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An Application for Speech and Language Therapy Using Customized Interaction Between Physical Objects and Mobile Devices

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Abstract: This paper presents a prototype that facilitates the work of Speech and Language Therapists (SLTs) by providing an Android mobile device application that allows the therapist to focus on the patient rather than taking notes during exercises. Each physical object used by the therapist in those exercises can be given digital properties using Near Field Communication (NFC) tags. The registration does not require a high level of ICT skills from the therapists. SLTs often use such objects in non-technology driven exercises that deal with classification, seriation and inclusion. The application offers such exercises developed in close collaboration with two SLTs, and our aim was to provide therapists with a way to efficiently record activities while working with a patient using a mobile application. The tool was validated through several expert reviews, a usability study as well as a trial with a patient in Paris, France.

Keywords: NFC-based interactions; speech and language therapy; mobile application

1. Introduction

Interacting with physical objects is a common everyday task. But object affordances are not necessarily limited to the physical world, but also to the digital one, e.g., a key card allows a door to be opened in a way that is not quite the same as a regular key does. Children from age 2 to 7 learn how to identify an object and give it meaning (Ginsburg and Opper, 1988). However, some children have trouble developing these skills and have problems associating words with objects or meanings. This problem can occur for adults as well in the case of, for example, victims of head trauma. Speech and language therapy helps people who are having such issues. Some examples of problems are *classification* (ability to group things according to common features), *seriation* (ability to sort objects or situations according to any feature, such as size, color, shape, or type), and *inclusion* (ability to assign groups of objects as a sub-set of a larger class, beyond simple classification).

In the health and medical industry, the use of information and communication technologies (ICT) is increasing every year. The domain of speech and language therapy has been exploring the use of ICT to help aid children and adults (Drigas and Petrova, 2014). One of the few approaches that tackle the issue of classification, seriation and inclusion was created by Rodríguez et.al. (2008), exploring the use of desktop computer based tools. Our paper focuses instead on the exploration of the use of mobile devices, equipped with Near Field Communication (NFC) sensors, and is not bound to classic keyboard and mouse interactions. The application was developed using the Android platform on a tablet in close association with two French speech and language therapists (SLTs). This collaboration was done in order to gather specific requirements catered to the SLTs and what they need to conduct their exercises. The tool was validated by the SLTs in several iterations during its development, and a usability study was performed with five (non-patient) users. The study was concluded by a trial with a patient in order to prove the usefulness of the application for the SLTs.

The next section will present the related work and well as the motivation behind this project. The implementation section describes the different functionalities offered by the prototype. The methodology section explains how the different steps of the study were conducted, including the collaboration with the SLT while developing the application, the usability study and the trial with a patient. Following these sections, the outcomes are presented, detailing the interviews with the SLT, the

feedback given by users testing the usability of the tool and finally related the first impression of the SLT and the patient during the trial. In the conclusion, the limitations encountered during this study as well as description of future work are presented.

2. Related Work and Motivation

A lot of SLTs base their exercises on the work of Piaget and Inhelder (Piaget and Inhelder, 1959). Some researchers like Chalon-Blanc (2005) and Dolle (2005) refined this work later on, but they did not try to incorporate any new technology. The use of ICT in speech and language therapy brings positive reactions from therapists and patients according to Gowans et.al (2004). Moffat et.al. (2004) created a tool named ESI Planner that uses a PDA as a mobile platform to display images and sound stimulating the memory of patients. Boyd-Graber et.al. (2006) developed a hybrid approach that combine PC and mobile devices to help patient communicating using images and sound. These two tools were created to help outside the medical consultations and not under the supervision of the therapist. Many tools used by SLTs are either hand crafted or specialized board games as mentioned by Feugnet (2010). She relates the creation of a board game for SLTs and pointed out some major companies in France that design and sell material for SLTs. She noted that most of the games were re-editions of older games rather than new tools. One of the few projects exploring the issue of classification with ICT was developed by Rodríguez et.al. (2008). Their desktop computer software, named Cuéntame, deals with shapes and colors and was designed for children. It offers full customization of the exercises in order to adapt to each patient's needs. The team developed as well two other tools, Pre-Lingua and Vocaliza. Pre-Lingua is a tool that can "assist the work in speech therapy" (Rodriguez et.al., 2008). Vocaliza provides personalized profiles for patients; sound and images are associated to the profiles and are used to help patient with personalized content. These three tools show several concepts that are used also in our project such as the personalization of the content and the assistance rather than replacement of the therapists. Our application also makes use of mobile devices to facilitate the interactions between patient and therapist. Another addition is the use of NFC tags for personalizing already owned and used therapy objects, instead of having to invest in buying new pedagogic materials. The combination of new technology with familiar tools is also recommended in pedagogy as suggested by Kim and Smith (2015) for the implementation of new mobile learning tool.

A key card, a remote control or a smart phone are common physical objects that can produce digital responses. Each digital response is triggered by a physical manipulation of these devices. These objects serve a specific purpose and must be bought in consequence. Solutions have been explored to personalize already owned objects and use them to trigger digital responses. The Near Field Communication (NFC) technology (Want, 2011) is available in most of the modern smartphones and tablets. It allows wireless short-range data exchanges over 3 to 4 centimeters (theoretically up to 20 centimeters). NFC technology can be used to replace manual typing, menu selections, and other user interface actions with acts of touching. The technology will not replace other means of interaction, such as the keyboard, but it allows fast interactions between an application and tagged objects. Magic Touch is a tool built by Thomas Pederson (2001). This tool is used to detect the position of physical objects in a room using Radio Frequency identification (RFID) tags. Other technologies like magnets can be used to interact with physical objects. Bianchi and Oakley (2013) showed how one can interact with physical objects named *appcessories* and smartphones using magnetic fields. However, the use of magnetic field has issues such as external interferences and the need of calibration of the devices.

Different research groups have focused their efforts on the use of mobile devices and more particularly multimedia for learning. Nordmark and Milrad have developed a seamless learning approach supporting mobile digital storytelling for educational purposes (Nordmark and Milrad 2015). They believe that the mobile device is a perfect platform for learning that can support collaborative work. Ivanov (2013) used also mobile devices (with NFC) in order to help young children learn within a pervasive environment. His system is helping with the basis of classification, seriation and inclusion, and the personalization of physical objects is similar as the one proposed in our paper.

Based on the above, our application was created using mobile devices in order to facilitate the collaboration between therapists and patients. The NFC technology was chosen for its simplicity of use and its relatively cheap price, as well as its affinity to work with mobile devices.

3. Implementation

The realized solution consists of a mobile device (a Nexus 10 tablet), an Android application (SDK 10 minimum, recommended 14 and above in order to handle NFC), and several NFC tags. It allows for the registration of physical objects into the application's database, the creation of exercises, and the visualization (for the SLT) of data gathered during the exercises. Interacting with physical objects was a requirement from the therapist who was initially consulted at the beginning of the project. Another request was the possibility of using their own objects, rather than buying new ones, which introduced the use of NFC tags. The use of NFC technology additionally allows for more intuitive interactions by simply touching the device to an object, compared to e.g., using buttons for selecting an object. The application is articulated around three main menus: *Object Management*, *Patient Management*, and *Exercise*.

In order to register a physical object in the system, the therapist must first attach a NFC tag to the object. Then, the tag must be scanned through the use of their mobile device in either the *Object Management* or *Patient Management* section. Each NFC tag has a unique identifier that will be registered into the database of the application and associated to a digital property. A usual digital property can be a label, like *Animal* or *Color*. An object is registered on a specific device's database and is later modifiable, both the property and the physical object associated to it. Being able to replace an associated object is important, e.g., in the case that a patient accidentally misplaces or damages it.

The SLT can personalize the object with a digital property (like *Animal* or *Color*). It is possible to register objects on two levels, as *classes* or *elements*. A class contains $0 \rightarrow \infty$ elements and an element is contained to $1 \rightarrow \infty$ classes. This system allows the therapist to also combine classes to form new ones, e.g., combing the class *animal* and *flying* into a new class *flying animal*.

The therapists requested a way to record every step and detail of the exercises. The log system allows a SLT to obtain data on almost every aspect of the session, as long as it is related to the use of the tool. Each patient is assigned a NFC tag, which is associated to the database for every exercise performed by this specific patient. The data can be accessed within the application in the form of a table displaying the time and the interaction with the device.

Once all necessary objects are tagged and registered in the system, the therapist and the patient are able to perform a classification, seriation, or inclusion exercise (or a combination of the three). The patient must be in the database to start an exercise.

In order to construct an exercise, the therapist must either scan the NFC tag of a class or an element. Then, to add more classes or elements, the SLT can scan another class or element NFC tag (or remove one by scanning the tag a second time). However, the first tag scanned will determine what type of exercise it will be: either find the elements contained in the classes selected, or find to which classes the elements selected belong to. For every class or element scanned, its associated name will be display on the mobile device. Scanning the other type of tag (i.e., an element or a class), will trigger the start of the exercise. Once the exercise starts, it is not possible to modify the conditions. The patient is able to scan as many items as possible once the SLT has constructed the exercise. Not a single interaction with the screen is needed until the therapist decides to end the exercise by pressing the *finish exercise* button. At the end of an exercise, the SLT can input a comment to add any additional notes about this particular session. This can help when reviewing an exercise several weeks or months later in order to understand a particular context associated to an exercise.

4. Methodology

In order to develop this tool for speech and language therapist, several steps were planned. The first one was the conduction of a literature survey about the different technologies that could be used. An initial concept prototype with NFC functionality was built and tested by 20 non-patient participants, followed by further gathering of requirements from the SLT. Several semi-structured interviews were conducted along the development to ensure that the requirements were followed and to revise them if needed; three iterations of the prototype were made following this pattern. Once the last iteration was validated, a

usability study was conducted with five (non-patient) participants. The final step of the study was a trial with a patient.

The software application was developed following the Agile development approach. The SLT who was involved from the beginning of the project followed through until the end. Another SLT joined in the middle of the project in order to further help define and refine the requirements. Regular meetings were planned every two weeks in order to discuss the advancements of the project. In addition, three main meetings were planned to specifically define, refine and validate the requirements.

A series of unstructured interviews took place in order to develop the prototype. A first (online) interview was conducted with a SLT to present the concept prototype and discuss the specific needs of the SLT. A follow-up meeting took place two weeks later in Tours, France, to demonstrate the prototype. The therapist was asked to perform the same tasks as the one performed by the participants that tested the concept prototype. After having experience with the prototype, the therapist was asked to reflect on her domain and decide whether it could be useful during sessions with her patients. This meeting confirmed that the prototype would be very useful for SLT. The context of classification, seriation and inclusion was chosen as a trial. It could also be useful for other disorders; this list was later refined by the second SLT. The list includes meta phonology, mathematics logic, lexical organization & evocation, grammar, lexical orthography, memory work, and text comprehension.

Every two weeks, online meetings took place to check on the progress, to confirm that the development followed the requirements and most importantly, they were conducted to keep both parties involved in the entire development process. The last interview was conducted in Paris, France, in one of the SLTs office. This was an occasion to create an evaluation of the application with the SLTs own material. Both therapists were present and were asked to use the prototype as though conducting a real session. One of the two acted as the therapist, the other acted as the patient (and vice versa).

It is notable to mention that the two therapists do not share a similar work environment. One is a self-employed SLT, and the other is employed at a hospital. Their methods and budget are different and this affects the way therapists work with their patients. During this meeting, the SLTs were asked to evaluate the usability of the final version, the interface design and the flow of the application, the interactions with NFC within the application, the usefulness in real situation of the prototype, as well as to validate the final requirements.

Before delivering the prototype to the therapist to try out with a patient (in France), a usability study was conducted in Sweden (with non-patient participants), and several tests with the therapist to ensure that there would be no technical issues. Because of the medical confidentiality, an observer could not be present during the sessions. The therapist was provided with a tablet (Nexus 10), 100 NFC cards (0.60 euros a piece) and 24 NFC stickers (1.80 euros a piece). During a period of two months, the therapist and the patient used alternatively the SLT regular methods and the tool developed for this study. They met for a total of seven sessions and used the prototype four times. After each session, the therapist was asked questions about her experience when using the prototype and the log of the exercises was collected (anonymously).

This evaluation trial served the purpose of confirming if the prototype would be useful for SLTs in real situations by saving them time during a session, allowing them to focus more on the patient rather than on taking notes, allowing them to keep track of the learning process of the patient, and finally making sure that using the prototype was not a burden for the therapists.

5. Outcomes

The initial interview gave some general feedback on the speech and language therapy profession: (1) SLTs in general do not use a lot of ICT during their sessions, (2) the newer generation of SLTs started to be interested in technologies, but the older generation of SLTs does not trust technology and are sometimes considered to be technophobes, (3) the particular therapist interviewed had no knowledge about any projects involving ICT in their field, and (4) the use of ICT, and especially interactions with physical objects that have been digitally enhanced, is appealing for many scenarios.

Allowing the SLT to have a hands-on experience with the concept prototype helped to illustrate how the NFC stickers could allow the personalization of physical objects, as well as: (1) confirmed the interest of the SLT for the project, (2) confirmed the usefulness of such a tool for the domain of speech and

language therapy, (3) defined requirements, and (4) defined the type of exercises that the prototype could help with (classification, seriation and inclusion were selected for the trial).

The presentation of the next version of the prototype was well received by the SLT and the possibilities were understood and approved. The second therapist was briefed by her peer on how the prototype works and what kind of interactions were possible. Having a second SLT in the conversation gave more insight on the field of speech and language therapy and helped refine the previous requirements. The last interview with the two SLTs that took place in France, was conducted to validate the final prototype. The therapists used the material they owned in association with the NFC stickers and cards to create the same type of exercises they would do in a regular session. It was agreed during this session that after the last minor modifications, the final prototype could be tested with a patient.

As the observer was not allowed during the session with the patient, unstructured interviews were conducted with the therapist after each of the seven sessions. No personal information was gathered on the patient, only data directly related to the use of the tool as well as the learning outcomes for the patient. On the first session, the patient was curious and exited to work with new technologies. The therapist was initially nervous about using the tool with a patient, however she became more comfortable in the following sessions. The SLT chose to create before the session some classes and elements and created two more classes with four elements in each with the patient in order to demonstrate the use of the application.

The next session was done without using the prototype. The patient mentioned that is was more fun to use the application and the NFC stickers. The therapist observed that the patient organized the objects the same way as they were organized in the previous session (with the use of the tablet). The next sessions, alternatively with and without the prototype, saw progress in the patient's ability to do the exercises -- according to the SLT. It was mentioned that while the application is not required to help the patient, it assists the therapist by allowing her to focus more on the patient and not having to take that many notes. In average, twenty-three NFC tags (attached or not to an object) were used during a session.

Both patient and therapist mentioned that the prototype was easy to use and the patient also mentioned a notion of fun.

6. Conclusion

This paper presents the development of an Android application for mobile devices that uses NFC technology to aid the work of speech and language therapists (SLTs). The main focus of the application was to introduce an easy to use technical solution to conduct classification, seriation and inclusion exercises during speech therapy sessions. The tool gathers data automatically and facilitates exercises with patients using NFC stickers placed on physical objects, used by the SLTs during these sessions.

A literature survey was conducted to determine what is state of the art for technologies dealing with interactions between physical objects and mobile devices. A concept prototype was created and tested to determine which technology would be best for the realization of this tool. The development of the application included the involvement of two SLTs through the multiple iterations. Regular interviews were conducted with the SLTs in order to determine their needs and further define the requirements. To validate the prototype, a usability study and a trial with a patient were conducted. The usability study and the trial produced encouraging results regarding the usefulness of the prototype.

The application was perceived useful by the SLTs as it can allow them to gain time and does not disturb their regular workflow, nor the learning process of the patients. The patient seemed more enthusiastic while using the application according to the SLT. Gathering data automatically was declared useful according to the therapist who participated in the trial. The tool serves as support for an SLT rather than replacing them. In terms of patient data privacy, the collected data remain on the device used and are stored in the database of the application, instead of on an online server or some other kind of publicly accessible storage solution.

It is important to note some limitations. The application was developed in collaboration, initially, with one SLT and a second one joined later in the development. It is safe to assume that the application mainly follows the view of these two therapists and does not necessarily represent the majority of the profession, even if they represent two different branches of SLT practice (based on hospital, and self-employed). The main limitation of this initial work is the lack of a clinical trial. Only one patient and one therapist participated in the final trial. This can be partially explained by the fact that therapists

do not always have patients requiring help with classification, seriation and inclusion, and during the time allocated to this project, only one patient was available. A larger number of participants would be required to validate the data and make sure it is usable for the majority of therapists and patients, and this is part of the planned future work. The therapists and patient participating in this study were French, and the practices in some other countries may differ; if possible, in the future, more countries will be included.

As mentioned also above, the data privacy, especially medical data, is another critical concern. In some countries such as France, the medical confidentiality has to be taken very seriously while developing eHealth applications. The collected data remain on the device of the therapist. Encryption of data was not part of this project, but should be strongly considered.

References

Bianchi, A., & Oakley, I. (2013, February). Designing tangible magnetic appcessories. In *Proceedings of the 7th International Conference on Tangible, Embedded and Embodied Interaction* (pp. 255-258). ACM.

Boyd-Graber, J. L., Nikolova, S. S., Moffatt, K. A., Kin, K. C., Lee, J. Y., Mackey, L. W., Tremaine, M. M. & Klawe, M. M. (2006, April). Participatory design with proxies: developing a desktop-PDA system to support people with aphasia. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 151-160). ACM.

Chalon-Blanc, A. (2005). Inventer, compter et classer: De Piaget aux débats actuels. Armand Colin.

Drigas, A., & Petrova, A. (2014). ICTs in Speech and Language Therapy. *iJEP, 4*(1), 49-54.

Feugnet, C. (2010). *Création et expérimentation du jeu "A l'abordage des notions de sériation, classification et inclusion"* (Master's Thesis, University of Bordeaux II, Bordeaux, France). Retrieved from http://dumas.ccsd.cnrs.fr/dumas-01302499/document

Ginsburg, H. P., & Opper, S. (1988). *Piaget's theory of intellectual development*. Prentice-Hall, Inc.

Gowans, G., Campbell, J., Alm, N., Dye, R., Astell, A., & Ellis, M. (2004, April). Designing a multimedia conversation aid for reminiscence therapy in dementia care environments. In *CHI'04 Extended Abstracts on Human Factors in Computing Systems* (pp. 825-836). ACM.

Ivanov, R. (2013, June). NFC-based pervasive learning service for children. In *Proceedings of the 14th International Conference on Computer Systems and Technologies* (pp. 329-336). ACM.

Dolle, J. M. (1974). Pour comprendre Jean Piaget (Vol. 11). Privat.

Kim, Y., & Smith, D. (2015). Pedagogical and technological augmentation of mobile learning for young children interactive learning environments. *Interactive Learning Environments*, 1-13.

Moffatt, K., McGrenere, J., Purves, B., & Klawe, M. (2004, April). The participatory design of a sound and image enhanced daily planner for people with aphasia. In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 407-414). ACM.

Nordmark, S., & Milrad, M. (2015). Tell Your Story About History: A Mobile Seamless Learning Approach to Support Mobile Digital Storytelling (mDS). In *Seamless Learning in the Age of Mobile Connectivity* (pp. 353-376). Springer Singapore.

Pederson, T. (2001). Magic touch: A simple object location tracking system enabling the development of physical-virtual artefacts in office environments. *Personal and Ubiquitous Computing, 5*(1), 54-57.

Piaget, J., & Inhelder, B. (1959). Inhelder, B., & Piaget, J. (1959). La Genèse des Structures Logiques Élémentaires Classifications Et Sériations. In *Revue Philosophique de Louvain*, 57(55), 489-490.

Rodríguez, W. R., Saz, O., Lleida, E., Vaquero, C., & Escartín, A. (2008, October). COMUNICA-tools for speech and language therapy. In *WOCCI* (p. 12).

Want, R. (2011). Near field communication. *IEEE Pervasive Computing*, (3), 4-7.