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Introduction



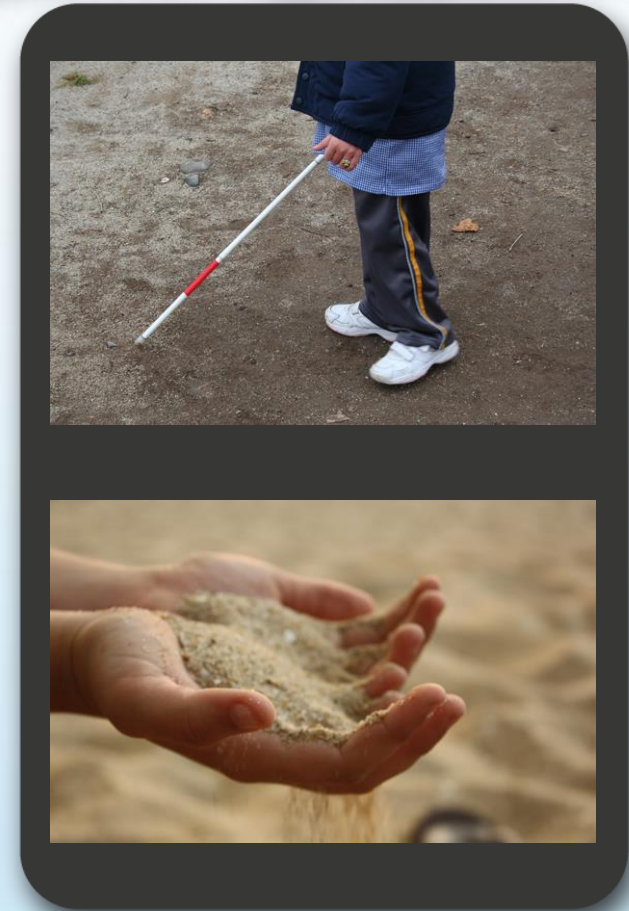
- There are advanced devices that allow for simulating three-dimensional spaces, forces and textures.
- It is possible to convey visual information from the virtual world to the blind user through a haptic device.
- Novint Falcon provides high-fidelity force feedback -The device allows to represent the textures, viscosity, hardness and force.



Introduction



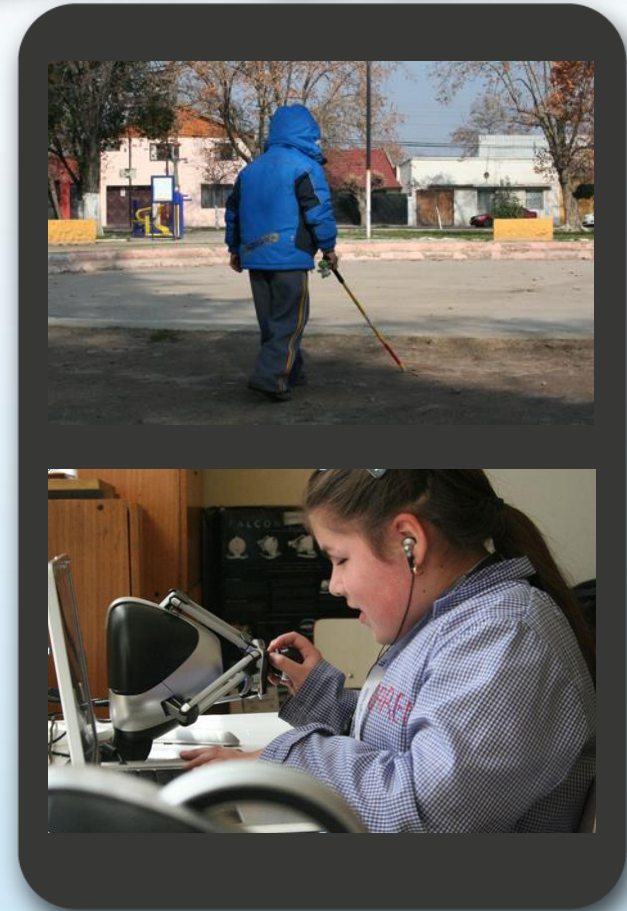
- For people who are blind, the sense of hearing is more important than normal, in that together with haptic perception, these two senses become the main receptors of information from the environment.
- Orientation is a process through which an individual uses the various senses to establish his position in relation to other significant objects.
- Mobility is the ability, will and facility to move about in the surrounding environment.



Introduction



- Orientation and mobility in outdoor, unknown spaces for people with visual impairment is a significant challenge.
- With the purpose of developing O&M skills, this study proposes the creation of a virtual, 3D world through audio and haptic interfaces, which allows the user to navigate through virtual space and identify the surrounding objects and thus orient himself.



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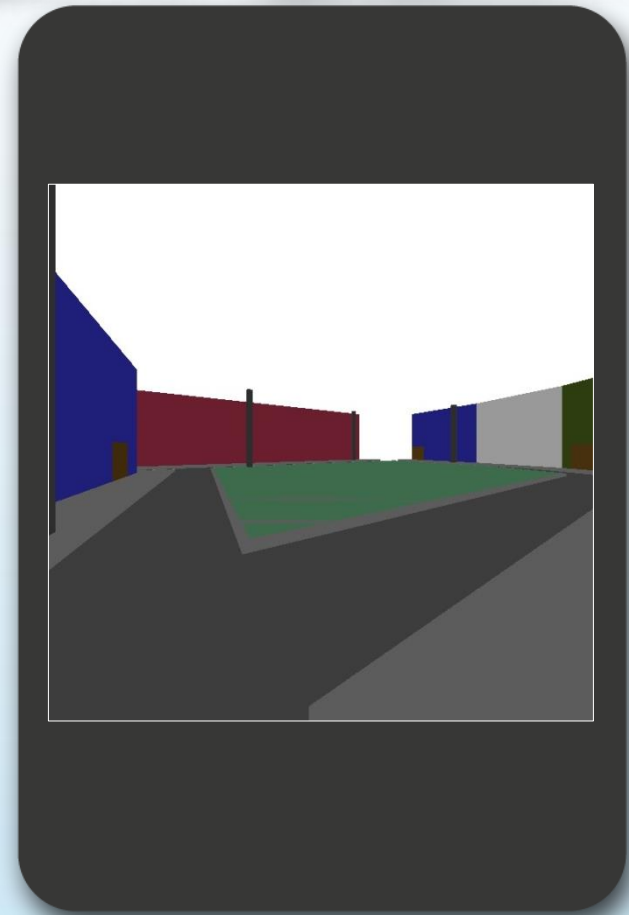
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Audiopolis



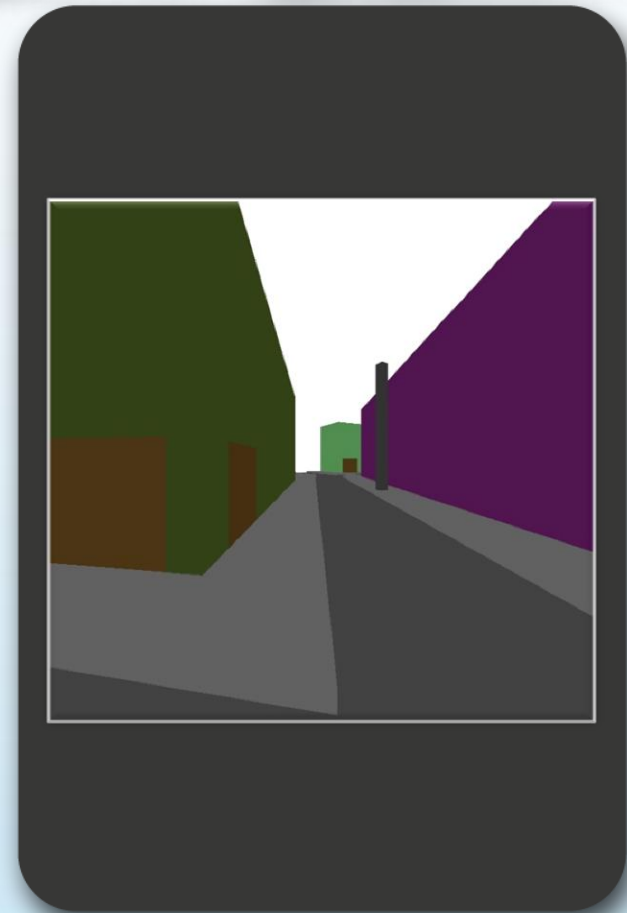
- Audiopolis is based on a detective metaphor.
- The user plays the part of a detective who must find a band of thieves and the objects they have stolen.
- The detective have to find hidden clues that indicate where is the thief.
- Afterwards, the player must navigate through the city following the various clues until he finds the thief.



Audiopolis



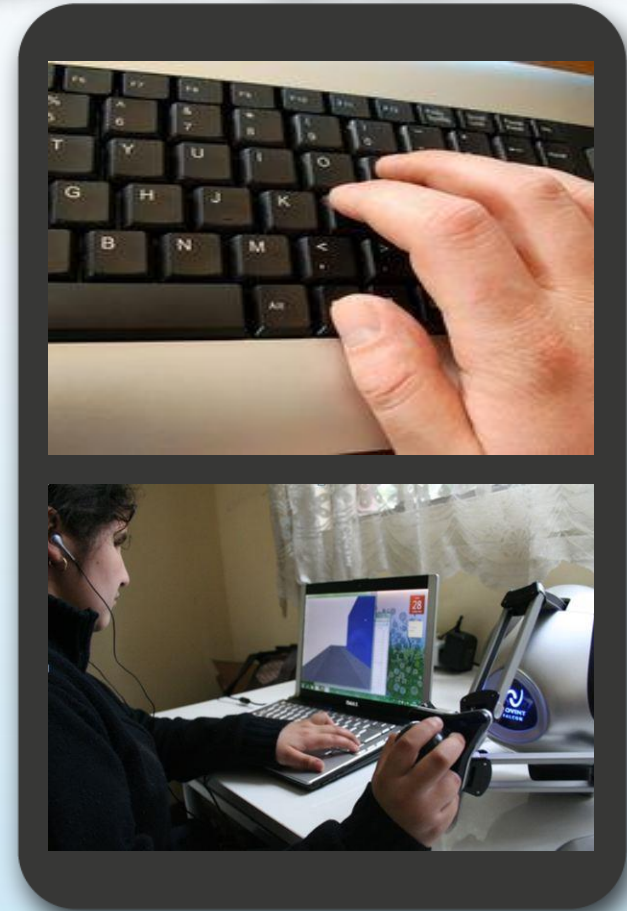
- The videogame is a three-dimensional virtual environment.
- Initially, the player is provided with instructions on the tasks that must be completed.
- The player can ask for information in order to arrive at a given destination, utilizing the clock technique.
- Once the player arrives to the indicated destination, a contextual question about the place is formed as a clue.



Audiopolis



- The game has 3 modalities in accordance with the interfaces involved:
 - Audio Interface Modality
 - Haptic Interface Modality.
 - Haptic and Audio Interface Modality

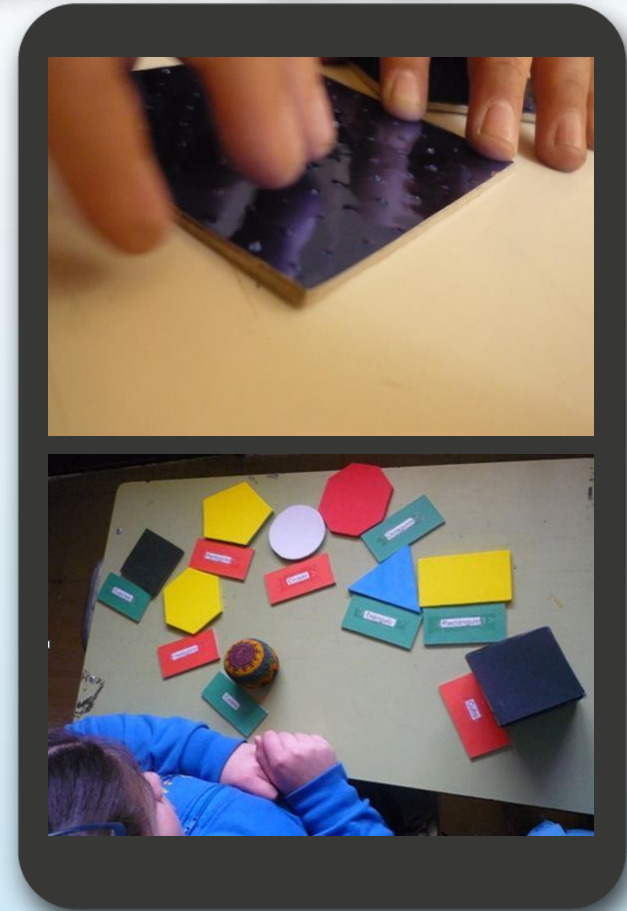


Audiopolis



Usability evaluation of Audiopolis was implemented.

- The evaluation is made up of two parts:
 - Iconic usability: evaluate whether or not the user correctly associates the various elements of the videogame.
 - End-user usability evaluation: was done after having made changes and redesigns according to the results obtained in the iconic usability evaluation.
- The cognitive impact evaluation is ongoing.



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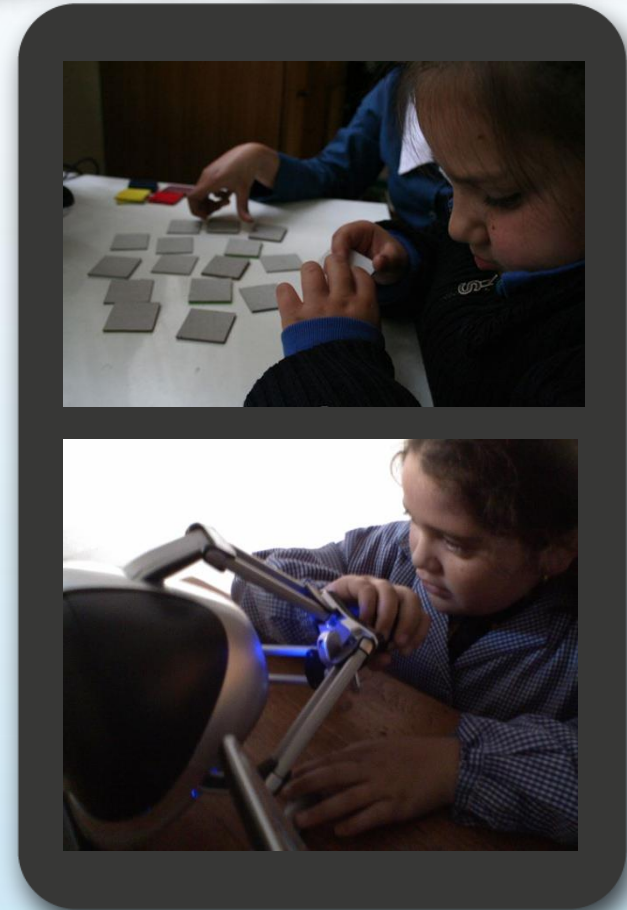
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Sample



- For the iconic usability evaluation, a sample of 18 learners with ages between 10 and 15 years old.
- In the end-user usability evaluation a subset of 9 learners.
- The sample population was divided into 3 groups :
 - Interaction with the videogame's audio interface.
 - Interaction with the videogame's haptic interface.
 - Interaction with both audio and haptic interfaces integrated together.



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Instrument



- For the usability evaluation two questionnaires were utilized:
 - The SUE questionnaire (Software Usability Elements)
 - The SUBC Questionnaire (Software Usability for Blind Children Questionnaire)
- Prior to the cognitive evaluation, preparatory activities with the videogame were held:
 - Preparatory sounds guidelines
 - Preparatory geometric shapes guideline
 - Preparatory clock technique guideline



Procedure



- The SUE questionnaire was applied during six, 1.5-hour work sessions.
- In the first two work sessions with sounds. In the following two work sessions, the concrete shapes were evaluated. In the fifth session, each learner worked with the haptic device.
- In the sixth and last session, each learner had to evaluate his tactile sensation of the textures, virtually represented through the Novint Falcon.
- Afterwards, the end-user usability questionnaire was applied to 8 learners.

Results Icon Usability

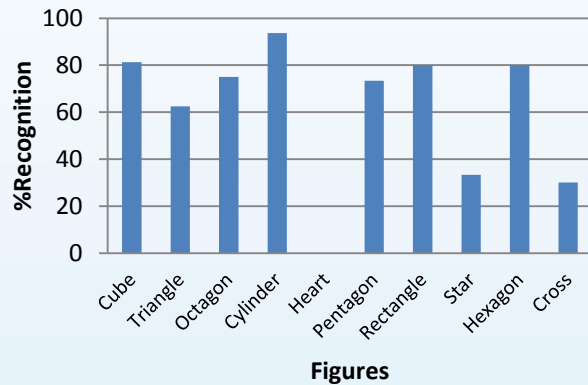


- It was observed that an initial group of sounds, corresponding to horns, cars, doors and environmental sound, were identified correctly for the most part.
- It was observed that most of the learners identified regular shapes with the haptic device (75.4%); but this was not the case with complex shapes.
- The virtual textures represented with the haptic device, the results show that the learners were able to correctly describe the textures (79.4% recognition)

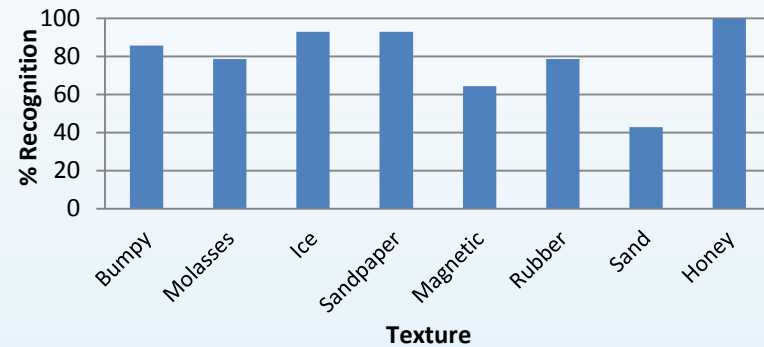
Results Icon Usability



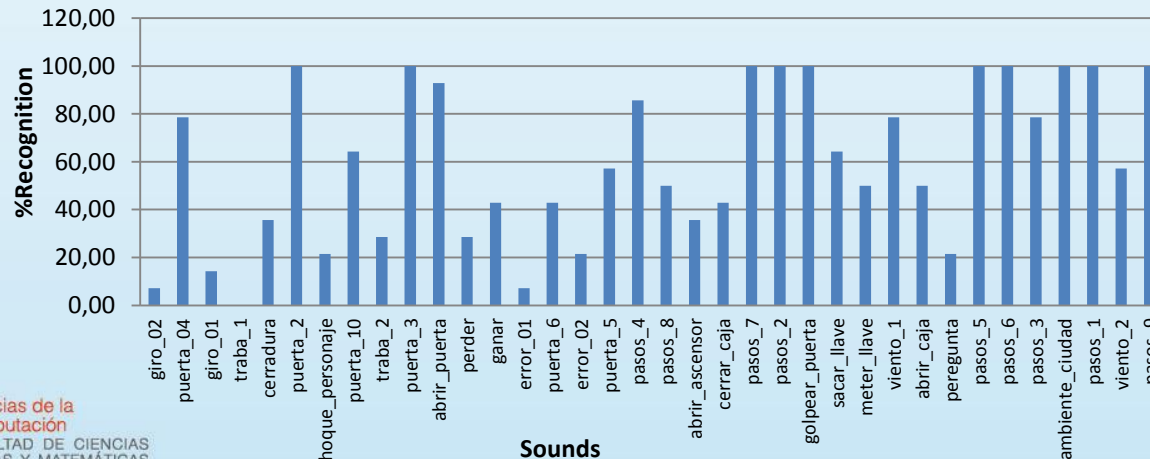
% Figures Recognition



% Texture Recognition



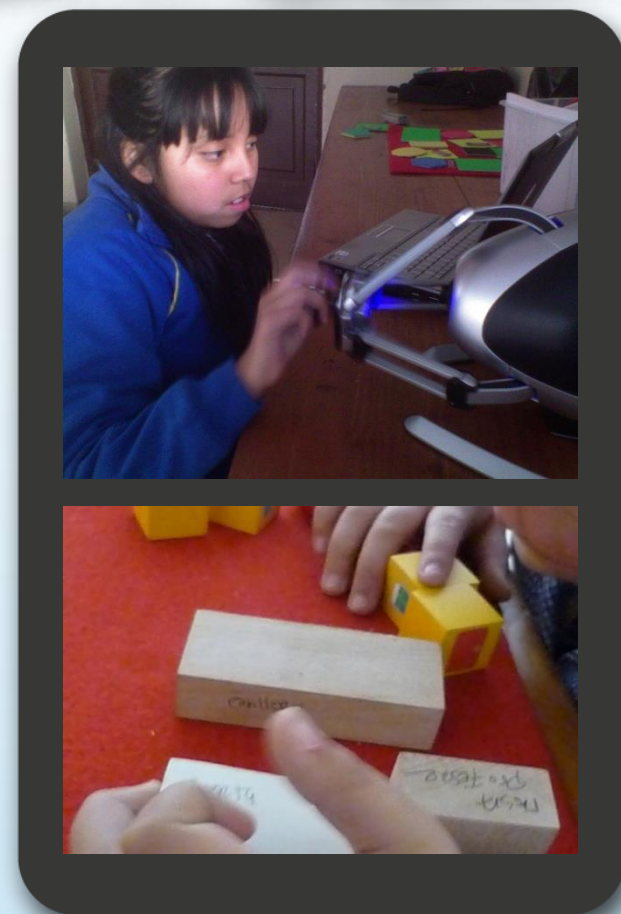
% Sounds Recognition



Results Final Usability



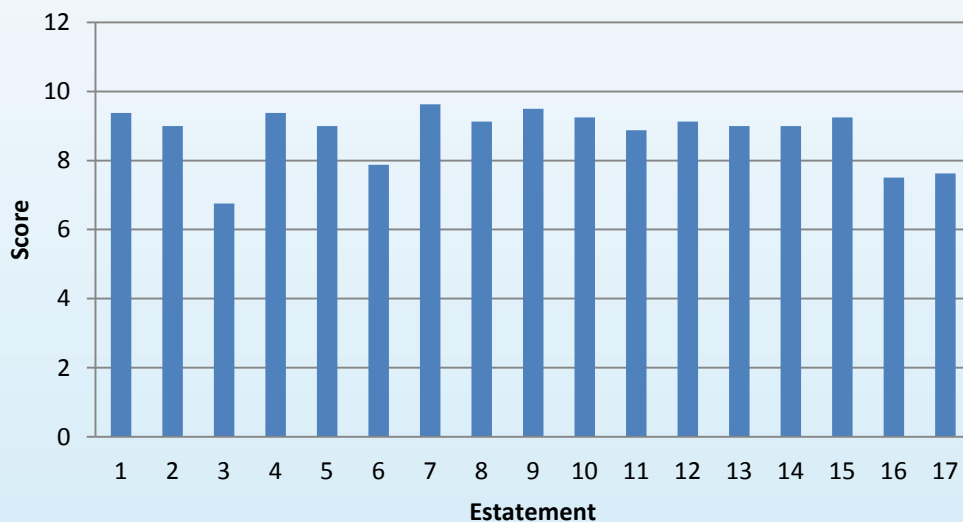
- It was observed that Audiopolis is highly usable and understandable to the users with visual impairment.
- In “Control and Use” category, it was observed that for the users it is easy to use the videogame.
- In the “Sounds” category, all of the statements obtained average scores higher than 9
- In the “Haptic device” category, it was observed that the users liked to interact with the device.



Results Final Usability



Final Usability Evaluation



- 1) I like the videogame,
- 2) The videogame is fun,
- 3) The videogame is challenging,
- 4) The videogame makes me fell active,
- 5) I would play this game again,
- 6) I felt in control of the situation in the videogame
- 7) The videogame is interactive,
- 8) The videogame is easy to use
- 9) The videogame is motivating,
- 10) The videogame adapts to my rhythm,
- 11) The videogame allowed me to understand new things,
- 12) I like the sounds of the videogame,
- 13) The sounds of the videogame are clearly identifiable,
- 14) The sounds of the videogame provided me with information,
- 15) I like the tactile sensation of the haptic device in the videogame.
- 16) The elements of the videogame are clearly identifiable by touch using the haptic device.
- 17) The tactile sensation of the haptic device provided me with information.



Results Final Usability



- In the open-ended questions, the users commented that in general the videogame was fun and interactive, but that it would be good to add more elements from a typical city environment.
- Regarding the preparatory activities with the clock technique, the users achieved an average score of 79.3% accuracy when using the instrument.
- In the case of geometric shapes they achieved an average score of 81.8%,
- In the case of sounds they reached an average of 83.8% accuracy.

Discussion



- This study presents the design and evaluation of Audiopolis, a virtual city represented by audio and haptic feedback for the development of O&M skills in people who are blind.
- Most of the users perceived the sounds, textures and shapes (both concrete and virtual) without any trouble through the use of audio and haptic interfaces.
- The users associate the majority of the sounds with the elements represented in the videogame
- The users are able to identify various simple geometric shapes with their hands by touching the contours of the shape, but are unable to do so with complex shapes.

Discussion



- The textures were all recognizable to the users.
- In addition, the users were able to interact relatively easily with the videogame, and were able to quickly adapt to its mode of use.
- They found the videogame to be motivating, and stated that they would use it again.
- Currently, we have improved the videogame again, and the cognitive impact evaluation is being performed, through planned cognitive tasks using the videogame.



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