD Level 2 and Level 3), Intellectual Disability, those who use alternative communicative systems and include more women.

Furthermore, a possible direction of work could be to investigate how ICT-based spatial support can contribute to increasing the autonomy in the movement of PWA.

6. Conclusions

Our system helps PWA focus on the sensory aspects of places, which no other technology solutions have done before. In addition, we offer personalized help by giving suggestions for places that match users' interests and taking into account their sensory features (seeking and avoiding). Finally, we test our solution with PWA. This is not often done in previous studies.

One of the main aspects of the innovation of the PIUMA project is the direct involvement of PWA in the design, construction and improvement of the device. It is important because it collects the direct impressions and suggestions of autistic people in the ideation, design and implementation of an App, increasing its customization.

Our PIUMA App design promotes communication, participation and independence based on the characteristics of autistic people reducing cognitive, information and sensory overload. Our project results in an App that supports PWA in their movements in the city, helping them in the management of their daily lives, and promoting their autonomy and active participation in urban contexts.

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