Designing wearable and playful accessories to encourage free-play amongst school aged children

Conception, participatory design and evaluation

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Abstract

According to social studies, everyday life has reduced children's opportunities for free-play, which, in the long term, can compromise their social and physical development. Previous HCI studies have been addressing the question of how to apply sensing and reactive technologies to encourage free-play by, for example, augmenting playgrounds and shared objects with these technologies. This dissertation explores the design process and evaluation of wearable digital accessories to encourage and facilitate free-play amongst school-aged children in alternative free-play settings. This is done in order to take advantage of free-play opportunities that arise on the move and to encourage body challenges and social experiences through individual exploration. In this context, the thesis discusses (a) three design cases of playful accessories, (b) a quantitative and qualitative evaluation to assess the ability of the accessories to encourage free-play, (c) the design process of playful experiences with the participation of children and older people (60+). This thesis also provides a set of design opportunities that can be taken into account in the research of future digitally-augmented objects to encourage free-play.

Resumen

De acuerdo a los estudios sociales, la vida cotidiana ha reducido las oportunidades de que los niños puedan disfrutar del juego libre, lo cual a largo plazo, puede perjudicar su desarrollo social y físico. La investigación en Interacción Persona Ordenador, ha abordado ésta cuestión de como usar sensores y reactores para estimular el juego libre, por ejemplo interviniendo los parques infantitles u objetos de uso compartido con estas tecnologías. Esta disertación explora el proceso de diseño y evaluación the accesorios digitales para ponerse, diseñados para motivar el juego libre entre los niños de edad escolar, en contextos alternativos. Esto se ha hecho para aprovechar las oportunidades de juego libre que pueden surgir cuando los niños estan en camino a algun lugar, asi como para motivar retos corporales y experiencias socials a partir de experiencias individuales. En este contexto la tesis discute (a) tres casso de estudios de accesorios juguetones, (b) una evaluacion cuantitativa y cualitativa sobre la capacidad de los accesorios para motivar el jugo libre, (c) el proceso de diseño de las experiencias jugables con la participación de niños y personas mayores (60+). Además, esta disertación presenta un conjunto de oportunidades de diseño que pueden ser tenidas en cuenta en la investigación de futuros objetos para motivar el juego libre.

Resum

D'acord als estudis socials, la vida quotidiana ha reduït les oportunitats que els nens puguin gaudir del joc lliure, la qual cosa a llarg termini, pot perjudicar el seu desenvolupament social i físic. La investigació en Interacció Persona Ordinador, ha abordat aquesta qüestió de com utilitzar sensors i reactors per estimular el free-play, per exemple intervenint els parcs infantils o objectes d'ús compartit amb aquestes tecnologies. Aquesta dissertació explora el procés de disseny i avaluació d'accessoris digitals per posar-se, dissenyats per motivar el joc lliure entre els nens d'edat escolar, en contextos alternatius de joc lliure. Això s'ha fet per aprofitar les oportunitats de joc lliure que poden sorgir quan estàs en camí a algun lloc, així com per motivar reptes corporals i experiències socials a partir d'experiències individuals. En aquest context la tesi discuteix (a) tres casos d'estudis de playful accessories, (b) una avaluació quantitativa i qualitativa per avaluar la capacitat dels accessoris per motivar el joc lliure, (c) el procés de disseny de les experiències jugables amb la participació de nens i persones grans (60 +). A més, aquesta dissertació presenta un conjunt d'oportunitats de disseny que poden ser tingudes en compte en la investigació de futurs objectes per motivar el joc lliure.

Table of Contents

List of Figures

List of Tables

1. Introduction

This dissertation addresses the conception, (participatory) design and evaluation of wearable and playful accessories intended to encourage free-play amongst (primary school aged) children. The following two scenarios, which frame the research and contributions summarised in this introduction, illustrate a number of design and research opportunities enabled by the way of understanding, conceiving and analysing augmented free-play discussed in this dissertation.

Free-play while commuting: Two children (8 and 10 years old) have spent the weekend with their dad and mum in the countryside. It is Sunday, 3:30 pm. They are now on their way back home. The family decides to take the four o'clock train service to Barcelona Sants. They get on the train and the trip begins. The kids get quickly bored and start to play. Yet, the play opportunities on the train are limited. However, this time the kids are wearing their augmented belt packs. They keep their favourite toys and tools in the belt pack, which in turn provides them with an extra entertainment opportunity for the trip. The belt pack is augmented with sensors and reactive technologies. The pack emits a light and a sound when the kids make abrupt body movements. It is a quarter past four. The two children are trying out the pack. They do not want their body movements to be detected by the pack. They take turns to use it and compete for the strangest "invisible" position. They are sometimes detected, i.e. the belt pack emits a light and a sound, which makes them laugh. They are ready for taking up new challenges. It is 4:30 pm. They take out their puppets from the belt pack, and make them dance. They dance with them too in order to make "music" – the sounds emitted by the belt back. They are having a whale of a time on the train, having playful and creative experiences, despite (or due to) the limitation of play resources available. Also, their dad and mum have realised that their kids have been unglued from screen-based entertainment for, at least, the trip. It is a quarter to five. They get off the train, wearing the belt pack, and more free-play opportunities await them.

Play while researching: We observe three children in their everyday playground. In this outdoor area provided for children to play on, they are challenged with new playful objects and game proposals. They can also easily adapt the objects according to their play interests, without having to stop from playing. We, and other HCI researchers, use this playground as a means to have children involved in the (participatory) design of new playful objects. The researchers observe them while playing on the playground and introduce adaptable objects into the ecology of the existing playground. The interactions, and playful qualities of future digitally-augmented free-play objects, derive from this playground.

These two scenarios envision the design (through research) of interactive objects that encourage free-play amongst children. The remainder of this introductory chapter is organised as follows. Section 1.1 addresses research areas, problems and solutions proposed. Section 1.2 summarises the main research questions, and Section 1.3, the methodological approach. Section 1.4 presents the main contributions, which are discussed in Section 1.5.

1.1 Research areas, problems and solutions proposed

Free-play

Free-play is the spontaneous emergence of play driven by the creativity of children (See Figure 1). During free-play, children can get to see in fabric countless playful objects, such as a cape or a flying carpet. In terms of Callois, in his seminal Man, Play and Games (Callois, 1961), free-play is Paidia play, which could be defined as the own construction of meaning, which includes expression, spontaneity, improvisation, no logical ending point, is infinite and chaotic. The opposite of Paidia play is Ludus play, which is structured and predefined play, finite, with goals and rules.

Figure 1: Free-play example, games with a ribbon

According to developmental psychology, free-play is key in the development of social and physical skills during childhood (Berk, 2006). However, previous research suggests the opportunities for children for free-play are declining (Singer et al., 2009). This is due in part to the popularity of screen-based entertainment, structured entertainment, an ever-growing number of extracurricular activities (See Figure 2), and the focus on academic goals (Veitch et al., 2010). While this might be true, we considered that exploring free-play and interactive technologies was a worthwhile exercise.

Figure 2: Examples of extra curricular activities and structured entertainment.

Sensing and reacting technologies have been used to encourage free-play. Previous approaches have explored the augmentation of playgrounds and shared objects (Sturn et al., 2008; Bekker et al., 2009). Regarding playgrounds, Sturm et al. analysed how playground experiences can be enhanced with sensors and actuators (Sturn et al., 2008). Ferris and Bannon (2002) designed an augmented play environment to explore innovative ways to stimulate discovery, play and adventure amongst children. *Breathless* represents an unusual evolution of swings to inspire the design of future playful systems (Egglestone et al, 2011), while *Aerial Tunes* is a "collaborative, tangible interface, based on balls hovering in mid-air, which can be manipulated (…) to explore and experiment with an ambient soundscape" (Alroe et al., 2012 p.1). With respect to shared objects, *RoboMusic* uses *I-Blocks* to allow users to experiment with music. Each block is associated with a selection of musical loops, which can be manipulated by rotating, attaching and detaching cubes to and from each other (Falkenberg et al., 2011). *ColorFlare* is an augmented tube designed for children aged 8-12 with the aim of supporting open-ended play (Hof et al., 2010). Manson *et al.* use a table-top environment to foster fantasy play among pre-school children (Manson et al., 2010). Finally, in a wearable approach, *Tagaboo* is a system that uses RFID technology to enhance common open-ended games, such as tag, hide and seek or memory (Konkel et al., 2004), which represent an approach towards play as and added value to wearable technologies (Steffen et al., 2009).

However, most of today's children find it difficult to spend large amounts of time on playgrounds, and devote time to free-play at home. We take into consideration the limitations for free-playing at home and on playgrounds, but are not discouraged by them. We look for alternative free-play scenarios that fit in the busy routines and hectic life style of most of today's families. Our approach proposes the use of Playful Accessories (PA): wearable artefacts, endowed of their clothing cultural function (See Figure 3), which allow children to wear them at almost anytime. The artefacts are augmented with sensing and reactive technologies in order to take advantage of alternative opportunities for free-play on the move.

Figure 3: Ideas of playful accesories

This dissertation presents three cases studies in the design of playful accessories: *FeetUp*, *Statue*, and the *Wearable Sounds Kit* (*WSK*). *FeetUp* is a pair of shoes that blinks and beeps while jumping, and encourages jumping challenges. *Statue* is a belt pack that blinks and beeps while moving, thereby augmenting statue games. The *WSK* is an accessory to make sounds while moving and it encourages mostly fantasy and rhythmic play. All of them encourage social, physical and open-ended play, and have been designed following a strong Participatory Design approach.

Participatory design

Within Human-Computer Interaction (HCI), whether children should be involved in the design of new interactive systems aimed at them is not a question. Yet, how to have them involved in design is, we argue, far from easy. The challenges range from coping with a potential lack of affinity with the PD activities to the need of empowering them to suggest design ideas.

To cope with these challenges, a number of PD studies have proposed design or topic training, which should empower participants to contribute to a design process (Yip et al., 2013). Others use sketch techniques to encourage children to create design ideas (Mitchell and Nørgaard, 2011). However, we argue in this thesis that these and similar strategies tend to result in abstract thinking or de-contextualized crafting activities, which detach participants from their play experiences. Moreover, they do not cope well enough with the challenges of affinity or empowerment, as discussed later.

This dissertation reflects on intertwining ethnography with PD in an attempt to overcome the aforementioned challenges. This is done by integrating into PD three key guiding principles of ethnography, understanding experiences holistically, taking a member's point of view and conducting research in their everyday settings (Blomberg et al., 1993). Building on these principles, this dissertation presents the embedding approach, which is aimed at coping with the aforementioned challenges by embedding PD in community-based activities and using adaptable prototypes for simulating holistically the intended user experience with the yet-to-be design technology.

The embedding approach has been applied in the design of two interactive systems, the *WSK* with children, and a Knowledge Games Platforms (KGP) with older people (60+). We embedded the PD studies, for example, in an ICT class, in a summer party and in a play rehearsal (See Figure 4). More than 170 (older) participants were involved in the design of the KGP, and 8 highly motivated children contributed effectively to the design of the *WSK*, which was used by over 100 children (aged 3-17) in Ars Electronica Festival 2012 in Austria.

Figure 4: Embedding PD in a play rehearsal

1.2 Three main research questions

With the aim of understanding how to (a) make interactive technologies into digitally-augmented objects that encourage free-play, and (b) have children effectively involved in the design of these objects, this dissertation addresses the following three main research questions:

- Question 1. How did *FeetUp*, *Statue*, and the *Wearable Sounds Kit*, fit in and enrich free-play? Which design features of the playful accessories are related to which dimensions of free-play?
- Question 2. Are there new design opportunities to create interactive objects that encourage free-play? If yes, what are these opportunities?
- Question 3. How can we conduct Participatory Design with children to empower them to contribute in the design of playful technologies for them?

1.3 Methodological (research & design) approach

In an attempt to involve children's ideas, interests and feelings in the design of technologies targeted at them (Druin, 1999), the methodological approach of this dissertation aimed at intertwining PD with ethnography. Although both PD and ethnography seem to be opposite terms - the former is aimed at creating the future, while the latter is aimed at understanding the present - some of the strongest arguments for supporting this intertwining are:

"Innovation is an imagination of what could be based in knowledge of what is"
"Awareness of the current context is a resource for proposing meaningful change"
(Blomberg and Karasti, 2013)

The ethnographic approach allows us to capture user ideas, interests and feelings, in the inspiring contexts where users belong to, and where they usually expand their creativity, therefore it "relies on the ability of all humans to figure out what's going on through participation in social life" (Blomberg and Karasti, 2013). PD, which is defined in the seminal Participatory Design Principles and Practices as "a new approach towards computer systems design in which the people destined to use the system play a critical role in designing it", encouraged us to find techniques to empower children to make contributions throughout the design process.

Consequently, the conceptual design of Playful Accessories, and the design of three of them, *FeetUp*, *Statue* and the *WSK*, was grounded in fieldwork. We observed, and talked with, children while playing on playgrounds, during and after school hours, and at home, in an attempt to create the general concept of Playful Accessories. At intermediate stages of design, and to validate the design concept/s define the qualities of the intended systems, to "foster ownership of the process, technology and media" (Botero and Hyysalo p.49) we embedded PD activities in community-based activities of children. An example of these activities is the preparation of a play during a summer school. Finally, we created the interactive systems and evaluated them in out-of-laboratory conditions, such as Ars Electronica Festival 2012, using in situ observations and quantitative video analysis.

1.4 Main contributions of the thesis

Evocative accessories stimulating free-play experiences

(Rosales et al., 2011b) proposed a concept of playful accessories (PA) and the first PA designed, *FeetUp*, shoes that blink and beep while jumping. (Rosales et al., 2011c) presents the second PA, *Statue*, a belt pack that blinks and beeps while moving, and presents an exploratory evaluation of *FeetUp* and *Statue*. Both PAs are wearable. Thus, children can take advantage of any boring moment to turn it into free-play. These PA react to body movements, as the playing with the body was observed to be a major ingredient in free-play. (Rosales et al., 2014c) presents the design and evaluation of the *Wearable Sounds Kit* (*WSK*), the third PA that can be attached to the arms or legs of children, to emit sounds while moving.

(Rosales et al., 2011b) presents an early explorative evaluation of *FeetUp*. (Rosales et al., 2011c) describes an explorative evaluation of *FeetUp* and *Statue*. Both papers provide an initial overview of how playful accessories are integrated in the free-play of kids. (Rosales et al., 2014c) provides more detailed methods to measure and understand the evocative power to encourage free-play of interactive objects through the study of the *WSK* amongst more than 250 participants from which more than 100 were children (7-12 years old).

9 kids tested *FeetUp* and *Statue* in groups of 3 to 5 children at an after-school center. Each group experienced each accessory for 30 minutes under the monitoring and companionship of at least 3 observers and educators. Structured observations (Markopoulos et al., 2008), guided

the understanding on how objects stimulated free play and which kind of activities the objects promoted. *FeetUp* and *Statue* were both successful in eliciting free-play, although the observations, and the parameters, were not as controlled as they were with *WSK*. *Statue* evoked variations in children's everyday games related to being statue, providing apparently more scaffolding for free-play, while *FeetUp* was apparently less legible and more difficult to appropriate than *Statue*. *Statue* was so simple that kids could start playing immediately. With *FeetUp*, in a first phase, each kid spontaneously searched their personal connection with the accessory; some of them tried classic ballet, other danced capoeira, while others did handstands and breakdancing. Further, building on this personal connection, the accessory elicited social challenges, by them sharing their personal experiences. Both accessories provided simple sound feedback (the sound of a piezo speaker), and the sound provoked great interest as they provided meanings for it, some of them imagined they were robots, they were Mars, or that they were in the commander of a space shift. This led us to the creation of a third PA, which focused more on the sound feedback, the *WSK*.

With *WSK*, we wanted to follow a more structured evaluation (Figure 5). 278 (age 3-75) participants, from which 78 were school-aged children, interacted with the accessory. We gathered 35 hours of free-play (field work). While many free-play products are evaluated in controlled environments and structured activities, we turn to free-play contexts in order to understand the potential of the technologies in natural social contexts of use and in a spontaneous dynamic of use.

Figure 5: WSK evaluation

Some methodological aspects of the evaluation included:

- Conducting the evaluation in a public event (See Figure 6) to allow self-filtering of participants, whereby they decided to engage or not in the activity in a spontaneously way, based on the affinity with what they see others are doing. Children choose their play options according to their interests. Inviting them to participate in an evaluation, without they knowing what they are going to do, does not assure participants are going be your real future users. By accepting that kids can have diverse play interests, self-filtering assures the affinity of participants with the intended experience, and should provide us with more accurate feedback.

Figure 6: Evaluation of WSK in a public event at ARS Electrónica Festival

- Allow each participant to involve his or her natural play partners in the evaluation, which helps us to understand the social context where the future object is likely to be used. This "points to the importance of understanding activities with reference to the larger setting and array of related activities" (Blomberg and Karasti 2013, p.88).
- Gather information based on observations of researchers. They can describe children's activities, when children tend not to describe because of beeing are deeply immersed in the play activities. It "relies on the ability of all humans to figure out what's going on through participation in social life" (Blomberg and Karasti, 2013).

- After the play sessions, we used an adapted version of the play observation scale (Rubin, 2001) for coding the videos of the play sessions. We used and interobserver reliability test to validate the variations of the osbervation scale. The scale include social aspects and play patterns to observe.

Not surprisingly, the results indicate that children were more involved in free-play than adults. Yet, teenagers were involved in free-play as well, as opposed to pre-school aged children. Probably pre-school children did not cope well with the sounds of the interaction or the *WSK* was not (physically) suitable for them. School-aged children and teenagers incorporated the *WSK* effectively into their free-play, and the *WSK* encouraged different free-play patterns, including motor play, rhythmic, fantasy and social play. The findings also stress the relevance of (a) sounds made by everyday objects, which were more often used than the sounds of musical instruments, and (b) providing school-aged children with a personal device with several choices as to where to wear it or which sounds it makes, in order to encourage them to explore the *WSK* and to create personal experiences with it. These results challenge the idea that shared objects are required to encourage free-play (Bekker et al., 2009).

Design opportunities for objects to encourage free-play

Building on the results of the evaluations of the three playful accessories, we reflect on a number of new opportunities of research on the design interactive systems that facilitate and foster free-play by encouraging children driven play. This is intended to expand previous research on values of open-ended play objects to support free-play by (Bekker et al., 2009) and (Sturn et al., 2008). They point at supporting social interaction to encourage collaboration and competition without predefined goals in order to allow participants to define their own goals in a open ended approach, and keeping the collaboration and competition: simple, as "children need to be able to start using them straight away" (Sturn et al., p.261), challenging, it "creates a sense of achievement and enjoyment" (p.261), and providing feedback "allow the user to influence and react to the behaviour of the system" (p.262).

Some of the new opportunities introduced by this dissertation include:

- Alternative free-playing contexts, other than the traditional play settings, such as the playground or home. Playful accessories draw on the ubiquity of wearable artefacts to provide children with opportunities for encouraging free-play on the go, when they are detached from the oversupply of structured entertainment, and can devote their play interest to sparkle their imagination.

- Individual play objects. Design objects suitable for individual free-play (while supporting social interaction). It allows individual exploration, i.e. individual participants creating own play meanings and exploring their own creativity. Meanwhile, it respects the natural stages of the social experiences, which include the transition from solitary to imitation, observation, parallel play, and finally associative and cooperative play (Parten, 1933).
- No digital network interaction amongst players. By designing interactive systems which can be used individually, and avoiding digital networks that define the rules to interact amongst users, children are able to define their own rules of interaction and create their own play network.
- Wearable artifacts augmented with sensing and reacting technologies "provide the player with immediate feedback and thus enhance their personal experience to a personal level" (Pagliarini and Lund, 2011 p.384), which motivate users to create their own play meanings.
- Providing play as an added value to everyday and ubiquitous objects. This assures that children are going to have it all the time, and allows them to use its play opportunities in unexpected moments and places where they find themselves with nothing else to do. For instance, both *FeetUp* and *Statue* are objects that kids can wear all day long and play with it, whenever play opportunities arise.
- Sounds of things, detached from the real things, have an evocative power and encourage imaginary play, which is a key element of free-play.
- Ambiguity as a resource to play. Ambiguity can be "intriguing, mysterious, and delightful" (Gaver et al., 2003) and therefore sparkles the imagination and motivates free-play. For example, the ambiguity of unclear, or undefined sounds in WSK motivated children to provide their own meanings by playing.
- Explorative features. Exploration provides enough time to let imagination flow. For example, the WSK provides children with a set of 30 sounds of things. Children can choose a sound,

explore the list of sounds, and find their own way to appropriate the device.

- Finally, grounding the interaction in everyday play activities assures a connection with the play interests of future users. For instance, *Statue* is grounded in the diverse games children usually play when being a statue, and the explorative evaluation showed how it was used to increase the complexity of those games.

Participatory design: the embedding approach

The contributions summarised below are presented in three papers: (Rosales et al., 2011c) in Chapter 2, (Rosales et al., 2014a) in Chapter 3 and (Rosales et al., 2012) in Annex I. All of them draw upon the design process of interactive systems. (Rosales et al., 2011c) and (Rosales et al., 2012) present early PD studies conducted to design interactive systems for children or older people. Building on these two studies, the dissertation proposes the embedding approach in paper (Rosales et al., 2014a).

Despite the relevance of PD (Robertson and Simonsen, 2013), previous studies have reported challenges when involving older people and children in PD studies. These challenges include the difficulty to cope with the abstraction of the design process, the affinity between participants and the activities of the study, and the recruitment and the empowerment of participants to be able to contribute to design (Otjacques et al., 2010; Rice and Carmichael, 2011; Uzor and Skelton, 2012).

To cope with these challenges, a number of PD studies have proposed diverse approaches, such as design or topic training (Yip et al., 2013) or sketch techniques (Mitchell and Nørgaard (2011)), which should empower children and older people to contribute to a design process. However, we argue that these strategies result in abstract thinking or de-contextualized crafting activities, which detach participants from their play experiences, which could (and indeed, do) trigger new play ideas. Moreover, we argue that they do not cope well enough with the challenges of affinity or empowerment. Community-based PD position PD amongst communities (Disalvo et al., 2013) and “fosters ownership of the process, technology and media” (Botero and Hyysalo p.49). This dissertation agrees with Disalvo and Botero, and takes one step further forward by seeking strategies to embed PD in community-based activities with the participation of older people and children.

The embedding approach has been applied in two R&D projects, *Wearable Sounds Kit* (*WSK*), the sound feedback wearable accessory designed to foster and facilitate free-play amongst children, and WorthPlay, a platform of knowledge-based games (KGP) (Rosales et al., 2014a) that older people, with different levels of previous experience with ICTs, found it worthwhile to play (2014b).

The embedding approach makes the following contributions to PD.

- Reflects on practical approaches for intertwining ethnography with PD, using three guiding principles of ethnography, holism, taking a member's point of view and everyday settings, for "giving voice to people in their own local context" (Fetterman, 2010, p.1).
- Points at the interplay of ethnography and PD by embedding PD in children and older people's everyday activities, to which they feel and are able to contribute, by using their own interests, skills and habits.
- Argues against abstract techniques commonly used in PD and the interwining of ethnography with PD based on using the former to 'inform' the latter. The embedding approach aims at real-life experiences to inform the design processes.
- Seeks strategies to embed PD in community-based activities by slightly modifying them with the intended experience to allow participants to focus on the experience rather than on the interface and "to create opportunities to learn about the other's domain of knowledge" (Blomberg and Karasti, 2013).
- Uses adaptable prototypes and face-to-face interaction to simulate the intended experience, for participants to be able to adapt it to their own interest.

1.5 Further reflections on the contributions

Having reviewed the main contributions of this thesis in the previous section and indicated how they were made, it might be worthwhile now to reflect briefly on where these contributions are taking us in terms of pushing current research forward.

Where does this dissertation fit in HCI research? Both the research and design approach adopted in this dissertation highlights the relevance and potential of framing and conducting HCI research within the real-life of users. In particular, the contributions have shown that spontaneous participation in activities that are meaningful to the participants are a mine of information, since they feel comfortable enough to contribute to research / design activities. We have understood their ideas, interests and feelings by using ethnographically-inspired methods, and applied this knowledge to the ideation, co-creation and evaluation of new interactive experiences in their lives. This situates this dissertation in the third or current HCI wave (Bodker, 2006).

This dissertation seems to 'take upside down' much research related to the use of interactive technologies to encourage free-play, as this body of work has primarily focused on augmenting playgrounds and shared objects. However, (most) children have scarce opportunities to visit playgrounds, while homes are saturated of play devices. My research stresses the relevance of creating products that can be integrated in the everyday routines of children. By doing so, products can take advantage of alternative opportunities for free-play, such as playing "on the move" or playing during typical boring moments for many children, e.g. adults meeting. My research also considers the natural creative process, which moves from individual exploration to social experience through the use of individual devices.

1.6 Organisation of this dissertation

The body of this dissertation consists of 3 papers. A journal (JCR) and conference paper published, and a journal paper (JCR) under review. They are representative of the research undertaken in the thesis. 10 publications, which show the wide range of activities conducted and results published throughout the thesis, are discussed in Annex I.

The papers that form the body of this report have been divided thematically into two chapters. Each chapter is preceded by a one-page summary of results.

Chapter 2, Case studies, presents one conference and one journal (JCR) paper (1), (2):

(1) A. Rosales, E. Arroyo, and J. Blat, "Playful accessories," in Design Research IASDR, 2011, pp. 1–7.

(2) Rosales, A., Sayago, S., Carrascal, J.P., & Blat, J. (2014). On the evocative power and play value of a wearable movement-to-sound interaction accessory in the free-play of schoolchildren. Ambient Intell. smart Environ. 6(3), pp. 313-330.

The first (Rosales et al., 2011c), presents the user study that led to the proposal of the playful accessories concept (PA), considering the hectic life style and short opportunities for free-play. It also presents the design concept of two PA *Statue* and *FeetUp*, and an explorative evaluation. The second (Rosales et al., 2014c), introduces the *Wearable Sounds Kit*, the third PA that can be worn in any extremity of the body, to make sounds while moving, its participatory design process, and its evaluation in a free-play context.

Chapter 3, Participatory design, presents a journal paper (3) under review.

(3) A. Rosales, S. Sayago, R. Valeria, and J. Blat, "Embedding Participatory Design in community-based activities of children and older people

While in Chapter 2 and Annex 1 we introduce short PD studies as part of other papers, two with kids (Rosales et al., 2011b; Rosales et al., 2011c), and one with older people (Rosales et al., 2012), which sparkled the idea of understanding proper techniques to conduct PD studies, in this chapter we present one paper specifically related to the PD approach proposed as part of this dissertation. In the paper, we propose an ethnographically-inspired approach to overcome main challenges of PD studies with children and older people, and empower them to use their own skills, interests and habits to be able to contribute to PD. We call it, the embedding approach, because it aims at embedding the PD studies in the everyday and meaningful activities of participants. By embedding we strength of PD activities that contribute on participant's activities, rather than ask participants to contribute to a PD study.

Finally, Annex I discusses other research activities carried out during the PhD period. One position paper analyses briefly the relevance of creating new objects to encourage free-play. The others explore earlier stages of the research process of the playful accessories. One paper presents two preliminary participatory design studies involving ethnographically-inspired methods, in the development of two interactive projects for people with special needs. It also includes one master degree project supervised and carried out in the context of free-play, to corroborate the findings of this Phd. We indicate some ethnographic and evaluation activities on a range playful technologies carried out and co-ordinated in research projects with other targets of users, which have partially resulted in some papers in eLearning, novel user interfaces, and technical reports.

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2. Three playful accessories: design and evaluation

This chapter describes the design concept of three playful accessories and presents the prototypes designed, developed and evaluated. This chapter also provides a number of new design opportunities for digitally-augmented objects to encourage free-play amongst school-aged children.

This chapter is divided into two sections and consists of two papers:

Section 2.1 presents a conference paper, which discusses the concept of playful accessories, building on two ethnographic explorations. Rather than playing with objects, the kids we observed during free-play devoted most of their energy to challenging their body and playing games that tested their strength, velocity, and coordination. In addition to this, our conversations with the children revealed that their everyday was plenty of duties, and they had almost no opportunities for free-play. Thus, we proposed the development of playful accessories, which react on children's movements, to encourage free-play on the go. Two playful accessories are presented, *Statue* and *FeetUp*. *Statue* is a belt pack that blinks and beeps while the user is moving, and encourages statue games. *FeetUp* is a pair of shoes that blinks and beeps while jumping, and encourages jumping challenges. The prototypes were designed by following a participatory design process and evaluated in explorative studies. The main finding is a set of design opportunities for other objects to encourage free-play. These opportunities range from providing added playful value to everyday wearable accessories and the augmentation of it with feedback on body movements to the relevance of using individual objects, with no predefined goals, and concrete rules systems, to encourage free-play.

Section 2.2 presents a journal paper, wherein the Wearable Sounds Kit (WSK), the third playful accessory, is introduced and evaluated. The WSK makes sounds while the kid moves. Children can choose the position of the accessory and explore a list of 30 sound of things or musical instruments. The paper presents a participatory design process, conducted with 20 children, aimed to make key design decisions, once the concept of the accessory was defined. Subsequently, it describes an evaluation study conducted with over 100 participants, in a socially open context. Play experiences were analyzed through research observations, informal interviews, and video coding. Video coding was conducted using an adaptation of the play observation scale, and validated with an inter-observer realibility test. The main findings show that (school-aged) kids effectively found playful uses of the accessory, they were engaged in motor play, fantasy play, as well as rhythmic play. Furthermore, it showed that sound of objects were more playful than sounds of musical instruments, and although quantitavely, boys were more engaged in fantasy play than girls, they were also engaged in fantasy play, but devoted more time to the exploration of the creative uses of diverse sounds.

2.1 Playful accessories. Design process of two objects to encourage free-play experiences

A. Rosales, E. Arroyo, and J. Blat, (2011)"Playful accessories" in Design Research IASDR, 2011, Delft, The Nethernland, pp.1–7.

Available at: https://www.dropbox.com/s/rusq94llk3glnu3/iasdr_2011_Rosales_et_al_Playful_accessories.pdf

Abstract

In this paper we describe the design process of two playful accessories for children to play anywhere and anytime. We explain ethnographic phase to define a General Design Concept to design objects to encouraging free-play. We describe the two interactive designs emerged from this concept and the preliminary results of user's evaluation. The General Design Concept propose the use of playful accessories for children; simple interaction systems embedded in every day accessories, to increase their opportunities to take advantage of face to face interactions for free play and practice social skills. Preliminary user's experiences describe how Playful Accessories encourages free-play.

Keywords:

free-play, social interaction, accessories.

A. Introduction

Entertaining 7-year-old children is not a big achievement as long as there is something around them. Whatever you give them, they explore it, try it out, and try to enjoy it. Children can be playing video games the entire day, playing in a swimming pool for hours, or playing with simple objects like a stick, a bag or a ribbon

The real challenge is give objects that will stimulate them to experience diverse activities that would help to develop diverse skills such as exploring their imagination and creativity, practicing social skills and being physically active.

Children are in continuous training; by playing children mimic other's experiences and learn about them (Nachmanovitch, 1990). In this way they build their own values and develop skills in such a form that their way of being will be strongly influenced by all their experiences (Piaget, 1966).

Unfortunately, nowadays children spend most part of their leisure time in front of screens (Sturm, 2008), (Soler-adillon, 2009) this prevents them from having valuable face-to-face interaction, important to develop real life social skills (Mandryk, 2001), (Creighton, 2010). Through this work, we seek to define guidelines for designing objects that provide adequate stimulation to facilitate developing social skills by playing.

Our approach supports the design of objects to encourage social interaction by free play (Bekker, 2009), (Creighton, 2010); spontaneous, collaborative, open-ended, creative, funs, pleasurable and physically active play, usually with a pretend element (Rosales, 2010).

In this paper we describe the design process of two objects to encourage, children 6 to 9, to practice social skills through free play. First we describe the ethnographic phase to understand children's habits related with free play, including objects, activities and routines. This ethnographic phase lead us to define a general design concept, where different objects that encourage free play can be proposed.

The general design concept proposes the design of playful accessories and it is described in the paper. Then, we describe the participatory design process (Vaajakallio, 2010) that took place to define the specific interactive designs developed, and the two prototypes emerged from it: *Statue* and *FeetUp*. Finally we describe a preliminary evaluation process about how, according to structured observations (Markopoulos, 2008), those objects encourage free play.

B. Ethnographic studies (Free-play and children's routines)

The design process started by two ethnographic studies in order to identify further implications for design (Dourish, 2006) building on the relationship between free play and children's routines. These studies aim at define the General Design Concept as framework to propose specific objects to promote free play. We involved children in the research of the implications of design, using ethnographic methods (Dourish, 2006) to include their feelings, interest and constrains since the beginning of the project (Druin, 2002).

B.1 Children and free play

A preliminary ethnographic phase studied the relationship between the objects children use during free play and the activities they perform. We observed children playing in places where they usually have opportunities for free play: school breaks, the park and their houses. Through 24 independent sessions we identified a list of evocative objects children include in their games, as well as the activities surrounding those objects. Our observations indicated that the most common object in children activities is their own body. As they are developing motor skills, they often feel engaged in physical challenges. They naturally play games related with physical aspects of their body, such as gravity, coordination, aim, strength, synchronization, etc. That is, the body is the always-present object children play with.

Related to the activities, we categorized them into 2 groups: games and explorations. For example, regarding activities involving dance, they can explore it freely, or play specific music related games. Explorations can include just moving around, enjoy the music ant try to move according to that. The games include a common goal and a setup of rules and constrain, e.g. a game where everybody has to move until the music stops, if someone moves he/she looses. Games and explorations can be collaborative, open-ended, and spontaneous. Games have rules (flexible or not) and a final objective (flexible or not) in which someone loses or wins and usually have a specific name. Whereas mere explorations have no defined rules and goals, can be shorter, are changing constantly, and are difficult to see by external obververs (Markopoulos, 2008). Researchers cannot read what children are thinking; asking them directly would be useless and they could look like they are doing nothing, but in their imagination they could be experiencing their own explorations. Both, explorations and games can be described as free-play depending on the degree of freedom they have to let emerge the activity or make it evolve.

B.2 Children's routines

A second ethnographic study identified that kids participating in the studio, had little opportunities for free-play. We investigated their routines by immersing into the spare time of 8 families in Barcelona, and by having informal conversations with them about their habits and routines.

Although each family is different, coordinating routines is a big challenge for all of them. In Spain children usually go to school from 9 to 17, and very often they go to extracurricular activities from 17 to 19. During this kind of structured activities they have no opportunities for free play, because they are not allowed to do whatever they want, educators plan the activities according to their own requirements, there is rules kids can not change freely, and there is specific goals to achieve. During this time they have a long brake at lunch that they can spend at home or at school. The ones who enjoy their lunchtime at school spend at least one hour of free time. After 17hrs some children are allowed to spend some free time at the park or at home. After that, they have time to do their homework, play a little bit more, eat and go to sleep.

If week-days offer some opportunities for free-play, during the weekends children we studied have few small opportunities for free-play, since they still have to take care of many family duties that are typical boring moments, or they are attending to more structured activities. Boring moments for children can include transportation, visiting grandparents, shopping or simply having to go with parents in their family duties because they cannot leave kids at home alone.

Interestingly enough, we observed that during their free time children did not always played free-play activities: spontaneous, collaborative, open-ended, creative, fun, pleasurable and physically active activities. Often they would to play with video consoles in the lunchtime at school, watch T.V. at home, or involve in the practice structured sports after school.

During their spare time at home, some of them are part of single-child families, and do not have the companionship of another child which is fundamental for free-play. Some other children live in apartment buildings where they are not encouraged to move freely. In the city, streets are not used as a space to play, as it can happen in typical neighbors of houses or in housing complex, where kids are at the glance of their parents while parents are doing home duties. Thus, a typical free-play such as going out to play is only possible at parks, and only allowed under the companionship of some adult, thus children depend on their availability to do it.

After observing children's routines we agree with Veitch (2010) that some of these characteristics of the environment limit children's opportunities for free-play and some characteristics of modern live style as well. However, we also conclude that in their routine they often experience typical small boring moments, that they can take advantage of with their playful attitude and some additional feedback. Clothes or accessories, as gloves, funny packs, or shoes, are objects they often take with them everyday and everywhere. Adding a playful value to those accessories can encourage them to take advantage of those moments to create new opportunities for free play. Accessories are objects attached to children's body, augmented with sensors can react according to body's activities. Playful accessories are smart clothes that give feedback to children's activities to encourage playing around specific body behaviors.

We follow Steffen idea (2009) according to what, adding a playful value to clothes for children, takes advantage of the possibility of current technology to create smart clothes, which only would be useful adding relevant values as suggested by Steffen (2009).

C. General design concept

The previous exploration, allowed us, to define a general design approach for objects that stimulate free play and allow children to practice of social skills.

We suggest the design of playful accessories for children according to the following design values:

1. Every-day accessories
2. Augmented with feedback to body challenges
3. For individual and shared use
4. Using simple set of rules
5. And no pre-defined and binding play function

Everyday accessories

The use of accessories that kids usually take with them everywhere seeks to take advantage of every small opportunity within children's routines to enjoy a free play experience.

Direct feedback

Playful accessories react to a specific body behavior, to involve the body, the object they use more often in their games, and provide audiovisual feedback when it happens, to encourage this body challenge.

Individual and shared use

Each child can explore and, play with the accessory by himself, or share the experience with others. During the individual use they have the opportunity to explore their own creativity, and when several children have the same accessory, they share the same kind of information, facilitating play around the accessory.

Simple set of rules

A concrete rule system in each accessory reacts to only one behavior with only one kind of feedback, thus children must use their imagination and creativity to explore the possibilities to play with this concrete system.

No binding function

The accessories satisfy a dressing function, however, they do no have a specific play function. For instance, they do not afford a specific use, such a water gun; instead, they encourage children to imagine how to use them in their games.

While trying to imagine how to play with it, or while playing with the accessory, children must explain ideas, argue/discuss, negotiate, and reach agreements, thus they are able to practice quite important social skills.

D. Participatory Design

Current trends in HCI suggest involving children in a participatory design process in order to voice their opinions and inform the design with their own interest, emotions and feelings (Druin, 2002). In addition to involving users in the ethnographic and conceptualization phase, they also participated in the design phase as well. Children contributed initial ideas and concepts, assisted in problem solving and the final evaluation.

D.1 Brainstorming with children

The process started with 6 sketches of imaginary powerful accessories (See Figure 7 and Figure 8) adapted from the methodology described by Morajevi as comicboarding (2007). We explained children that these objects were powerful ("magical", and "limitless") and asked them to imagine what these "powerful" objects would do, how the objects would behave, and what they could do with it.

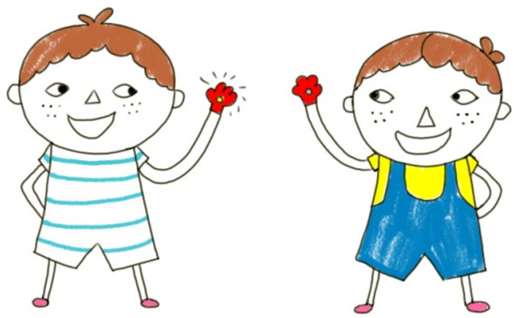

Figure 7: Glove interaction sketch

Figure 8: Broche interaction sketch

They could enhance initial sketches, make new draws or explain their ideas. We repeated those questions until reaching a concept for a possible interactive system, including shape, reactors, rules and possible uses. Finally, between children and researchers selected two design concepts to be developed further: *FeetUp* and *Statue*. *FeetUp* are shoes that blink while jumping, and *Statue* is a fanny pack that blinks while the user is moving.

D.2 Iterative prototyping

We implemented the prototypes in stages. First we implemented one function and tested it with children by asking them to imagine the prototype had all the features included, and to play as if it were fully implemented prototyp. This provided us with the adequate context to capture children's likes, dislikes, curiosities and needs at each step of the design process.

For example, children naturally suggested the use of sound to complement the experience whenever it was impossible to see the visual feedback while playing. Children also helped define the adequate sensor threshold values to increase the playfulness of objects and also identified several ergonomics and many robustness issues. And moreover kids were testing the ideas and show us how they were enjoying the accessory and practicing social skills.

After each new prototype test, we obtained a list of things to improve and the new functionality to add in the following step.

E. Object Design Concepts

In this section we describe the resulting design concepts according to the previous phases.

E.1 Statue

Statue is a playful accessory embedded in a fanny pack that provides audiovisual feedback whenever the user moves (See Figure 9). *Statue* stimulates children to play around controlled movements; one of the most frequent activities they are challenged while playing folk games. Being statue, move stealthy or try to hide.

Object Design

For the object design we considered the use of an existing object children can wear and have with them all the time. We used a fanny pack, something easy to wear, something they can wear every day, they can use it to keep personal things, and finally, they can play whenever they find an opportunity to do it (See Figure 9).

Figure 9: Statue Prototype

Motion measurement is embedded in the fanny pack, it is placed around the waist thus it can detect movements from the upper side of the body or the bottom.

The audiovisual feedback is embedded in the surface of the fanny pack, allowing everyone to see it and listen to it.

Setup

The hardware includes 1 accelerometer, 1 microcontroller embedded inside the fanny pack, 1 piezo speaker and 2 external LED arrays.

Interaction rules

The interaction system reacts to a specific factor: children's movement. An accelerometer detects every movement in the Y and Z axis, the microcontroller detects when it exceeds a certain threshold, to exclude slow movements, and when it happens triggers a signal to blink LEDs and play chimes on a piezo speaker. The system discards the information of horizontal movements, thus kids can find the way to walk and not make the accessory blink.

E.2 FeetUp

FeetUp is a playful accessory embedded in a pair of shoes that provides visual feedback whenever the user jumps, or is off the ground (See Figure 10). *FeetUp* stimulates children to play against gravity, one of their most frequent activities related to free-play.

Object Design

For the object design we considered the use of an existing object children usually wear when they are outside. We embedded visual feedback directly into children's shoes in order to associate the jump activities with the part of the body mainly involved in the activity.

Figure 10: FeetUp Prototype

Interaction rules

The interaction system reacts to a simple factor; children jumping. The shoes give feedback when children are jumping; they blink when both feet are not touching any surface.

Setup

The hardware includes 2 pressure sensors, 2 microcontrollers, 2 emitter and receiver radios and 2 LED arrays. The pressure sensor is placed under the sock inside each shoe, and detects how much pressure is being applied in the heel. The sensor detects when each foot had been lifted from the floor. One microcontroller, attached to the each sock around the ankle, reads sensor data, validates sensor values and sends a radio frequency signal to the same device on the other foot. When both microcontrollers confirm that the two pressure sensors have been lifted, they activate an LEDs mounted on the shoe surface.

F. Evaluation

9 kids tested each accessory in groups of 3 to 5 children at after-school activities center. Each group experienced each accessory for 30 minutes under the monitoring and companionship of at least 3 observers and educators. Structured observations (Markopoulos, 2008), guided the understanding on how objects stimulated free play and which kind of activities the objects promoted.

Results

Children spontaneously explored the accessories trying to discover how they worked. During the discovery process they collaborated with each other describing and sharing their discoveries with their peers.

In particular, when playing with the *Statue* accessory, children spontaneously propose several games to play using the accessory feedback. They proposed playing around 10 different folk games, such as "hide and seek" or "frozen tag".

Figure 11: Slow Race Game with Statue

During the sessions they played few of those games (See Figure 11), and the audiovisual feedback from the accessory gave them information to argue when somebody where doing good or bad, and made popular games more interesting, adding a new level of difficulty.

On the contrary to the statue session, when playing with *FeetUp*, the exploration process took longer. All of participants were involved in discovering how they worked, and came up with hypothesis and arguments to discuss about it.

After agree about how it works, children enjoyed looking at the lights and moving around, each child explored the accessory in their own way: one played classic ballet, other danced capoeira, while others did handstands and brake dance.

It was difficult to involve all children in one single game during the evaluation session; however, some of them got interested in the explorations of other children and had valuable social interactions with them. While someone were trying to explain how to make handstands, for example, the one who were tying to learn about, try to ask the right questions to improve his/her handstands.

Children played open-ended activities while being physically active all the time using both accessories. They used their own creativity and imagination to find ways to include the accessories in their games.

G. Conclusion and future work

We have presented the design process to create a General Design Concept to propose objects to encourage free play. We have presented two prototyped objects that emerged from this design concept.

We evaluated the resulting accessories in order to understand how they encourage free play. Both designs stimulated spontaneously open ended, collaborative and physical activities.

Although, discovery, communication and physical challenges were widely experienced during the *FeetUp* sessions than during the *Statue* sessions; playfulness was more obvious on it.

Future objects should encourage the playability of *Statue* and the challenges of *FeetUp*. In order to approach it, future work will include continue ethnographic phase looking for other core activities of folk games, to involve in the concept of future playful accessories. Also will include evaluate the actual General Design Concept with new insights emerged from the evaluation session, to involve it in the design of future accessories.

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2.2 On the evocative power and play value of a wearable movement-to-sound interaction accessory in the free-play of schoolchildren

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Abstract

This paper discusses the evocative power and play value of the Wearable Sounds Kit (WSK), a movement-to-sound interaction accessory. Whilst movement-to-sound interaction is attracting growing research attention in HCI, very little of it has been conducted in the context of free-play with children. This paper presents a participatory design study of the WSK with 20 school-aged children (7-12 years old) in a free-play scenario, and an evaluation of the WSK in a playground at Ars Electronica Festival with over 70 school-aged children. The evaluation addressed three research questions: can school-aged children incorporate the WSK into their free-play? What free-play patterns are encouraged by the WSK? Which design features of the WSK influence the free-play experience? By conducting qualitative and quantitative data gathering methods and analyses, which include first-hand observations and video-coding, this paper shows that school-aged children can effectively incorporate the WSK into their free-play, and that thea accessory encourages different types of free-play. The results also show differences in the free-play mediated by the accessory depending on the age group and sex of the player, and these

differences reinforce the play value of the WSK. Some implications for designing technologically-oriented playful toys are also discussed.

Keywords:

Free-play, movement-to-sound interaction, participatory design, evocative power, play value

A. Introduction

Free-play is unstructured and spontaneous play driven by children [9,10,66], whose creativity and imagination enables them to incorporate everyday objects, such as sticks or bags, into their free-play, and to define the meanings that these evocative objects have in their play [35]. Research in developmental psychology has shown that free-play is of great benefit to the cognitive, emotional, social and motor development of children [4,37,60]. However, most of today's children have problems fitting this type of play into their everyday activities, due to the proliferation of screen-based entertainment, an ever-growing number of extracurricular activities, as well as competition from structured games and entertainment [21,23,55,64]. Previous HCI studies have indicated that designing interactive objects that open up new opportunities for free-play is a worthwhile exercise [24,25,59]. In this paper, the evocative power and play value of the Wearable Sounds Kit (WSK) is discussed. WSK is a movement-to-sound interaction playful accessory (See Figure 12).

Figure 12: Girls playing with WSK

A.1 Design Rationale

This paper focuses on wearable movement-to-sound, because wearable accessories augmented with sensors and actuators technologies can potentially encourage motor play, which is a key element of free-play, and "provide the player with immediate feedback and thus enhance their personal experience to a personal level" [43, p. 384].

According to Cross [11], music, regarded as the production and perception of sound, is necessary and key to human development, which involves sound, movement and meaning. Furthermore, singing and clapping gameshave been popular amongst children since the Middle Ages [40]. Thus, a wearable movement-to-sound interactive device can (and should) support and enhance free-play. However, and whereas wearable and movement-to-sound technologies are receiving growing research attention in HCI, very little of it has hitherto addressed free-play. This paper aims to fill this gap with the WSK and the lessons learned from both its participatory design and evaluating the play value and evocative power of the accessory.

A.2 Participatory Design Process of the WSK

The central tenet of Participatory Design (PD) is to involve end-users and their ideas in the design process [51]. Additionally, the PD study reported in this paper provided 20 children (aged 8-10) with an early version of the WSK, which they used during a summer school to augment the characters of a play they defined and performed at the end of the summer school. Several key design decisions to improve the WSK were made during this process, for example, selecting a bend sensor as the input of the system and creating a set of 30 sounds, including sounds of everyday objects and musical instruments. These decisions were made based on how the children used the WSK. As discussed in *Section C,* this PD approach, focusing on introducing PD into everyday activities, enabled the children to explore their ideas through a physical accessory. These real-life experiences might be difficult to elicit through the use of more abstract techniques, such as sketching or storytelling [38,39,62].

A.3 Evaluating the Play Value and Evocative Power of the WSK

The evocative power and the play value of the second version of the WSK, which incorporated the results of the PD study, were evaluated in a playroom at Arts Electronica Festival 2012. 278 participants, aged 3-75+, took part in the evaluation. Evocative power refers to the power of an object to sparkle playful ideas, while the play value refers to the likeness that target users will play with a toy according to the length of play and the variety of it [29]. Overall, the results show that school-aged children (7-12 years old) and teenagers (13-17) spent significantly more time playing with the WSK than did pre-school children (3-6), young adults (18-29) and adults (30+). School-aged children also found more creative uses of the accessory and were more involved in free-play activities.

By analyzing a random subset of videos of the school-aged children with the WSK, the paper discusses in detail the different types of play encouraged by the WSK and the effect that the type of sound and the part of the body in which the WSK was worn had on free-play. As discussed in *Section E*, the results show that the WSK encouraged dramatic, rhythmic motor and social play. The results indicate that the accessory is suitable for both individual and group play. The findings also stress the relevance of sounds made by everyday objects, which were more often used than the sounds of musical instruments, and of providing school-aged children with a personal device with several choices as to where to wear it or which sounds it makes, in order to encourage them to explore the WSK and to create personal experiences with it. These results challenge the idea that shared objects are required to encourage free-play [3], and put forward that dramatic body movements with which children communicate their ideas are key to encourage their free-play, as well as others more widely accepted aspects, i.e. sense of control and natural movements [5].

The remainder of the paper is organized as follows. *Section B* reviews previous studies of free-play, movement to sound interaction and wearable technologies. *Section C* presents the design process and the design features of the WSK. *Section D* describes the evaluation of the evocative power and play value of the WSK. *Section E* presents the results of this evaluation. *Section F* draws some implications for designing movement-to-sound interactive technologies to encourage free-play. *Section G* discusses the results, methodological approach and contributions. The main conclusions and future work perspectives are presented in *Section H*.

B. Related Work

B.1 Free-Play

By drawing on the physical rules of objects, children spontaneously attach their own play meanings to everyday objects. They do this according to their play interests, developmental stage and motor skills, and this is widely regarded as free-play.

Several play patterns relevant in the development of children are associated with free-play. Motor play contributes to the development of fine and gross motor skills, coordination, strength and agility, among others [18]. Social free-play helps children develop social skills and their own personality [37]. Dramatic play - and its related terms, such as pretend play, imaginary play, or fantasy play - is key to cognitive development and communication, helping children understand how society works [55,65]. This paper explores which of these play patterns associated with free-play are elicited (and how) by the WSK.

Sensory motor play, social free-play and fantasy play appear throughout early childhood and much of the literature on free-play focuses on pre-school children [23,30,53,56]. However, free-play happens throughout the whole childhood, since motor, social and cognitive skills, amongst others, are in continuous development [4]. Moreover, the interest of children in these different patterns of free-play is influenced by sex preferences [55,56]. Therefore, the play value of specific objects increases, provided that objects are suitable for different play interests [29]. This study explores how age and sex impacts on the play value of a movement to sound accessory.

B.2 Free-Play and Digital Technologies: Augmented Everyday Objects and Playgrounds

With the advent of microcontrollers, there has been a growing interest in using interactive technologies for creating new playful experiences. For example, the Center for Playware at Technical University of Denmark has focused on developing platforms for producing diverse play and playful experiences, which combine constructive and sensor/motor play. They developed I-blocks, Fable, and Modular Robotic Tiles. I-Blocks use interactive building blocks, whose behaviour can be manipulated by changing spatial and kinesthetic conditions [34]. Fable is a modular system to encourage children to develop robots [42]. Modular Robotic Tiles is a flexible system designed to engage users in physical activities [33].

In addition to these developments, digitally augmented everyday objects and playgrounds have been designed to support free-play. RoboMusic uses I-Blocks to allow people to experiment with music. Each block is associated with a selection of musical loops, which can be manipulated by rotating, attaching and detaching cubes to and from each other [14]. ColorFlare is an augmented tube designed for children aged 8-12 with the aim of supporting open-ended play [24]. Mansor uses a table-top environment to foster fantasy play among pre-school children [35]. Tagaboo is a wearable system that uses RFID technology to enhance common open-ended games, such as tag, hide and seek or memory [28]. Other prototypes are The Seed and Pod [16], Jogo [10] and Morel [25].

Augmented playgrounds have also been studied. Sturm et al. analysed how playground experiences can be enhanced with sensors and actuators [59]. Ferris and Bannon [17] designed an augmented play environment to explore innovative ways to stimulate discovery, play and adventure among children. Breathless represents an unusual evolution of swings to inspire the design of future playful systems [13], while Aerial Tunes is a "collaborative, tangible interface, based on balls hovering in mid-air, which can be manipulated (…) to explore and experiment with an ambient soundscape" [1, p. 1].

Surprisingly, few user studies exist to investigate the potential for augmented everyday wearable accessories to encourage free-play as previous research conducted by the authors has shown [48, 49]. Exceptions include *Statue*, a belt pack augmented with an accelerometer, lights and a piezo speaker that reacts to children's movements. The pack encourages children to play games in which they pretend to be a statue, such as Blind Man's Buff [49]. *FeetUp* is a game involving the use of shoes augmented with a pressure sensor, lights and a piezo speaker. These shoes blink and emit sounds when the player jumps. This combination of visual and sound stimuli motivated children to challenge their abilities to jump [48]. These studies demonstrated the value of sound in free-play, and the interest that children have in assigning different meanings to different sounds. Despite the fact that the piezo speaker emitted very simple sounds, the children associated these sounds with robots, aliens or machines, and pretended to imitate them in their free-play, for example, moving like a robot. These studies paved the way for this paper, the aim of which is to understand the play value and evocative power in free-play of movement-to-sound interaction. In the next section, previous and related research within this domain is reviewed.

B.3 Movement-to-Sound Interaction

Towards Enhancing the Expressive Possibilities of Musicians and Dancers

There is a growing body of research exploring the expressive possibilities that form the intersection between dance, theatre and digital technologies to augment the expressive possibilities of professional performers [15,22]. Language games [69] represent a series of performances in which a professional dancer uses a puppeteer motion-capture suit to create music while moving on the stage. The system includes 16 sensors, video cameras and real instruments played by the signals received from the system. Dance Space is one such example, whereby a computer vision system tracks body movements and gestures, displaying sound and graphics accordingly [58]. In addition to computer vision, Gonzalez and Carrol incorporate accelerometers, gyroscopes and microphones, which dancers wear to augment their performances [22]. In the theatre, actors use interactive digital media to augment their performances, being "able to respond to movement and gesture in believable, esthetical, and expressive manners" [58, p. 479].

Most of these studies adopt computer vision systems and confine user interactions to specific areas of the stage. These systems also tend to provide end-users with visual feedback, which, despite being relevant for enhancing the performance of dancers and musicians, can potentially reduce freedom of movement and face-to-face interaction in free-play. Wearable movement-to-sound technologies, especially those related to music, might be more suitable for free-play.

Wearable Musical Technologies and Manipulating Sounds in Free-Play

As stated in the seminal study conducted by Opie and Opie [40], children usually involve songs and sound effects in their play. Consequently, wearable musical interfaces have attracted significant research attention. Two recent examples include TouchSound, a wearable device that generates sounds and music by touching everyday objects [45], and Ubiquitous Drums, a tangible, wearable musical instrument built directly into clothing [57]. However, and perhaps surprisingly, very little is still known about how children (can) integrate wearable musical technologies into their free-play, and the play value of doing so. The Wearable Sounds Kit, which is described in the following section, represents a step towards this goal.

C. The Wearable Sounds Kit

A PD study was conducted in a real-life scenario to inform the design of a wearable sounds prototype that school-aged children could actually incorporate in their free-play. *Section c.1* presents the PD study and *c.2* the technical and design aspects of a second version of the WSK.

C.1 PD Study for Informing the Design of the WSK

The aim of the study was to inform the design process of the WSK by building on everyday experiences. To this end, a PD approach was adopted, as involving consumers (users) in the design process is key to create technologies they can effectively use [51], especially at intermediate stages of the design process [63], when the concept of the technology has been defined (e.g. the WSK) but numerous design decisions are still to be made [52].

A noteworthy challenge of PD is "to develop empathetic understanding of another's experience" [31, p. 108], as gaining this understanding rests on participants being deeply involved in the design, and motivated to contribute to and draw on their expertise to participate in design sessions. This study was conducted in a real-life scenario of free-play, wherein children could participate based on their own motivation to personalize the WSK.

Context and Scenario of Free-Play

The PD study was conducted within a summer school, as part of the activities that a group of 20 children, aged eight to ten, normally undertook. Teachers at the school proposed the children to create and rehearse a play on their own. In other words, the children themselves were asked to define the structure of the play, the storyline, and the characters, and they were free to participate in it or not. This presented us with an interesting scenario of free-play for our purposes, since it was both part of the everyday activities of a group of children and rather unstructured and spontaneous, which are the key elements of free-play (See *Section A*). Thus, those children who were interested in participating in the activity, were invited to figure out how they could involve a wearable sound effect into their characters and construct their own wearable sounds accessory. To do so, the children were provided with an early version of the WSK, discussed in the next section. They were informed about the fact that this activity was related to research project, and agreed to participate in it.

Materials

The WSK included four different types of sensors, a LiPo battery, a microcontroller, and a conductive fabric to connect the different parts of the system. The sensors included a bend sensor, an accelerometer, a force sensitive resistor and a piezo vibration, which could be attached to any surface by using double-sided tape. The microcontroller was programmed to detect the sensor's values and to send a signal to an external computer, which the children could use to explore a MIDI library level two - a digital library of 256 sounds of musical objects [68] - to select the sound to play when they interacted with the sensor. Most of the sounds in the MIDI library were related to musical instruments.

Participatory Design Sessions

Six, two-hour sessions were conducted. In the first session, the teacher and the researchers involved in this study presented the general idea of the creation of the play and the WSK. In the second and third sessions, the children defined the characters and experimented with the WSK in groups of three in turns. Every child interacted with one prototype (See Figure 13) . Two researchers spoke with the children and observed them while they were exploring the WSK.

Figure 13: Character during a rehearsal

During the fourth and fifth session, eight children, who had already defined their characters and were interested in using the sounds effects, personalized the sound effect system according to their interests and used it during the rehearsal. They worked with the researchers to adjust the accessory or improve the design, depending on their needs and interests. The last session was the final rehearsal and presentation of the play.

The last three sessions combined telling, enacting and making activities [6]. In the telling activities, children were asked to explain how their character would use the prototype. In the enacting activities, children were allowed to use their prototypes through their chosen characters. In the making activities, they personalized the WSK by either adopting the kit's existing functionality or working with the researchers to adapt the prototype according to their interests. This combination of telling, making and enacting provide the basis for forming a temporary community in which the new can be envisioned [6].

Results and Design Decisions

Eight of the most motivated children (out of 20) were involved in the study. This allowed us to get a preliminary understanding of how children of their age could use the WSK in their free-play, and the design of the accessory was changed accordingly, as described in Table 1, and summarized next.

Table 1: Design Choices WSK

Key finding	Design choices WSK
Children used the bend sensor more than any of the others.	Final prototype has a bend sensor.
Children used the sensor in different parts of their body.	A set of bend sensors with a mixed variety of shapes was created. These sensors can be worn on the waist, wrist, elbow, knee, or attached to any part of the body
Sounds of everyday objects seemed to evoke more playful interest than sounds of musical instruments.	A list of sounds with those used by the children was created. This consisted of 18 sounds of objects and 12 of musical instruments.

Based on their preferences, it was decided to focus on the bend sensor and select 30 sounds, which included sounds of everyday objects and musical instruments. Articulation movements were identified as the most relevant for our study, since these movements encouraged numerous playful and dramatic situations. Design decisions related to robustness and ergonomics were also made based on the results of this PD study, such as the use of conductive elastics and the different sizes of the accessory. The version of the WSK used in the evaluation is presented in the following section.

C.2 Description of the Wearable Sounds Kit: Design, Hardware and Software Aspects

Drawing on the results of the PD study, a new version of the WSK was developed. The aim of this version was to provide children with a simple interactive system, combining body movements with sounds and allowing for two options of personalization: the position of the sensor, and the selection of the sound. There is no perceivable major delay between the movement and the sound emitted, although the sound and movement can have different durations. Other possibilities, such as letting children build their own accessory, program the interaction or record their own sounds, were not contemplated, as the focus was on the analysis of the playful experiences of movement to sound interaction, and not on the benefits of the constructing playful sound interactions, which has already been explored by Trappe [61].

The hardware of the WSK includes two bracelets. One bracelet is augmented with a bend sensor and can be worn on the arms and legs. The second bracelet includes a LiPo battery and a Jeenode, which is a microcontroller with a built-in radio transceiver. The two bracelets are connected using conductive elastics and Velcro (See Figure 14).

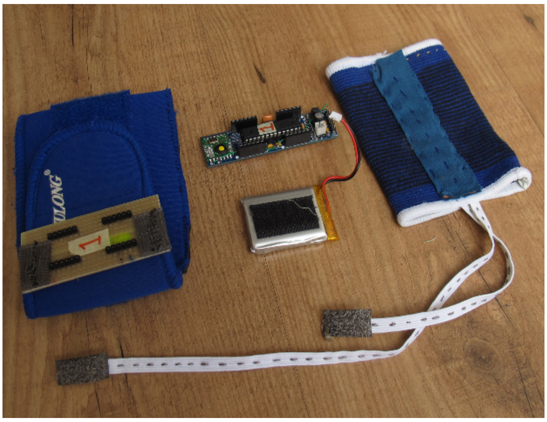

Figure 14: WSK Hardware

The software of the WSK consists of two Jeenode patches. The first patch transmits the strength of user's movements, and his/her ID, via radio frequency, while the remaining patch is used as a receiver, which is connected to a computer through an FTDI cable. This Jeenode receives messages from up to four users all wearing the device at the same time, and sends the data it gets from each user to the serial port of the computer. In addition to the Jeenode patches, a Pure Data patch reads the signal from the serial port and provides the user interface to allow end-users to select the sound to reproduce. It also maps the signal from the bend sensor onto one MIDI note, and sends the collected data to a number of instances of a General MIDI synthesizer. The synthesizers' outputs are reproduced through a multichannel audio interface, which distributes the sound to four different speakers. This allows every user to identify his/her corresponding sound source with the spatial reference of his speaker position. The WSK can be worn on any part of the arms and legs. Whenever the person wearing the WSK moves, the accessory makes a sound, which is played through an external speaker available in the playroom. The pitch of the note of the sound changes depending on the strength of the movement.

D. The Full-Scale Evaluation

The research questions addressed in the evaluation are defined in *Section D.1*. The context in which the study was conducted is described in *Section D.2*. The profile and number of the participants are both outlined in *Section D.3,* and the data gathering and analysis methods are detailed in *Section D.4*.

D.1 Main Objective and Three Research Questions

As stated in the introduction to this paper, the main aim of our study was to evaluate the evocative power and play value of the WSK. Thus, the first and probably, most important research question to address is whether school-aged children can effectively incorporate the WSK into their free-play. Play value is defined as "the likeliness that a toy will be played with by the user" [29, p1]. The amount, variety and length of play are key dimensions of play value in the answer of this question [29].

A second research question, which was considered worth addressing from the point of view of free-play, related to the variety of play: How do children play with the WSK? Here, the objective was to identify what (if any) free-play patterns are encouraged by the WSK, and if these patterns vary according to age and sex. Categorizing play experiences aids in "understanding the different play affordances perceived by different users" [29], and exploring age and sex should therefore help us deepen the discussion on designing for free-play. For instance, as stated in *Section B.1*, free-play is mostly related to pre-school children and fantasy play [4,35], and boys have been found to be more likely to engage in physical play than girls [55,56]. Thus, understanding whether other age groups engage in free-play with the WSK and if their patterns of play are related to fantasy, motor, social and rhythmic play would considerably contribute to current understanding of designing for free-play experiences.

A third (key) question, taken from a more technological and design oriented perspective, looks at which features of the WSK, such as the type of sound or the position of the sensor, influence the movement-to-sound play experience. This information should (and could) aid in understanding how movement-to-sound technologically-enabled toys can be designed, which, in light of emerging interaction paradigms (such as wearable computing), might enable children to wear playful accessories augmented with digital technologies in the near future.

D.2 Overall Context and Free-Play Environment

To address these questions, it was necessary to conduct the evaluation in a more extensive free-play environment than in the previous PD study, as a larger number of children were needed to discuss the evocative power and play value of the WSK. Consequently, the evaluation was conducted in one of the 14 playrooms at Ars Electronica Festival 2012, which had a special section for children (3-17).

The playrooms were containers (6x5 meters) located in a public park along the River Danube. No payment was required to take part in the activities organized in the playrooms. One of the playrooms was set up specifically for the Wearable Sounds project, offering visitors the possibility to interact with the WSK. The playroom was equipped with the essential furniture and the digital technology to interact with the WSK (See Figure 15).

Figure 15: Setup

This playroom can be considered a (social) free-play environment. Children (and other visitors) were free to enter or leave the room at any time, there were no specific goals to achieve, play was driven by the participants, and constrained by the limits of the interactive object and the playroom. Visitors could only use the WSK within the playroom, and were asked to return it before leaving. Four kits at most could be used at any one time. The playroom remained open for seven hours a day during the entire five-day festival. Participants were informed about the research project and agreed to participate in it.

D.3 Participants

Although the WSK was designed with children aged between eight and ten, play "happens only when a player desires to play" [8, p.6]. Thus, all visitors who were interested in trying out the WSK were encouraged to take part. If all the WSKs were being used, new participants were asked to wait until one or more players voluntarily left the room. Participants could involve their natural social play partners in their free-play. They could also play alone, with their relatives, bring their own friends or interact with other people playing at the same they had not met before.

This flexibility, as discussed further in the results, provided us with an opportunity to investigate the appropriate age target of the WSK. Overall, 278 participants, including pre-school children, school-aged children, teenagers, young adults and adults used the WSK. The distribution of participants by age is depicted in Figure 16.

D.4 Data Gathering and Analysis

D.4.1 In-Situ Observations and Conversations

Two fixed video cameras located in the playground recorded 35 hours worth of the activities conducted in the room. The WSK software recorded sound choices and sensors activity.

A monitor from Ars Electronica hosted the visitors and guided them through the activity. Three direct observers – all researchers – were present for the activities, and at least two researchers were present in each session. One direct observer provided technical support to the monitor. S/he attempted not to interfere in the spontaneous activities of the visitors and took paper-based notes of their sex, age, arrival and departure time, and the ID of the WSK used. The direct observer conducted informal interviews with the children and/or their relatives, in which s/he asked them about their game experiences and how their

WSK activities were related to their everyday lives. These interviews were conducted when the participants were about to leave the playground. The second observer did not interact with participants and focused on taking notes of their activities.

The direct observers and the monitor discussed among themselves their impressions of what was going on at different moments of the day (e.g. while waiting for more participants to come along, solving technical issues and having lunch), and these comments were also written down in their notes. At the end of the day, the observers analysed their notes by discussing the data they had gathered and drew conclusions on their first-hand observations and conversations.

D.4.2 Video Coding and Analysis

Observations suggested that four minutes was the average time that school-aged children needed to put the accessory on and understand how it worked. Thus, only the observations of those children who played with the WSK for more than four minutes (68 out of 78) were taken into account for further analysis.

A random sample of 30 of these children was selected for the analysis. Six participants used the WSK alone while the rest did so in company of others, who could be part of the selected sample or not. For the statistical analysis, play experiences were considered independent. This methodological issue is discussed further in *Section G*.

The first author edited a three-minute video of each child in the sample. This edited summary, which excluded the first four minutes of exploration, was produced to make video analysis more manageable. The videos were representative of the complete sequence of activities of each child and included all the different activities they performed, in lengths proportional to the actual length of the activity.

Ten video observers, who were not previously involved in the research, coded the edited summaries of the videos. Two different observers coded each video to identify whether the children created any (free)-play meaning - beyond its mere exploration - and characterized their play patterns.

It is important to note that, when analyzing video material, evaluator effect, in which different evaluators might associate activities with different topics depending on their perspective, should be minimized

[26]. Two methodological elements are relevant to mitigate this effect: the observations must be structured, and the inter-observer reliability must be checked [2].

An adapted version of the Play Observations Scale designed by Rubin [50] was used so that the analysis of the observations was structured. This scale is based on "two long-standing play hierarchies, one social (Parten), the other, cognitive (Piaget)" [50, p. 2]. The scale has proven useful in determining (among others) individual differences in play patterns as well as age and sex differences in children's play [50]. While the scale is related to pre-school children [44, 46], the scale can also be used to analyse school-aged children's play [50].

The scale was adapted to focus the analysis on the play aspects of the WSK. Categories that were not applicable, such as playing predefined games or constructing games, were excluded. The adapted play observation scale was tested among the video observers in two pilot studies, before defining the final observation scale. In these studies, the video observers were asked to use the scale over two videos to analyse whether the categories were intelligible.

To code the videos, the observers were asked to follow the play experiences of a specific child (among all the participants in the video). Observers described all the activities the child performed in intervals of ten seconds (e.g. 0-9, 10-19…) and associated their descriptions with one category of the play patterns scale and one of the social one. If more than one category in each list was observed during the intervals, they selected the category that was considered the most complex.

The categories, and their relationship with Rubin's Scales, are described in Table 2. Categories zero to three are not free-play activities, while thecategories four to six describe free-play ones, since they address specific creative uses the children could find for the accessory.

Table 2: Observation Categories

WSK Analysis		**WSK Coding Categories**	**Coding Scales**	**Rubin's Categories**
Patterns not directly related with Free-play	0	Not WSK interaction	Play patterns Scale	Non play behaviour
	1	Computer interaction		Exploration
	2	Exploring the hardware		
	3	Minimal effort		
Patterns related with Free-play	4	Motor Play		Functional play
	5	Rhythmic Play		
	6	Dramatic play		Dramatic Play
No social play	A	Individual Play	Social Scale	Solitary Play
Social Play	B	Social Play		Parallel Play
				Group Play

Inter-observer reliability of the coding scales was tested using Cohen-kappa coefficients. It was calculated amongst all the observations of the 10 video observers. The play pattern scale obtained a 76.6% agreement, which is usually regarded as a good agreement (Fair 40-60%, Good 60-75%, Excellent Above 75%) [47]. The social scale obtained a fair 48.8% agreement and therefore quantitative data was excluded from further analysis.

E. Findings

This section addresses our findings against each of the three research questions described in *Section D.1*.

E.1 Can School-Aged Children Effectively Incorporate the WSK Into their Free-Play?

In the following section, we describe (in both quantitative and qualitative terms) differences in the amount of time spent with the WSK and the activities associated with creative uses of the accessory by school-aged children and the other participants who participated in the study are discussed in quantitative and qualitative terms next.

E.1.1 Playtime

The participants who used the WSK in the playground (278) were grouped into pre-school children (age 3-6), school-aged children (age 7-12), teenagers (age 13-17), young adults (18-29) and adults (+30) (See Figure 16).

A Kruskal-Wallis test, comparing time spent by participants amongst different age-groups, indicates that there is a significant difference in the median time of play, x2(4, N =278) = 63.479, p = .000. Post-hoc analysis, using the Mann-Whitney test, with the level of significance established at 0.05/4 =0.0125, indicated that the amount of time spent by school-aged children (Mdn=7), who were one of the largest groups in the sample was significantly larger than the time spent by adults (Mdn=4), U= 1504.50, z=6.87, young adults (Mdn=4), U= 1119.00, z=6.04, and pre-school children (Mdn=4.5), U=340.50, z=3.41 (See Figure 17).

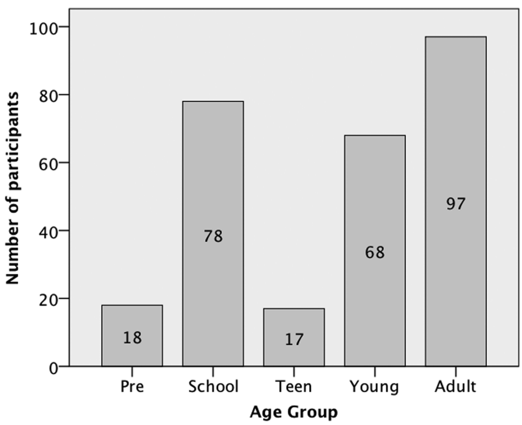

Figure 16: Number of participants by age group (N=278) Pre-school (age 3-6), school (age 7-12), teen (age 13-17), young (18-29) adults (+30).

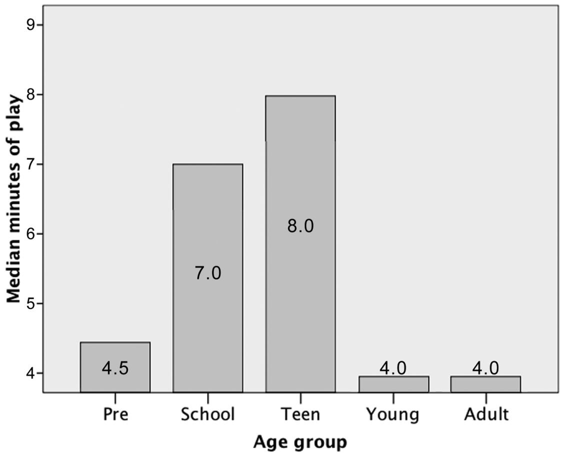

Figure 17: Median time of play by age group

Thus, school-aged children were more willing to incorporate the WSK into their free-play, and did so for a significantly longer period of time, than those from the other age groups.

Although free-play is common amongst pre-school children (3-6), the observations indicated that, while they were initially motivated by the effect of making different sounds while moving, in typical motor play, they did not care which of the sounds was emitted. We found they just enjoyed creating the noise. After a couple of minutes, they were completely distracted by the sounds and constantly moved randomly. The accessory was too big for very young children (3-4) and the WSK did not react properly to their movements. Furthermore, the sounds were not familiar to them, and they were not able to read the list of sounds displayed on the computer. The study did not allow us to fully ascertain the potential of the WSK in their free-play, and this issue deserves further exploration.

With respect to teenagers, whilst post-hoc tests did not reveal a significant difference in the amount of time spent between teenagers (Mdn=8) and schoolchildren (Mdn=7), $U = 654.00$, $z = 0.09$, a small number of teens (17 teenagers vs. 78 school-aged children) participated in the study. However, they conducted free-play activities with the WSK, including group games, rhythmic games and dramatic play. Yet, the small sample was not enough to either reach significance or understand in some detail the potential or limitations of the accessory for them.

Young adults (18-30) tried to understand how the WSK worked and were also interested in taking pictures of it. The direct observers agreed that none of these adults were likely to use the WSK for a reasonable long period of time, as they found less playful uses of the WSK than did school-aged children or teenagers.

Adults (30+) were the largest group in the sample. Yet, they rarely engaged in free-play with the WSK. The direct observations indicated that those adults who played longer and more creatively were those who visited the playground with their children. Other adults interested in the WSK reported being musicians. Most single adults or groups of adults were mainly interested in understanding how the accessory worked.

E.1.2 Quantifying the Free-Play Experiences

According to the ten video observers (See *section D.4.2*), the WSK encouraged free-play among 66% of the sample involved in the video analysis, while 33% were not engaged in free-play (See video: https://www.youtube.com/watch?v=LBBe8iDeFrs). With respect to those school-aged children who did engage in free-play, between 20 and 90% of their activity was associated with creative use (See Table 3). Otherwise, more than 80% of the activities conducted by the school-aged children who did not engage in free-play consisted of exploring the accessory, changing sounds in the computer, testing new sounds, or performing minimal movements to get the sound. These differences in the evocative power of the WSK amongst the school-aged children seem to be related to the idea that children's play interests are strongly related to personality traits [18,24].

Table 3: Percentage of free-play activities by participants

Free-Play	**Total children**	**Girls**	**Boys**
0 *	1	1	-
1-20% *	9	6	3
21-40%	5	4	1
41-60%	9	2	7
61-80%	4	-	4
>81%	2	-	2

*Not considered as a free-play experience

E.2 What Free-Play Patterns are Encouraged by the WSK?

The video observers coded the presence or absence of free-play (creation of play meaning) and the type associated with it, i.e. motor, rhythmic, dramatic or social play (See *section D.4.2* for more details) amongst 30 school-aged children. Results were analyzed depending on age and sex variables.

E.2.1 Motor Play

Most of the activities associated with free-play (52%) were described by the video observers as motor play (See Table 4). The children made different and numerous natural body movements to explore the sounds available, such as jumping, sliding on the floor, moving their arms as fast as they could, touching all the surfaces in the playroom with the sensor or doing somersaults (See **Figure 18**). These movements did not seem to have any specific meaning for them beyond the fun of moving.

Figure 18: Motor play of one child

The predominance of motor play among active school-aged children in the sample (85%) (See Table 5) seem to be consistent with the fact that repetitive body movements are common at this developmental stage, helping them to develop physical skills [41].

Table 4: Percentage of each play pattern amongst all free-play patterns

Play Patterns	**%**
Motor Play	52%
Rhythmic Play	17%
Dramatic Play	47%

Table 5: Percentage of active schoo-aged children involved in each play pattern

Play Patterns	**%**
Motor Play	85%
Rhythmic Play	30%
Dramatic Play	65%

E.2.2 Rhythmic Play

Dance movements, and the performance of rhythmic movements, were clearly observed in 30% of the active school-aged children of the sample (See Table 5). However, all rhythmic players were aged 10-12. This might be due to the fact that, according to the observers, rhythmic play requires precise movements, which players aged seven to nine find difficult to make. This could indicate that the accessory provides different play opportunities depending on the age of the children.

Links between participants' own personal interests and opportunities for the WSK were also discovered in informal interviews with parents and children. For instance, the parents of a WSK dancer reported that he had been recently taking dancing classes and was highly interested in dance.

Rhythmic play was associated with social play, players performing for others, or imitating and synchronizing movements with other WSK players – this aspect is discussed further in *Section E.2.4*.

E.2.3 Dramatic Play

65% of the active school-aged children in the sample were engaged in dramatic play (See Table 5). The systematic reports of the video observers associated dramatic play with different activities in which the meaning of the sound was related to a physical movement, such as: "a kid playing drums", "playing with a sword", "making defense and attack movements", "pretending to be a bird", "playing with a gun" and "driving a car" (See Figure 19).

Figure 19: Boy pretending to play a guitar with a guitar sound and the sensor in the elbow.

Both boys and girls tended to create narratives by combining, for example, the sound of a gunshot and a phone with a tweet in an improvised short story, going beyond the obvious meaning of sounds and providing re-interpretations, e.g. playing the sound named 'orchestra' while pretending to be a clown.

Indeed, the relevance of pretend play can be seen in the sounds that school-aged children chose. Sounds corresponding to everyday objects were more used than those of musical instruments. This aspect is discussed further in 7.3.2. Sounds of cars, phones, animals and guns were the most commonly chosen by school-aged children to use during fantasy play in order to create imaginary situations.

Dramatic play often involved social play while playing with the WSK. For instance, participants often tried to involve others in the pretend action, e.g. "she moves both hands like waves and invites her friend to do the same", or to share their experiences with others – relatives, observers and other people around – by showing what they have been doing.

E.2.4 Social Play

Although the WSK is an individual accessory, social play was fostered. This can be seen from the following representative extracts of the video observers: "He moves while dancing towards his mother", "they are imitating the movements other children make", "She is throwing her fist, imitating the movement of her friend", and "a girl is dancing and her friend imitates her" (See Figure 12).

All video observers pointed out that school-aged children combined iteratively individual phases of object exploration with individual free-play experiences and social free-play experiences. This relates to Parten's description of social behaviours of children during free-play, whereby children move from solitary to parallel, associative, and group play [44].

Social play involved complex rule-based games, despite the fact that those provided by the WSK were reasonably simple. Noteworthy examples of these rule-based games were "guess what I'm doing" or clapping games, e.g. "the father with the sensor in his hand touches the head of the girl. She responded by tiptoeing towards her father to touch his head with her hand augmented with the sensor. Then, they changed the sounds a few times, creating a form of musical and rhythmic clapping play".

E.2.5 Age and Sex Analysis

Within the sample (N=30) Mann-Whitney test, indicated that the percentage of free-play by boys (Mdn=47.22), was significantly larger than the percentage of girls (Mdn=11.11), U=39.50, z=2.98, $p<.05$, r= -0.54, (See Table 3).

This could be related to our observed relevance of physical play in their free-play, and the reported fact that "boys do more of all these kinds of play (physical play) than girls" [56, p. 271]. However, video observers suggested that the girls spent more time on the exploration phase of creation of play meaning than on playing the games invented using the accessory. Thus, they experimented more with diverse sounds than actually playing with the WSK. However this exploration phase were not codified as free-play activity.

A Kruskal-Wallis test was conducted to evaluate if the percentage of free-play is different depending on the age of the children (7-12). It was found that the differences were not statistically significant x2(5, N =30) = 6.32, p = .276.

E.3 How do the Different Features of the WSK Influence the Movement-to-Sound Play Experience?

In 5.3.1, it is argued that the sounds of objects that schoolchildren are more familiar with resulted in more playful experiences. Additionally, there should be support for diverse types of sounds to cater for different play interests. In 5.3.2, different interactive experiences depending on the part of the body in which the WSK was worn are discussed.

E.3.1 Sounds of Familiar Objects are More Playful and Diversity Should be Supported

During the PD study, the sounds of objects were used more than the sounds of musical instruments. In order to understand this initial finding further, a log of all the interactions with the WSK in the playground was recorded, and the sound preferences of the sample of 30 school-aged children was analysed. A Wilcoxon test on the total number of times the available sounds were played (36.628) by the sample of school-aged children (30 participants), indicated that sounds of objects were more often used (Mdn=622) than those of musical instruments (Mdn=259), $z = -3.62$, $p < .005$. (Figure 20).

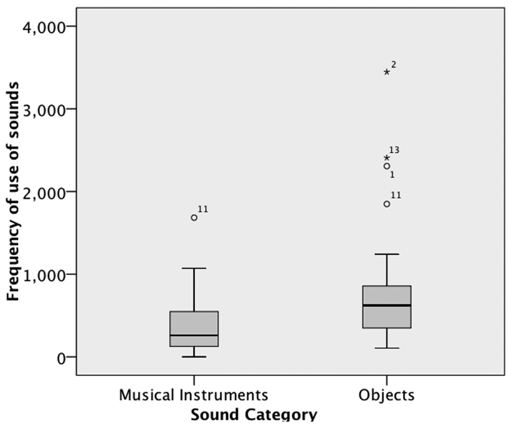

Figure 20: Frequency of use of musical or objects sounds.

As depicted in Figure 21, the sounds of objects (natural or industrial) were amongst the six most often used in the sample. These sounds corresponded to objects that school-aged children are likely to be familiar with, and therefore, can more easily incorporate into their fantasy or pretend play. However, some exceptions were noted. Marimba and train sounds, which were the least used (only 1%), were the favourite sounds of two female participants. Musical instruments (melodic or percussion), which were the least used in general, were the favourite sounds of seven participants (five girls, two boys).

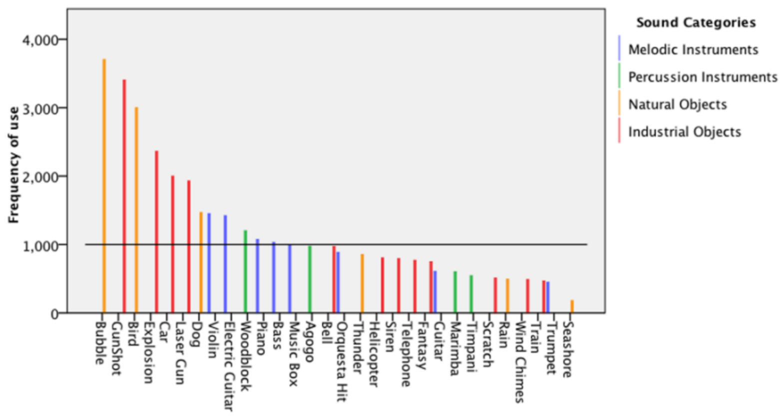

Figure 21: Frequency of use of each sound

Observations showed that most boys engaged significantly with gun play, while girls had more diverse interests, for instance, they were interested in birds, bubbles and phones, and tended to explore more play opportunities of diverse sounds than their male counterparts. This is consistent with the diverse play interests of school-aged girls and boys [18].

Overall, these results indicate that, beyond popular choices, providing school-aged children – at least, those in our sample - with the possibility of exploring different types of sounds allowed them to foster their imagination, and to find personal connections between each sound and the WSK.

E.3.2 Control, Easiness and Body Engagement

In keeping with the idea that body movement fosters engagement in digital games [5], both video and direct observers reported that a combination of natural, controllable, dramatic and very noticeable movements allowed for different types of free-play. Moreover, video observers pointed out the following different interactive experiences depending on the part of the body upon which the WSK was worn:

On the Feet

Wearing the sensor on the sole of each foot encouraged school-aged children to make natural movements, such as walking, jumping, running, crawling and doing summersaults. In such cases, the WSK was easy to use, but unfortunately not easy to control, as it made sounds every time participants took a step. Both direct and video observers reported that the school-aged children found themselves involved in motor play, which included diverse body challenges when using the sensor on their feet. However, wearing the WSK on the feet led to less dramatic possibilities than those school-aged children had when they wore the WSK on other parts of the body.

On the Knees

Wearing the sensor on the knees was similar to wearing it on the feet – it encouraged diverse body movements and mostly motor play. However, by wearing the WSK on their knees, school-aged children had more control, since they could walk by making slight movements, which the sensor did not detect. On the other hand, this position afforded less dramatic possibilities.

On the Hands

Both direct and video observations indicated that the sensor was very controllable when it was worn on the hand, as making a fist activates the sensor. However, the movement is not natural for many activities and did not provide either dramatic or motor opportunities. Yet, wearing the WSK in this part of the body is barely noticeable and this makes it suitable for hidden activities.

On the Elbows

The school-aged children could walk without making a sound while wearing WSK sensor on their elbows. Making a sound was achieved by bending their left or right arm, and this makes the WSK easy to use and control. Moreover, moving the elbows is a common body movement in numerous dramatic activities, such as driving, throwing and flying, and this provided school-aged children with far more playful opportunities than when they wore the sensor in other parts of the body.

F. Explorative and Dramatic Options: Some Implications for Design

This section elaborates on the design features of the WSK. Some implications for the design of future technologies to encourage free-play through movement to sound interaction can be drawn from the results.

Explorative Design and Ambiguity

Future designs of the WSK should ensure that there are opportunities for exploration, as this allows children to identify personal connections with the object, and enables an adequate context to elicit their imagination and exploration of what they can achieve. In this context, drawing on ambiguity as a resource of design [19] - for example using the ambiguity of sounds to sparkle imagination - opens the space for personal interpretations.

High Variability is Relevant

Designing for exceptions was key to support unusual play interests. Although some sounds were not widely used by the school-aged children, they were extensively used by individual users who found them evocative, such as a ten year-old boy who was highly interested in dancing to the sound of a violin. This is an example where the WSK should be sensitive to personal play interests.

Movement as a Resource of Play

A proper balance between sense of control and natural movements, described by Bianchi-Berthouze [5], and the support of dramatic gestures, is required to facilitate the emergence of free-play. When the WSK was used with the bend sensor embedded in an elbow bracelet, the direct observers indicated more free-play opportunities than when the WSK was worn on other parts of the body, due to the numerous dramatic opportunities offered through arm movements.

Individual Objects Can be Used to Encourage Social Experiences and Free-Play

Despite being an object aimed at individual players, the results have shown that the WSK does not isolate children from their social context. Rather, children spontaneously shared their experiences with others who can become directly involved or merely an audience for the child's performance. Examples of play included imitation, synchronization, performances and turn taking games. These different forms of social interaction and expression occur in a play environment where children's attention is detached from screens or controllers, and geared towards motor experiences. Thus, children can look at each other directly, and establish face-to-face social interaction. The individual aspect of the object enabled children to explore their imagination and personal interests. By being detached from screens and controllers, children could move freely and make personal connections with other people around them, thereby allowing them to naturally move through different levels of social interaction [44].

G. Discussion

Section G.1 discusses the impact of the settings (both for the PD and evaluation studies) on free-play. *Section G.2* discusses the results of the play value and evocative power of the WSK. Methodological aspects related both to the evaluation and design of the WSK are discussed in 7.3, while limitations of the studies are presented in *Section G.4*.

G.1 Scenarios of Free-Play

Free-play is strongly related to spontaneous exploration. Derrida defines free-play as "infinite substitutions in the closure of a finite ensemble" [12]. Moreover, "play unfolds under the auspices of a set of constrains that allow players freedom to experiment" [32, p. 2353]. The physical and interactive possibilities of the WSK provide a starting point required for free-play, as does the setting in which the WSK is used. The combination of these two factors – accessory and context – can provide the space required by children for open interpretation [54]. In both the PD and evaluation studies, activities were led by the children. In the PD study, the discussions and activities moved from abstract concepts to the specific design – with the support of researchers – of tangible and playful prototypes, enabling children to express and spontaneously explore their ideas based on their real play interests. In the evaluation study, play emerged through the motivation, interests and ideas of children. Thus, in both scenarios, the exploration was rather spontaneous and uncontrolled, representing the hallmark of free-play.

G.2 Play Value and Evocative Power of the WSK

When compared to previous and related works, one might wonder whether a device like the WSK can encourage free-play amongst school-aged children, since the focus of free-play, especially fantasy play, tends to involve pre-school children (e.g. [9,23,30,35,36,53,56]). Yet, the results of our research show that school-aged children – at least, those who participated in our study - can incorporate movement-to-sound technologies into their free-play, including fantasy play. Moreover, there is room for thinking that previous technological developments, such as those reviewed in *Section B*, may not help us achieve the results of the WSK evaluations, in which free-play was fostered through a combination of natural body movements (detached from a computer screen) and audio feedback via the sounds of everyday objects.

On the other hand, it is important to note that some school-aged children did not engage in free-play with the WSK. This might be related to a general decrease in creative thinking amongst children after a certain age [27], and this reinforces the idea that there should be more free-play opportunities for kids. Alternatively, this lack of engagement with the WSK might simply be related to the fact that some school-aged children are not interested in such type of play [18].

Bekker et al. pointed out that shared objects encourage free-play [3]. The evaluation showed that individual objects like the WSK can achieve free-play by allowing the transition from individual creative exploration to parallel play and the social play techniques described by Parten [44]. In fact, the diverse play opportunities provided for different interests contributes to the play value of the accessory, ensuring that children at different stages of their childhood can involve WSK in their free-play.

Both girls and boys aged 7-12 engaged in different types of free-play, although boys were significantly more engaged in free-play than girls (See 5.2.5). This is possibly because, while girls devoted more time to exploring diverse play opportunities, boys engaged directly in the motor and fantasy play (especially through the use of gun sounds). Thus, girls made more creative uses of the accessory. On the one hand, this finding is consistent with the diverse play interests of girls and boys during school ages [56], and with the idea that boys are more interested in motor play than girls [24,56]. On the other hand, it challenges the general idea that girls are more interested in fantasy play than boys [55], but further research with larger groups of children is needed to either confirm or reject this hypothesis.

G.3 Methodological Aspects

G.3.1 Participatory Design: Approach

Previous research has shown that keeping participants motivated in PD studies is not easy [39] and that eliciting concrete design ideas is difficult [62]. By introducing PD activities into a real-life activity, participating children were highly motivated and involved in the process, and thus created objects that were meaningful to them. Also, relevant design issues were identified and our understanding of the fit of the WSK in school-aged children's free-play increased further. Embedding PD in everyday activities can inform the design process with real-life experiences, which strengthen the ecological validity of the results of other PD techniques, such as co-sketching and focus groups, which by their very nature are more detached from everyday activities. However, the approach taken in this study requires researchers to find, adapt and embed the research interest in appropriate situations that are realistic enough to be meaningful for the participants. Depending on the topic and/or the participants, this might not always be feasible.

G.3.2 Evaluation and Analysis of Play Value and Evocative Power of WSK

The evaluation of the WSK was conducted in a rather uncontrolled and social free-play environment, and thus much of the analysis conducted to reveal and explain individual and social free-play experiences rests predominately on the qualitative observations of the direct and video observers.

In an attempt to strengthen and enrich the qualitative analysis, a small number of tests of significance were conducted to identify differences in, for instance, the amount of playtime of each participant and types of sounds with the WSK, between and amongst different age and sex groups. As stated in *Section D*, the authors considered that these quantitative analyses met the independence condition. This decision might be controversial, since most participants did not play with the WSK on their own, but with a friend and/or an adult, which could have affected their individual free-play. Yet, this decision is grounded in the fact that play (and especially physical play), is mainly influenced both by personality and by play interests [18,24]. All the participants elected whether they wanted to play individually or with someone else, and the way in which the edited summaries of the videos were analyzed – focusing on a child – is consistent with this decision.

While it is common to use pictorial Likert scales in questionnaires with children [67], initial tests, in which paper-based questionnaires were administered while preparing the settings of the evaluation of the WSK at Ars Electronica, showed that these methods were difficult to conduct in the playground. Participants were not interested in answering formal questionnaires, as this appeared to make the process more formal thus impacting on the free-play nature of the exercise. It is also worth noting that subjective acceptance results summarized in a score in a questionnaire tend to say more about the users (e.g. praising the researcher, negative previous experiences, willingness to explore the technology) than about the accessory [7,20]. The setting and approach in this paper allowed us to achieve appropriate results by comparing different age groups, revealing different types of free-play and of engagement with the WSK that would not be highlighted through the use of a formal questionnaire.

To deepen our understanding of the evocative power of the WSK in encouraging free-play among children, an adaptation of the Play Observation Scale [50] was used in a detailed coding protocol to analyze a set of videos. On the one hand, this adaptation allowed us to identify that the WSK was effectively incorporated into the free-play of school-aged children and classify their free-play into, for instance, dramatic, rhythmic and motor play. On the other hand, a reliability test of the video analyses led us to discard the social scale of the results, and future studies might consider including a more detailed categorization of the levels of social involvement in their analyses. Further limitations are discussed in the following section.

G.4 Limitations

Regarding the version of the WSK used in the evaluation study, embedding the speakers in the bracelets in the version of the WSK used in the evaluation study may have helped the participants to move more freely and to listen to the sound feedback at the same time. By doing so, the study could have been conducted outside the playground. Yet, this option was not implemented in this version of the prototype, and thus this is one of the limitations of the study. To compensate for this limitation, the size of the playground and the time given to each participant to experiment with the WSK enabled each user to move freely around a playroom and distinguish their own sound with a spatial reference. The dimensions of the playroom and the limitation to have at most four users of the WSK also allowed the researchers to keep track of the users' activities, which may have been difficult in a larger setting with more participants.

Although almost 300 people were involved in the playground, there were not enough participants from certain age groups to offer statistical significance and draw general conclusions. Additionally, the playground was part of a very specific event – Ars Electronica, attended by young and adult people with an interest in electronic arts. These aspects make it difficult to claim that the results are, or can be, valid when the WSK is applied to other contexts, thus warranting further research.

H. Conclusions

This paper has looked into the evocative power and play value of a movement-to-sound accessory (WSK) in the free-play of a group of school-aged children. The results show that participants in the study incorporated the WSK effectively into their free-play, and the WSK encouraged different free-play patterns, including motor play, rhythmic, fantasy and social play. The results also indicate that different features of the WSK influenced movement-to-sound play experiences, by, for instance, showing that familiar sounds augment and encourage free-play. The results also highlight the importance of providing different types of sounds to allow different users to make personal connections with the accessory.

This paper makes three timely and important contributions to research on free-play and HCI research on wearable and movement-to-sound technologies. First, it has shown that new digital objects can be designed to effectively encourage free-play among school-aged children. Second, it has revealed a use of wearable technologies that can offer additional value for their users (school-aged children in this case), which is crucial in moving from screen-based technologies to real-life mobile products, offering opportunities for designing future meaningful interactive wearable products. This is in line with the idea that HCI must move away from the screen to consider other everyday interaction contexts. Thirdly, the research described in this paper offers methodological insights into recruiting and conducting studies under free-play settings, and highlights the relevance of informal settings to understand the potential of new technologies in their social contexts. Such insights may help other researchers identify alternative research techniques to apply to this particular domain.

In terms of future research, the authors plan to create a standalone prototype of the WSK to evaluate its play value and evocative power over the longer term, and in several everyday settings. The authors also plan to adapt the ergonomics and the contents of the actual version of the WSK to evaluate it with pre-school children, and define an evaluation study which is more suitable for teenagers, since doing so should help us gain a better understanding of playful uses of movement to sound technologies.

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3. Participatory Design Approach

Building on three participatory design studies, two with children - described in paper (Rosales et al., 2011) in chapter 2, and in paper (Rosales et al., 2011b) in Annex I, and another with older people presented in paper (Rosales et al., 2012) in Annex I – this chapter discusses the embedding approach. This chapter consists of a journal paper submitted to the International Journal of Human-Computer Studies on the 29th of May 2014 – currently, under review.

The journal paper presents the embedding approach, it aims at interviewing ethnographic methods with PD paradigms in order to find natural ways to cope with some of the most common challenges to conducting PD with children and older people. These challenges are (a) strengthening the affinity of the participants with the activities, which is closely related to the recrutiment, (b) the difficulty to cope with the abstraction of the design process, and (c) the empowerment of participants to be able to make useful contributions to design. To cope these challenges, some of the contributions of this section are (a) the use of real-life experiences with communities of practice, to assure the affinity of participants with the topic of interest, while contributing to our understanding of the social experience, (b) creating enjoyable and meaningful activities wherein participants are involved based on what they know how to do and enjoy doing, (c) letting the user simulate the intented interactive experience, by adapting the yet-to-be-designed technology to their own interests and providing feedback to the design process, thereby reducing the abstraction of design.

3.1 Embedding Participatory Design in community-based activities of children and older people

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Within HCI, whether children and older people should be involved in the design of new interactive systems aimed at them is not a question. Yet, how to get them involved in design is, we argue, far from easy. In this paper, we identify four key challenges to conduct PD effectively with older people and children and introduce a new Participatory Design (PD) approach to cope with these challenges, the embedding approach. We describe the chief characteristics of our approach: embedding PD in community-based activities and use adaptable prototypes for simulating holistically the intended user experience with the yet-to-be design technology. We describe how we embedded the PD studies in the design of the Wearable Sounds Kit, a sound feedback wearable to foster free-play amongst children, and the Knowledge Games Platform, which allows older people to play and create games that are worth playing by them. We discuss the novelty of the interplay of PD and ethnography in our embedding approach and its relationship with HCI research. We also discuss how our embedding approach relates to existing PD techniques. We suggest limitations and opportunities for further research.

A. Introduction

Within HCI, it is fairly well established that involving users in design is crucial in developing more playful, meaningful and accessible interactive systems. This is especially important when designing for (primary school-aged) children (aged 6-12) and older people (60+). With respect to children, they can be regarded as "an entirely different user population with their own culture, norms, and complexities" (Druin, 2002, p.1). Regarding older people, despite a growing ageing population, they have not been considered in the design of most interactive systems (Newell, 2011). Yet, conducting Participatory Design (PD), which is defined in the seminal Participatory Design Principles and Practices as "a new approach towards computer systems design in which the people destined to use the system play a critical role in designing it" (Schuler and Namioka, 1993, p. xi), with children or older people is far from easy, as acknowledged in the literature (reviewed in *Section C*) and apparent in our early experiences (*Section B*). The challenges range from coping with a potential lack of affinity of children with the PD activities to the need of empowering older people to suggest design ideas. Thus, we decided to find a way of conducting PD with children and older people that overcame these challenges. We focused on doing so at intermediate stages of design, when the transition from a design concept to a prototype (Sanders and Stappers, 2008) and numerous design decisions are made, oftentimes without a strong participation of users (Vanden Abeele and Van Rompaey, 2006). In this paper, we present our PD approach, which intertwines ethnography and PD, and that we call the embedding approach, because it is about embedding PD in everyday activities of future users by slightly modifying these activities with the intended experience, using ethnographically-inspired methods.

Linking ethnography to design has received a lot of research attention since the 1980s, when, motivated by a growing awareness that "human activities were in large part carried out in cooperation with others" (Blomberg et al 1993, p.124), there was a need to "analyse the collaborative, hence social, character of work and its activities" (Hughes et al 1994, p. 429). When designers and HCI researchers attempted to implement this view, traditional methods of requirements elicitations and work analysis at that time, such as customer surveys and operability assessment, were not enough (Blomberg et al 1993, Hughes et al 1994). Ethnography, with its focus on "telling a credible, rigorous, and authentic story (…) giving voice to people in their own local context" (Fetterman 2010, p.1), provided a unique perspective to understand better users' work activities and HCI turned to ethnography as a resource for design (Blomberg et al 1993). Since then, with interactive systems adopting an ever-growing number of different forms, and being used for work and non-work purposes in a myriad of settings by increasingly differentiated user groups, understanding how to get users involved in the design of future technologies has become a widespread ingredient in the design of technology (Robertson and Simonsen, 2013).

Thus far, ethnography, in its traditional form or in versions adapted for software engineering, e.g. quick-and-dirty, concurrent and evaluative ethnography (Randall et al., 2007), has mostly been used within HCI (a) as a method of requirements elicitation (e.g. Carmien et al., 2005), (b) for providing designers and researchers with a source for discussion in debriefing meetings (Hughes et al., 1994) and inspiration to create design concepts (e.g. Halse, 2008). In our PD approach, we go beyond (a) and (b) by using three key guiding principles of ethnography, namely, studying a phenomenon in their everyday settings, taking a holistic view and a members' perspective (Blomberg et al., 1993), and exploiting the role of fieldworker/designer as a research tool, in an attempt to both embed PD in everyday activities and simulate, by using PD techniques such as prototyping or "wizard of oz" (Buxton, 2010), the future interactive experiences in them.

We applied this the embedding approach in two R&D projects, Wearable Sounds Kit (WSK), a sound feedback wearable accessory designed to foster and facilitate free-play amongst children (Rosales et al., 2014b), and WorthPlay, a platform of knowledge-based games (KGP) (GTI, 2014) that older people, with different levels of previous experience with ICTs, found it worthwhile to play (Rosales et al., 2014a). The design concepts of both projects were grounded in user experiences (Rosales et al., 2011b; Rosales et al., 2013), and to move from concepts to prototypes, we embedded PD in community-based activities wherein older people and children participated (Disalvo et al., 2013). Examples of these community-based activities were a public event in an adult educational centre and the preparation of a play in a summer school for children. We argue that the embedding approach enabled us to overcome the challenges mentioned above and to generate design ideas, thereby helping us make design decisions for both the WSK and the KGP, which were used at the final stage of the projects, wherein key principles of ethnography continued to play a role, by a large number of people.

The remainder of the paper is organised as follows. As stated before, *Section B* summarises our early PD experiences and *Section C* presents a literature review on PD with children and older people. *Section D* shows two implementations of the embedding approach. We close the paper with a discussion on the strengths and limitations of the approach, followed by conclusions and future work perspectives.

B. Two early PD experiences

Following Sander's design process (Sanders and Stappers, 2008), we describe the purpose, activities and tools, venue and participants of two early PD experiences we carried out with children and older people, respectively, and discuss the unsatisfactory results that motivated our embedding approach.

B.1 Designing playful accessories

Purpose: Free-play, defined as the spontaneous emergence of play driven by the creativity of children, is crucial in their cognitive and emotional development (Berk, 2006). With the advent of interactive technologies in everyday things (Petersen et al., 08), and the role the body plays in children's free-play (Ginsburg, 2007), we focused on designing digitally augmented wearable accessories to foster and facilitate free-play (Rosales et al., 2011b).

Activities & Tools: We conducted a workshop, which was designed to help us with the ideation of digital wearable accessories. It was divided into 3, 1-hour sessions. The children were firstly introduced to artifacts needed to create a wearable circuit, including a battery, a conductive thread, LEDs, buttons, a piezo speaker, a photo resistor and a bend sensor. In the second session, they were asked to pencil their own playful circuit. In the third session, they created their playful circuit with the artifacts provided. Each kid worked on his/her own.

Venue & participants: The workshop was conducted with 12 children (aged 7 – 9; 3 girls and 9 boys) in an after-school center devoted to play. The first author, who had been, prior to the study, a facilitator in that center for 4 months, conducted the workshop, with the support of two members of the staff of the center and a colleague (researcher). They all helped the children to carry out the different tasks and conducted observations of their behaviors.

Results & discussion: Two children did make contributions. One of them created an interactive glove, which emitted a light when the person wearing it clenched his/her fists, and imagined that the glove had the powers of a superhero. The other kid created a t-shirt with an interactive face of a girl on it. In her words, it was a "t-shirt doll". The eyes of the doll consisted of two LEDS, and its mouth had a hidden button, which, when pressed (e.g. the doll was kissed by the right person), the girl's eyes were opened. Two children did not make any prototype. The rest of the children focused on drawing on a t-shirt and put some LEDS randomly, without providing us with any explanation about how they would play with this augmented t-shirt. Thus, they did not make any significant playful contribution. 10 children (N=12) were not empowered to contribute in the PD study. The results were clearly unsatisfactory. Most children showed almost no affinity with crafting textile circuits and found it difficult to cope with the abstract process of coming up with ideas for building a playful object with the resources provided. They focused more on drawing than on suggesting future uses of the accessory. Perhaps, this happened because we did not provide them with a suitable context for eliciting toy thinking.

B.2 Designing the login screen of an online bank-help

Purpose: We aimed to get older people to provide ideas for sketching the template and the login screen of an online platform whereby help could be exchanged amongst people living in their local area. This specific service was motivated by previous fieldwork, which had been conducted within the context of a 3-year project (life2.0, 2014), in which the participants and the authors had already been involved.

Activities & tools: We carried out a workshop aimed at eliciting design ideas for the login screen. We provided older people with examples of different login pages, and with a MS PowerPoint file with different user interface elements of a login page. We asked them to sketch, in the MS PowerPoint file, using the appropriate tools of the program (e.g. text boxes), the template and the login page of the bank-help page.

Participants & venue: 7 older people (aged 65 – 75; 2 women; 5 men), who had been participating for about a year in activities related to the project, were involved in the workshop, which lasted 2 hours. The workshop took place in the Internet room of the center, wherein they had been taking computer and Internet lessons at least for two years. This group was familiar with MS PowerPoint, and reported enjoying making presentations they e-mailed to their friends and used in family gatherings. They worked in groups of two or three, as they usually did in the computer lessons. The first author, along with two researchers, who had conducted fieldwork activities with this group during the first year of the project, acted as participant observers.

Results & discussion: The participants did what they had been asked for, but the workshop was unsuccessful. They focused on the visual style of their design solutions and their reasons were vague. For example, most of them designed a help button. Yet, our observations, conducted over a long period, indicated that they had never used this functionality before. When they were unsure about how to conduct a task, they usually asked for support to other participants or the instructors. When we asked them why they had designed a help button on the screens, their most common answer was, as one of our participants put it, “It should be there”. As opposed to children in 2.1, their affinity with the topic was not an issue, as they had been voluntarily involved in the project for a year or so. Still, they reported that they did not feel comfortable enough suggesting design ideas, because, as one of them put it, “there are people who study at university to become designers. We aren’t designers. We aren’t the right people to tell you how to design”. They contributed with ideas to the concrete part of choosing colors and fonts, but did not cope well with a more abstract part, such as deciding what user interface elements should be used, where and why, or the sequence of use of their own sketches.

C. Related work

While the key principle behind PD - the people aimed at using an interactive system must be involved in its design - is seldom unquestioned in HCI, the practice of PD is more controversial. According to Sanders (2008), this controversy surrounding the adoption of PD can be accounted for the fact that (a) participatory design / “co-designing threatens the existing power structures by requiring that control be relinquished and given to potential customers, consumers or end-users. It is very difficult for those who have been successful while being in control to give it up now or to imagine a new way of doing business that can also be successful” (p. 9), and (b) “the relationships between new technologies and future human experiences have just recently become very complex and integrated (…) moving from being technology-driven to oriented towards user experience" (p. 10). With the heterogeneity of the older population (Lindsay et al., 2012), stereotyped views of older men and women and ICTs, and the cognitive abilities of children under development (Berk, 2006), it is not difficult to imagine that many professionals can be daunted by the possibility of letting these two user groups decide how an interactive system should be designed. Also, designing future interactive systems and human experiences with them is not straightforward, as we argue next. We discuss four challenges that limit considerably the effective participation of older people and children in PD.

C.1 Challenges in PD with children and older people

C.1.1 Abstraction

Designing "is about bringing forth something that does not exist through material transformations and communicative acts involving design artifacts" (Binder, 2011, p.105), and in PD, "users are envisioning use before it actually takes place" (Mattelmäki and Sleeswijk, 2011, p.3). Hence, abstraction is an important element of PD, which needs to be dealt with effectively. Yet, when discussing about abstract concepts through brainstorming, co-sketching or paper prototyping, which is typical of PD studies, older people "may encounter some difficulties to imagine what the designers are talking about or what a sketch may represent in reality", (Otjacques et al., 2010, p.184) because of the inherent difficulty of creating a common imaginary amongst several people, especially if they do not know each other. Older people have also been reported to feel uncomfortable when they are asked to draw or sketch (Mitchell and Nørgaard, 2011; Rice and Carmichael, 2011; Uzor, and Skelton, 2012), and find it difficult to find the proper language to make concrete comments about interface design (Rice and Carmichael, 2011), because they are often unfamiliar with design language and practice, e.g. drawing sketches, or describing a sequence of use. When we tried to avoid abstraction by providing elements through MS PowerPoint, we led older people to focus on (moderately irrelevant) style details, without supporting their conceptualization. With respect to children, low-tech prototyping, "can lead children in a state of frustration" (Colombo and Landoni, 2013, p.291), while brainstorming do not "lead them to use their imagination to solve the problems" (Wakil and Dalsgaard, 2013 p.757), especially if the brainstorming is detached from real-life experiences.

C.1.2 Affinity & recruitment

"The heart of Participatory Design is participation" (Brandt et al., 2013, p.147). Thus, recruiting participants related with the topic seems important (Brandt et al., 2010). Indeed, (Grönvall and Kyng, 2011) stressed the relevance of affinity and recruitment when conducting PD in home-based healthcare with elderly chronic patients, because "They are at the leading edge of an important market trend" (Hippel, 2005, p.24). We discuss affinity and recruitment with children with normal cognitive abilities and older people with normative age-related changes in functional abilities next.

Two of the most common ways to recruit older people for PD are by means of (a) open calls, e.g. with flyers and posters (Uzor and Skelton, 2012), and (b) individual invitations. Thus, there is room for thinking that older people are likely to find themselves participating in activities with people they do not know. This situation might put (some of) off expressing their personal experiences and voicing their opinions (Uzor and Skelton, 2012). Recruiting participants by means of open calls makes it difficult to assess their degree of affinity with the topic of the study before it takes place. The participants recruited in (Grönvall and Kyng, 2011) reported having taken part in the study due to a number of reasons, such as socialisation or curiosity, which were not related to the topic of the research.

In (Yip et al., 2013), two groups of children, one with demonstrated interest in the topic of the study, and the other, with design skills, were invited to design a ScienceKit, which was aimed at providing a life-relevant learning environment to understand the importance of scientific thinking in everyday life. The group interested in the topic had participated in a Kitchen Chemistry after-school program (ASP), while the design group had been participating in a different ASP, aimed to co-design technology for children. The results revealed that both groups addressed similar design issues. Yet, the scientifically motivated group focused more on the subtle aspects of the Kitchen Chemistry activities, thereby providing more specific ideas for the ScienceKit.

C.1.3 Empowerment

Empowering children and older people to contribute in a PD study is a difficult task (Grönvall and Kyng, 2011; Lindsay et al., 2012; Mitchell and Nørgaard, 2011; Rice and Carmichael, 2011; Vaajakallio et al., 2010;). The challenges mentioned above account partially for it. If the level of abstraction is too high, and/or their affinity is low, it is reasonable to think that their participation in the activity is far from easy. The type of activities in PD sessions also plays a role in fostering empowerment. Vaajakallio et al. (2010) designed an eco-game with children to build user scenarios of their everyday life related to environmental issues. However, some children only added text and stickers to make images look funnier and nicer. In our early experience, we observed that most children focused on drawing their accessories rather than thinking about its play value. Vaajakallio et al interpreted this as "for children, how their designs look (…) is more important than how their designs provide solutions" (2010, p. 28). With older people, Lindsay reports that "Keeping older participants focused on the topics of discussion and giving them clear opportunities to present their ideas in meetings is a major challenge" (Lindsay et al., 2012 p.1201), and Rice points out that "the self-perception of inadequate drawing skills, demonstrate further barriers for some older adults to articulate their visions and aspirations for suitably designed technology" (Rice and Carmichael, 2011, p.1). Grönvall and Kyng (2011), who conducted PD in the homes of older people to develop technology-assisted treatments for chronic dizziness, found it difficult to keep the participants focused on the task at hand. The reasons reported by the participants for taking part in the study ranged from wishing to contribute to the project to being willing to have someone to talk with. In hindsight, Gronvall and Kyng (2011) pointed out that they missed out on the opportunity of understanding how (a) these varied interests could have been put to the service of their study and/or (b) they could have empowered the participants to draw more on their own interests, skills and habits.

C.2 Some strategies for addressing the challenges

Design training

(Yip et al., 2013) dealt with abstraction by training children in design skills. By doing so, the children were expected to develop the future thinking skills needed to reinforce their collaboration in design projects. However, the results were inconclusive: design-trained kids addressed similar design issues that non-design trained children (Yip et al., 2013).

Communities of everyday practice

In (Brandt et al., 2010), rather than using biological age to recruit participants, they argue for talking about situated elderliness, and, within this context, recruiting older people through communities of everyday practice, which is also addressed by Disalvo (Disalvo et al., 2013). Involving PD studies in communities is, to the best of our knowledge, an open topic.

Evolutionary design

Over a 9-year period, Botero and Hyysalo co-designed interactive systems with a community of older people to tailor them to their needs. They adopted a design-in-use approach, which they coined as evolutionary design, seen as a step towards strengthening the affinity of the participants with the topic of the study (Botero and Hyysalo, 2013). Conducting the study in a community of practice was useful to "foster ownership of the process, technology and media" (Botero and Hyysalo p.49). The long-term aspect of the study, and its focus on real-life use of the technologies developed, contributed to "responding to evolving needs through collective and cumulative design iterations" (Botero and Hyysalo, 2013. p.49).

Co-sketching

Mitchell and Nørgaard (2011) carried out co-sketching in an attempt to help both children and older people verbalize their thoughts and ideas in PD workshops. They asked them to finish uncompleted cartoons with a design concept or a scenario of use. The co-sketching was a useful concrete point of departure for exploring ideas with them. It also facilitated discussion and reflection. However, older adults felt uncomfortable when they were asked to draw, and when they, and children, did so, they "sketched about and talked about what interested them, not what they were asked to do" (Mitchell and Nørgaard, 2011, p. 7).

D. The embedding approach

Reflecting on the studies reviewed before, design training was not successful with children, as shown by (Yip et al., 2013). Moreover, design training is unlikely to cope with the abstraction challenge with older people, especially if they consider that they are not the right people to tell designers and researchers what they have to do, as they argued in our early studies (*Section B*). Co-sketching, with children and older people, is of limited usefulness. While it proved useful in

Mitchell and Nørgaard, (2011) to discuss concrete ideas, it did not empower either children or older people to go beyond the scenarios and contribute to the study with their own ideas. Similar results were obtained in our PD study, wherein older people were asked to co-sketch in a MS PowerPoint file. Evolutionary design coped with affinity in a deep and meaningful way with older people. Yet, it remains to be seen how it can be applied with children, who tend to need concrete, practical and short-term tasks to be engaged in PD sessions.

At initial and late stages of design, dealing with affinity, abstraction and empowerment is important to either generate design concepts or evaluate/re-design (parts of) an existing system. At intermediate stages, when concepts are fairly clear but design decisions are still to be made, the participation of end-users is paramount to decide the fine details of the system. However, dealing with affinity, abstraction and empowerment at that stage is potentially more complex than at initial ones, as we often move from generating lots of concepts/ideas to building one concrete prototype. Our PD approach for intermediate stages of design consists in embedding PD into everyday activities that are meaningful to the participants, in an attempt to reduce abstraction, strengthen their affinity with the topic of the study and empower them to contribute to make design decisions. To do so, the embedding approach draws on intertwining ethnography and PD as it is described in *Section D.1*, and has 3 key ingredients, described in *D.2*.

D.1 An approach for intertwining ethnography and PD

Intertwining ethnography and PD poses an important epistemological dilemma (Blomberg, 1993), because PD entails "imagining and planning with issues that are not-yet-existing" (Mattelmäki & SleeswijkVisser, 2011, p.1), while ethnography reflects on "the lifeways of diverse communities of people" (Blomberg et al., 1993, p.123). Yet, there has been considerable interest in using ethnography in PD (Andersen, 2013; Blomberg et al., 2013; Dourish, 2006; Halse, 2008, Randall et al., 2007;). In particular, "ethnographically-inspired fieldwork techniques open-ended interviews and (participant) observations, are employed to gain insights into unarticulated aspects of the work and to develop shared views on the work" (Kensing and Blomberg, 1998, p.176). These ethnographical insights into work practices have often been translated into, and represented as, system requirements, which has been criticised by reducing the value, even missing the point, of ethnography in design (Andersen, 2013; Dourish 2006). The embedding approach intertwines ethnography and PD in a different way to design future technologies.

We agree with (Blomberg et al., 1993) on "when designing radically new technologies, users are often unable to give meaningful responses to queries about how they might use such technologies. They need to be provided with a way of envisioning and experiencing the technology in the context of their own work practices before they can contribute to such a discussion. To create the context for such a discussion and to be useful partners in the joint exploration of the relation between work and technology, designers must have some understanding of the user's work" (p. 142). To gain this understanding, and to create new interactive experiences, the embedding approach studies a phenomenon in its everyday settings, takes a holistic view and a members' perspective, qualities borrowed from ethnography (Blomberg et al., 1993), in PD in an attempt to encourage practitioners, designers and developers to reflect on the best way of making the most out of the skills, interests and everyday realities of children and older people. In doing so, we argue that the approach helps us overcome the four challenges identified in *Section C*. We discuss next the three core ingredients of the embedding approach. In *Section E*, we show how we applied them in two PD studies and provide evidence of improvements made in the design process.

D.2 Three core ingredients

D.2.1 Community-based PD: context for coping with affinity, and facilitate recruitment

Community-based PD "foregrounds the social constructs and relations of groups in settings that include, but go well beyond, the formal organisational structures commonly foregrounded in more traditional workplace studies" (Disalvo et al., 2013). Communities tend to be formed around shared interests and activities. Thus, their members, or most of them, are expected to have first-hand experience in activities in which the community is engaged and share their knowledge and opinions with other members of the community. Most communities, at least in a traditional sense, tend to be co-located, i.e. they share a physical space wherein most of the activities are carried out. Our approach exploits these features of communities (common interests, social bonds and co-location) to strengthen the affinity of the participants with the PD study, facilitate their recruitment, as well as empowering them to contribute to make design decisions and reduce abstraction, as detailed next.

D.2.2 Embedding PD in everyday activities to empower participation

Focusing on everyday settings, taking a holistic and a members' perspective should help to develop a close-up view of how people go about doing everyday activities. Our approach, once the communities have been identified, develops this view by having designers/researchers immersed in the everyday realities of the community. This immersion should enable us to seek (a) activities related to the topic of the PD study, (b) a group of participants who regularly take part in them, and (c) participants who are interested in exploring new possibilities to augment their everyday activities. With these three elements, the designer / researcher can explore strategies to embed the PD study in everyday activities. S/he does so by slightly modifying the everyday activities with the intended experience, in such a way that participants use all their expertise and the activity can be informative about how a future system can potentially be used in everyday settings. Thus, as the PD activities are meaningful to those who take part in them, and they sense that can contribute to them with their own knowledge, talent and skills, the PD study strengthens empowerment and the affinity of the participants with the activities of the study.

D.2.3 Simulating the intended experience to reduce abstraction

Once we have identified the opportunity to embed the PD study in community-based activities, we build strategies to simulate the intended future experience. The simulation lies in the intersection between everyday activities, in which the yet-to-be-designed technology could be used, and design practice, which helps us modify the activities by simulating future interactive experiences. Our simulation consists of the following three elements. We understand the use of existing tools as a mechanism for change (e.g. (Blomberg et al., 1993)), because it should help us get an insight into how to adapt existing tools to other scenarios of use. We draw on adaptable or flexible prototypes (e.g. (Andersen, 2013)), as they allow users to experiment with a concrete – not abstract - future idea in such a way that not only can they explore different options but also adapt it according to their interest create new options. We also make the most of the face-to-face interaction between designers/researchers and the users in order to put into practice the to-be-created features of the future experience. We do so by adopting a kind of "wizard of oz" approach (Buxton, 2010) where users put into practice the intended experience, with face-to-face interaction, as by observing how people appropriate a design idea and adapt its rules to fit it in their daily practices, we should find a way of how to best match their interests with the future interactive system. The three elements allow us to concentrate on the design experience/s (Buxton, 2010).

E. Two PD studies adopting the embedding approach

We present two PD studies that adopted the embedding PD approach with older people and children. We summarize the design concepts, which were grounded in user experiences and devised at initial stages of design in both studies. Afterwards, we show how we moved from the concepts to an interactive system at intermediate stages of design by adopting our embedding approach. Finally, we present the systems developed and details of how they were used.

E.1 Worth playing digital games for older people

E.1.1 The initial design concepts and their grounding

WorthPlay (GTI, 2014) was a 2-year R&D project aimed at understanding and designing digital games worth playing by older people. By worth we mean games enabled by ICTs that both reinforce and exploit the strengths of older adults as individuals and game players while compensating for normative age-related changes in functional abilities. To envision the concept of a worth playing game, one of the first tasks of the project was to understand the digital gameplay of older people. Over a 3-month period, we conducted a rapid ethnographical study (Millen, 2000) in Àgora (AG), a highly participative lifelong-learning community. AG is committed to strengthening the social inclusion of older people and immigrants in Barcelona (Spain) by providing them with free courses on a wide range of areas, such as Internet and languages. Two different types of activities were conducted. The Gaming club consisted of a group of 8 older people who were interested in games and had different levels of computer skills and playing experience. They enrolled voluntarily in the club. The club met every week, in sessions of two hours long, during which the participants played, in different gaming platforms, several digital and non-digital games, ranging from Angry Birds, Farm Ville, or Mario Bros to dominoes (Figure 22). These games were proposed by researchers or by the participants. Otherwise, in the Play sessions, we explored the playing interests and practices of older people who were not especially interested in ICTs or gaming. We did so by talking about games, suggesting play activities, and playing games in some of the courses regularly carried out in AG, e.g. literature, literacy, Catalan and English. All activities involved 170 older people (75% women, 25% men).

Figure 22: Members of the gaming club playing casual games

Amongst other results (Rosales, 2013), a key finding related to the design concept was the wide variety of play interests within our participants. We met participants who were into beauty and pictures, painting games, taking photographs or tending to their garden. For these participants, a worth playing game could be one about simulations or arts. Yet, such a game, in our opinion, was highly unlikely to be considered worthwhile to play by other participants who were, for instance, more competitive and fond of sports. In an attempt to give support to this diversity of (play) interests, which seemed to be accounted for their wealth of life experience, and taking into account that all the participants were interested in learning and sharing their knowledge – AG was a learning community – we decided to design a web-based Platform that allowed them to create and play Knowledge Games. A KGP was therefore the design concept.

E.1.2 Moving from the concept to a prototype: PD at intermediate design stages

Having decided the design concept, the next step was to design and build the KGP. To this end, we considered that it was important to (a) validate the concept with the participants and (b) conduct PD with them to figure out what elements KGP should have and how should be designed. Although the ethnographical results were rich - we identified play interests and different elements of playability (e.g. the relevance of personal memories in game experiences) (Rosales, 2013) - we could have misunderstood them. Moreover, decisions had to be made to turn the results into an interactive game, and we considered that we had to make these decisions along with the participants. We show how we moved from the concept to a prototype by adopting our embedding PD approach.

Community-based PD: immersion and a game in a social gathering

The heart of the embedding approach is community, and the rapid ethnography allowed us to get ourselves immersed in AG. We introduced new ICT-related learning activities (such as the gaming club) and helped out in existing courses. More important, perhaps, was the fact that members of the staff of AG put forward the idea of organising a game for the final year party - a regular and important event in which AG participants present examples of what they have been doing in the courses. Their suggestion can be seen as an indicator of (a) the usefulness of our game-related activities in AG and (b) our immersion in this community. Based on their knowledge of the community, the participants and the topics most appealing to them, members of the staff of AG created the first version of the game, with our support. It was a game about neighbourhood memories: how has the neighbourhood changed over the course of the years? The game aimed to bring back the participants' memories and encourage them to share their lived experiences with others. This community-based activity, as we argue later on, was key to both reduce abstraction and increase the affinity of the participants with the topic of the PD study.

Simulating intended interactive experiences

Members of the staff created the initial contents of the game. In particular, they created the first 10 questions of the game. We designed the details (e.g. rules, points, types of questions and end point) of the game with the ideas provided by its creators. The KGP was simulated with the participants of an ICT group in the AG Internet room using the first version of the party game. We used the contents of the initial game, existing tools and face-to-face interaction to simulate it. This group was reluctant to play "games". They reported not perceiving the usefulness of playing games. Thus, the simulation integrated the core learning interest in the form of learning how to use Google Maps, since they were interested in this technology. The questions about the neighbourhood were geo-localized, i.e. we displayed them on a map of the area in Google Maps. The members of the staff who had created the game acted as judges of the answers and wrote the scores on a blackboard, using face-to-face interaction to simulate the KGP. After playing the game, the participants added new questions to the game, by using Google Maps. The exercise of simulation helped us validate further the design concept, a knowledge game played by participants who were not interested in games, and start to define some of its details, such as how to evaluate correct and incorrect answers, provide points and other rules that we narrowed further down during the summer party game (see below).

The community playing the summer party game

In the summer party, a second version of the game, with the questions created by the ICT group, was played. Google Maps was not used, as the party was an outdoor activity without computers. Instead, an adaptable prototype was used. A table with a printed map of the neighbourhood was used to foster participation, as passers-by could stop and talk to us. The paper map had numbered dots, which corresponded to a numbered list of questions. The questions were written on a board, which we placed next to the map. Members of the community spontaneously approached the table with the game, read the questions, and talked about it. This led them to contribute to the game (and consequently to the design process) with answers and questions, the content of which reflected their varied memories. The researchers acted as judges, providing feedback on the answers, using stickers, which were orange if the answer was correct, or yellow, if the participants had added a new question to the game (Figure 23).

82 members of the community took part in the summer party game. We observed how the participants encouraged others to play the game. This shows that their affinity with the game was strong and that playing it was meaningful to them, corroborating the expectations of the members of the staff of AG that had created the initial version of the game. The neighbourhood was an important part of the participants' lives. All of them had memories about it, and sharing them with others was, perhaps stereotypically, an activity that came natural to many of them.

Figure 23: Researchers and AG participants playing the analogic version of the game

The face-to-face interaction allowed us to simulate the most complex parts of the game and modify it on the spot – as it happens with paper prototyping (Snyder, 2003) and the visibility of the dots stimulated recruitment in the public event, all of which led us to make four key design decisions:

- There might be more than one correct answer to the same question, and the game should give support to this diversity to encourage them to play the game. Older people can have different memories about the same event, and, for them, their memories are true. A woman complained after being told that her answer was not right "If what I know is not valuable here, this game is not for me".

- The KGP should give support to social experiences and to knowledge sharing, as discussing answers was commonplace in the party and one of the elements that engaged the participants most in the activity. For example, with some easy questions (e.g. what used to be in this place before?), the participants provided different answers, depending mostly on when they came to the neighbourhood, and this variety of answers fostered an active and enjoyable discussion for the participants.
- The KGP should let players become co-authors of games, because they showed a big interest in both contributing to existing games and creating others from scratch. When they were asked, for example, about which factory was located in a particular place, they answered the question with the name/type of the factory and elaborated on that by talking about other factories that used to be in the neighbourhood as well. Thus, we considered that enabling them to create or contribute to games was worthwhile to keep them playing the intended game or encourage them to play it.
- The games should not force participants to specific paths. Achieving the goals of the game was a motivation for the participants to play. Our conversations and observations pointed out that their most important reasons for playing the game was their interest in sharing knowledge, learning new things and bringing back memories. They played the game at their own peace, selecting the questions they wanted to answer at any time, depending on their interests. Thus, we thought that if the final system forced them to follow a concrete path, it would probably put them off playing the game, by failing to support the play we witnessed in the simulation.

Embedding PD into everyday activities

Face to face supported simulation was an element of the summer game, but let us reflect further on the embedded aspect of the simulation. As shown, the different activities of the PD study were embedded into ordinary AG activities, such as preparing a social event, the event itself and learning about ICTs in a course, which empowered the participants to contribute to the PD activities by drawing on their wealth of knowledge in a way that was meaningful to them too. For example, they reported learning further about the neighbourhood and ICTs; as one of them put it, "Finally, today I understood how to deal with google maps!" This empowerment allowed us to evolve and validate both the concept and the detailed design decisions of the KGP (see next).

E.1.3 The WorthPlay game

The results of the PD activities helped us make a number of design decisions, which led to the design of the KGP. Those decisions were not envisioned while defining the concept of the platform by researchers, and were not envisioned by the AG staff preparing the game. The KGP (Figure 24) allows older people, and also members of their social circles (as teachers in AG), to play and create games. The games are a mix of open and closed questions, and geo-localised ones (i.e. questions associated with maps). After the PD stage, around 30 games were created and played in the KGP by older people in AG and in two more communities, one in Madrid (Spain) and another in Dundee (Scotland) (Rosales, 2014a). Table 6 shows more systematically key findings of the PD study and how they were mapped onto the platform.

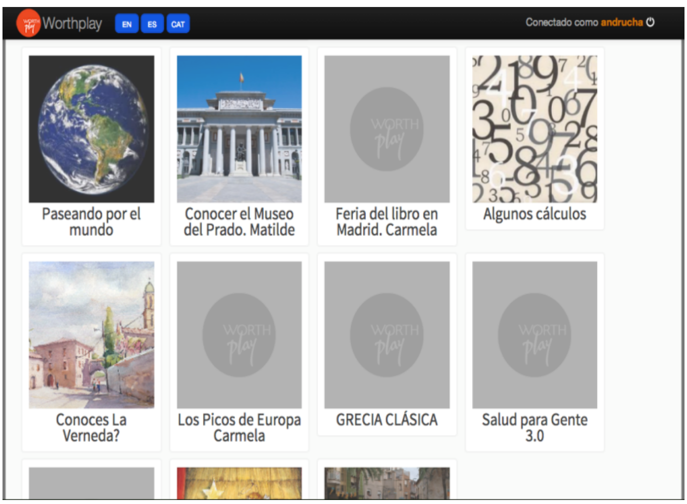

Figure 24: KGP

Table 6: Design decisions KGP

Evidences from the PD Study	Game Features
One question can have multiple correct answers.	Closed questions let the player choose amongst few answers. There is no right or wrong answer. In the results page, we present all the answers provided, highlighting (a) the most popular answer, (b) the answer chosen by the author of the question and (c) the answer chosen by the participant. While answering, participants can add an extra answer to closed questions if they consider the previous ones are incorrect In addition to closed questions, we include open questions to let the players share their memories in a free style.
One game can encourage participants to talk about the topic beyond the concrete questions.	The platform lets any user create his or her game/s. The platform allows players to add new questions to existing games.
AG participants are interested in sharing their knowledge in a constructive way.	Players can create new games, add new questions to existing games, provide answers and leave comments.
AG participants are not interested in dealing with the rules of the game or the rewarding system.	The platform has a pre-defined set of rules and a rewarding system, such as points. Players can only add new contents.
AG participants are interested in games that support their social experiences.	The contents uploaded to the platform show the name of the player and a picture of him/her to foster their playing (e.g. I know the person who wrote the question, let's read what he wrote).
Although it was complex to judge if one answer was right or wrong, the dots as rewards pleased participants and motivated them to play the game.	Any contribution to a game is rewarded with points. Extra points can be earned by choosing author's answer in closed questions, or if your answer is the most popular one in open questions, for instance.

AG participants did not want to be forced to specific behaviours.	There is no time control. There is no specific path to play the game. Players read the list of questions and decide which one they want to answer. They are not pushed to answer questions. They can leave them unanswered and keep playing. They can (stop) play(ing) games at any time.
The "Game" word was controversial amongst AG participants.	We do not use the word "Game" in the platform. Instead, we use playful activities, which was the word used by the participants.
Participants are interested in creating the contents of the game. However, they were not interested in setting up the rules of the game.	The KGP, have predefined rules to assign points, define milestones and end point. Game creators only have to focus on the contents of the game.

E.2 Designing a movement-to-sound playful digital accessory

E.2.1 The design concept: free play supported by an accessory

Free-play is highly relevant for the social, cognitive and physical development of children (Berk, 2006). However, in today's society, with the advent of screen and other forms of structured entertainment (Veitch et al., 2010), there short opportunities for free-play (Singer et al., 2009). In two previous studies (Rosales, 2011a, 2011b), by observing children engaged in free-play, we realised that the body of children is a key element in their free play. We also observed that numerous "boring" moments for them within their daily modern routine, such as waiting for their brother or sister to finish a football match, were actually opportunities for free-play. These observations encouraged us to consider the concept of digitally enhanced accessories (belts, shoes). Indeed, we designed and evaluated two prototypes (FeetUp, augmented shoes blinking when jumping and *Statue*, a belt blinking when moving). Those studies brought to light the evocative power of sounds to evoke fantasy play, which is key in free-play. Also, as singing and clapping games have been popular amongst children, being observed and recorded since the Middle Ages (Opie and Opie, 1988), we decided to take these studies one step further and came up with the idea of a Wearable Sounds Kit (WSK), a wearable movement-to-sound interactive accessory to support and enhance free-play.

E.2.2 From the concept to the design of the WSK

To validate the concept of a WSK, we considered that PD should (and could) help us understand possible playful uses of the kit, device affordances and components (e.g. sounds). We discuss how we carried the PD next.

Community-based PD

The PD study took place in a summer school, where children, during their summer holidays, spent part of the day, playing games. Most of the kids knew each other as they had taken part in after-school activities organised in the centre during the academic year. Thus, the summer school can be thought of as a community of play. This school supported free-play; spontaneous, collaborative, and social play, with a strong physical component (e.g. children running and jumping). Thus, the affinity of the children at that school with the topic of our study was, or could be expected to be, strong.

Embedding PD into regular activities: the rehearsal of a play

The study was embedded in an important activity within that school: the preparation of a play. Prior to that, we got ourselves involved in the community. We conducted other user research activities related to our research on free-play and kids. During conversations with the instructors, they stressed that the overarching aim of the school was to encourage children to explore new playful experiences, and encouraged us to provide new ideas for the summer school. While planning the activities, the instructors and us came up with the idea of proposing the children to do a play at the end of the summer school. The plot and its characters would be up to them, who would be encouraged to use an adaptable prototype of the WSK during its preparation. Since fantasy play is a key element of free-play, (which is described by Callois as Mimicry and Padia (Callois, 1961)), we considered that this should be an opportunity to validate the design concept and make design decisions, within a context of free-play.

20 children, aged 8 to 10, prepared the play through six, two-hour weekly sessions (Figure 13). They were invited to use the WSK to

augment their characters with sound effects. 8 of them, the most interested in the activity, led the play and volunteered to use the WSK in all the sessions. Taking into account the total number of children (20), the participation of only 8 of them can be regarded as a poor result. Yet, the proportion was much higher than in the workshop described in *Section B*. Moreover, our conversations with them revealed that they were strongly motivated to make an impressive performance, as their parents would be in the audience. Thus, they were highly motivated to make the most of the WSK. They had, and tried out, plenty of ideas. To give just one example, one of their characters was a super hero, who fought against the evil, and to beat him, needed a special sound, a super hero sound.

Simulating the intended experience

The WSK adaptable prototype consisted of 4 different types of sensors (bend, accelerometer, force sensitive resistor and piezo vibration). These sensors could be attached to any part of the body using Velcro or tape. By using a computer, the children could explore a midi library level 2 with 256 sounds of instruments to select the sound to be played when they interacted with the sensor. Children could choose the sensor, its position and the sound. Our design goals were to elicit which of the sensors, positions, and sounds fitted in and encouraged free-play. In addition to observing how the kids explored the WSK, we carried out face-to-face interaction to adjust the adaptable WSK as the activity evolved.

Two researchers helped the children to wear the sensors and select the sounds. The adaptable prototype confronted the children's imagined magical sounds with the constraints of hardware and software, which was instrumental in (a) empowering them show their creativity, which is part of free-play, e.g. some girls decided to contribute to the play with a gymnastic sketch and made sound effects with their feet, and (b) building concrete creative experiences which were technologically feasible, e.g. wearing the sensors in the hand to create a sound effect while clapping, thereby reducing the abstraction issue in the design process.

Based on the children preferences and use of the adaptable WSK, we made a number of design decisions:

- The WSK focused on the bend sensor, as it can be incorporated in natural movements often made by children ranging from flying and jumping to dancing, and also facilitates dramatic expression, which is key element of a play and of free-play (Caillois, 1961).
- Amongst the list of midi sounds, the group of 8 children focused mainly on sounds of everyday objects, such as cars, trains, dogs, birds, phone, guns, guitar and drummers. According to these children, these objects were highly familiar to them and part of their everyday play.

Table 7 shows more systematically key findings of the PD study and how they were mapped onto the accessory.

Table 7: Design decisions WSK

Evidences from the PD Study	**WSK Features**
The bend sensor gives support to the diverse play interests of children.	We choose the bend sensor to develop the prototype.
The bend sensor facilitates often-made articulation movements in free-play.	We embedded the bend sensor in a bracelet that could be worn in the elbow, knee or the ankle.
The 8 children involved the sounds of things they are familiar with in their free-play.	We choose 30 sounds used by kids during, the study, to include in the final system, and provide a visual interface for kids read the names of the sounds, and a button in the bracelet to change sounds.

E.2.3 The WSK

The functional design of the WSK was used in a user research study aimed at evaluating its evocative power and play value. More than 100 children experienced the WSK in a free-play setting (See Figure 12) within the Ars Electronica Festival 2012 in Austria. The accessory encouraged different types of free-play, including fantasy play, motor play, social play and rhythmic play. The results also show differences in the free-play mediated by the accessory depending on the age group (infants, school-aged children, teenagers and adult people) and sex of the player, which reinforce the play value of the WSK (Rosales, 2014b).

F. Discussion

F.1 Positioning the embedding approach within Participatory Design

The PD activities described in this paper (in *Section B* and *E*) have been framed in HCI research with children and older people with a strong ethnographical component. The design of future interactive systems was an important task therein. Apart from understanding how these two user groups could be involved in PD studies, we aimed to build innovative interactive systems that could be used in real-life settings by a reasonably large number of people. Over 300 individuals interacted with the WSK in Ars Electronica Festival 2012 (Rosales, 2014b) and 170 played the KGP (Rosales, 2014a). During the course of our research, we looked into participatory design methods.

Drawing on our two early PD experiences and literature review, we identified four key challenges, abstraction, affinity, recruitment and empowerment, which, in our opinion, needed to be addressed if PD was to be conducted effectively, at least with older people and children. We have not made explicit other challenges of conducting PD with older people. In particular, coping with older adults' lack of or little previous experience with ICTs (Davidson and Jensen, 2013) has not been highlighted in the paper. We considered that addressing the aforementioned challenges was a prerequisite for coping with this one, which was subsumed into them. In *Section E*, we have shown that conceiving, designing and conducting PD within everyday activities of a community, and using a variety of simulation techniques, are key to conduct effective PD activities with older people and children.

As the interplay between ethnography and PD is strong in this paper, it is relevant to find answers to the question of how (if possible) a designer or researcher can adopt our embedding approach, or incorporate its ingredients (community, embedment and simulation) in a PD study, if s/he – for a number of reasons – does (or can) not frame it within long-term ethnography. We consider that a designer/researcher conceiving a PD activity could introduce these ingredients by seeking appropriate answers to questions which we, in the course of our research, asked ourselves, such as: Where do people interested, or potentially interested in the intended experience, usually get-together? What type of activities do they usually undertake? To what degree are these activities related to the topic of the design study? How can the future technology or service be simulated and embedded within the selected activities in a way that empowers participants to contribute to them?

As (Brandt et. al., 2013) claim, PD, through its tools and techniques, has moved from solving problems to creating everyday design opportunities, "in the early years, tools and techniques of participation were seen as essential means to remedy a professional process of systems design. Today the tools and techniques are brought forward through practices of design participation in many other and very different fields, where they form constituents parts of the activities people are involved in" (p. 145). A deeper understanding of PD seems therefore necessary to make it more widespread and suitable for the design task at hand. In hindsight, the questions posed above helped us create a participatory mindset in the PD studies. We discuss this aspect our PD approach further below.

F.2 Participation in design through an ethnographical lens

Whilst "most Participatory Design projects are carried out within a relatively short timeframe" (Brandt et al., 2013, p.161), this paper, with PD activities conducted with (a) children over the course of a 4-year PhD thesis, which focused on wearable computing and free-play, and (b) older people in a 2-year project, preceded by a decade of HCI research with this segment of the population conducted by two of the authors, 'swims against the tide'. This (very) long-term aspect is worth discussing, especially if we consider that "investment in user studies (is) a big and expensive step" (Sanders and Stappers 2008, p.10). Our research has drawn, heavily, on classic, long-term ethnography, which we occasionally combined with other forms, such as quick-and-dirty or rapid ethnography (Millen, 2000; Randall, 2007), in long-term user studies. Our PD research was therefore intertwined with ethnography. Thus, it might come as no surprise to see that when we were faced with challenges in PD, we turned to three core elements of traditional ethnography: everyday settings, taking a holistic view and a members' perspective. We have shown, in *Section E*, how we got ourselves immersed in two communities, identified key activities, goals and practices, and witnessed how participants behaved when a yet-to-be-designed technology was integrated in some of their everyday activities. These ethnographical elements were mapped onto specific ingredients of our PD approach, namely, community, simulation and embedment. Framing the PD studies in established communities allowed us to conduct them in the everyday settings "in which the activities of interest occur" (Blomberg and Karasti 2013, p.88). The simulation "points to the importance of understanding activities with reference to the larger setting and array of related activities", which is related to holism (p.88). The embedment relates to taking a member's perspective by identifying and making the most of the participants' skills, interests and habits. Other key elements of ethnography, such as being both descriptive (Blomberg, 2003) and able to adopt etic/emic perspectives while gathering, analysing and reporting data (Fetterman, 2010), and ways of looking at ethnography (e.g. textual constructions of reality (Atkinson, 1990), might also be useful to reinforce, or find a source of inspiration for, the participatory mindset indicated above.

While PD is often (and has traditionally been) conducted at initial stages of design to get the concepts right, and, more recently, with the advent agile software development (Beyer, 2010), also at the end, the long timeframe characteristic of our research enabled us to carry out PD at intermediate stages of the projects as well, where many design decisions have to be made, often without the involvement of the participants (Vanden Abeele and Van Rompaey, 2006). Our research "reposition(s) ethnography not as a tool for design but as deeply integrated into the doing of design" (Blomberg and Karasti 2013, p. 99), and shares with (Botero and Hysalo, 2013) the goal of 'design-in-use', at intermediate stages, between ideation and implementation, because design is not separated from the intended use of the interactive system. Their "ageing together" concept leads us to discuss community aspects of our approach next.

F.3 Community, embedding, simulation and empowerment revisited

PD is a key element of second wave HCI studies (Bannon 1991), which were typically conducted in communities of work (e.g. an office) (Button and Sharrock, 2009). The shift towards User eXperience, typical of the third wave HCI, might incur in risks of "moving away from a commitment to users towards a more exploratory take-it-or-leave-it approach where designers seek inspiration from use, e.g. through cultural probes, rather than collaborating actively with users" (Bødker and Halskov, 2012, p.149).

In (Disalvo et al., 2013), the claim for "collaborating actively with users" stands out: "community-based PD foregrounds the social constructs and relations of groups in settings that include, but go well beyond, the formal organisational structures commonly foregrounded in more traditional workplace studies". Our PD approach provides a more concrete formulation of relevant 'social constructs' and 'structures' in the two communities where we conducted our PD studies (e.g. goals, such as learning and playing, and enabling activities, such as ICT courses and preparation of a play). The 'relations' element resounds with regarding users as social actors (Sayago 2010), as shown in the public game recruitment.

PD is a "vibrant environment for the discussion and dissemination of new tools and techniques" (Brandt et al., 2013, p.145). Thus, it is worth discussing further how our PD approach relates to existing tools and techniques. The embedding approach builds on Cooperative Inquiry (Druin, 1999), which is "an approach to research that includes three crucial aspects (…): (1) a multidisciplinary partnership with children; (2) field research that emphasizes understanding context, activities, and artefacts; (3) iterative low-tech and high-tech prototyping". Our approach provides a specific meaning of partnership: involvement of the researcher/designer within a well identified and understood community, which is itself the 'context' where the field research is done. Our activities are conducted and embedded within a community, and are meaningful to the participants. These activities are, or might be, slightly modified with the intended interactive experience. The prototyping aspect of the activities that we carried out used 'artefacts', such as paper-based maps. To be more precise, we used adaptable prototypes, which strike a balance between participants being able to contribute to the creation of a prototype and not missing their role as users. This adaptable prototyping therefore allows participants to focus on the intended experience as a whole rather than only on the particular digital interface, or in the techniques to create a prototype. In the embedding approach, distinguishing between low-tech and high-tech prototyping is less important than being able to adapt the prototype to the interests of participants, as these emerge during a PD activity. In both PD studies, this adaptability was achieved thanks to the face-to-face interaction of the researchers/designers with the participants, or amongst those participants who appropriated the intended experience and put it into practice.

"The heart of Participatory Design is participation" (Brandt et. al., 2013, p. 147). (Vines 2013) states that "participation can happen at very different degrees of engagement" (p. 432) and "although researchers act under the pretext of sharing control with users, they still act as interpreters through which activities are organised, discussions facilitated (…) and the fact that very often user involvement occurs in 'design sessions' or 'workshops' illustrates (…) that this is the language of the designer and not those of 'users'" (p.435). We have empowered children and older people to contribute to our PD studies by making the most of their skills, interests and knowledge, instead of asking them to do activities they do not enjoy doing or playing roles with which they are or feel unfamiliar. Examples are asking older people to bring back memories of their neighbourhood while playing a game in a community event, or challenging children to improve their performance in a play by augmenting their characters with 'cool' technologies. This empowerment aided in building a participatory mindset amongst the participants (not only researchers/designers) too.

F.4 Two main limitations and opportunities for future work

The results might not be extrapolated to other communities. Although this was not our objective, to try to address this limitation, at least, partially, we evaluated the interactive systems with participants who had not partaken in the PD studies, as we have indicated in *Section E*. This generalisation of the findings might also be hindered by the heterogeneity of children and older people. As stated in the introduction, children are "an entirely different user population with their own culture, norms, and complexities" (Druin, 2002, p.1), and "older people are different" (Gregor and Newell, 2001). We do not argue against diversity. Instead, we consider that it should be supported, as we did in the KGP and WSK, and that it can be seen as a future research opportunity. In particular, our PD approach has portrayed children, and especially, older people who tend to be reported as technophobic, as lead users (Hippel, 1988). While this view might be restricted to the communities we worked with, this portrayal of children and older people begs the question, which future studies can address, of how they can effectively inform the design of future technologies and not only the re-design of existing ones.

While we have discussed a number of concrete aspects related to PD and ethnography, the community component of the paper, despite its relevance, has been touched upon only in passing. (Disalvo et al., 2013) argue that "community-based PD foregrounds the social constructs and relations of groups in settings (…)", but what are these social constructs, how do they relate to each other, and how do they contribute to HCI? Our (ethnographical) immersion in the communities has been a double-edged sword. On the one hand, we have argued above that relevant social constructs for PD in the communities in which we work are the activities, the interests of the participants and their different roles, such as creators, mediators and passers-by. However, and on the other hand, there might be other social constructs and relations of groups that we did not see, because they (probably) became invisible as we got ourselves immersed in the communities. This is, at the same time, a limitation and opens up a number of research questions. For instance, are there social constructs that cut across community-based PD, and if so, what are the elements of such a community-based PD framework?

G. Conclusions

In this paper, we have identified four key challenges (abstraction, affinity, recruitment and empowerment) to carry out PD with children and older people in such a way that it empowers them to make significant design contributions. We have introduced a novel PD approach, which we have called the embedding approach that copes with these challenges. Three core principles of ethnography, everyday settings, taking a holistic view and a members' perspective, are its kernel and mapped onto the three ingredients of the embedding approach, community, embedding and simulation. We have shown how they were implemented within the framework of two projects, with children and older people, and the extend to which they were successful. We have tried to provide specific formulations intended to be helpful to designers and HCI researchers. We have positioned our PD approach within Participatory Design and related concepts, and discussed its intertwining with ethnography and fit in HCI waves.

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4. Conclusions

This dissertation has dealt with the conception, (participatory) design and evaluation of three playful accessories, FeetUp, Statue and the Wearable Sounds Kit. As stated in the introductory chapter, this dissertation aimed to address three main questions. For each one, we summarize the results, i.e. answers provided throughout the dissertation (mainly in Chapters 2 to 3), and the main contributions.

4.1 Research questions, results & contributions

Question 1. How did FeetUp, Statue, and the Wearable Sounds Kit, fitin and enrich free-play amongst school-aged children? How do thedesign features of the PA relate to the dimensions of free-play?

We evaluated the three PA accessories in several scenarios of free-play. While FeetUp and Statue were both evaluated in more initial studies and the environment was quite restricted, the WSK was evaluated in a detailed and extensive way, taking care the environment was not restrictive. All evaluations have shown how kids made creative uses of the PA in typical children-driven play, who were able to express themselves with the WSK, improvised with Statue and were spontaneous with FeetUp, configuring the typical free-play described by Callois (1961) and summarized in the introduction. Since all the PAs provide no predefined goals or rules, the games elicited had no logical ending point.

The simplicity of Statue allowed kids to start playing with it inmediatly. Moreover, Statue allowed them to improvise in everyday games related to being statue, creating new goals and rules by themsevles e.g. they played statue and seek, as a variation of hide and seek. With FeetUp, kids got spontaneously engaged in activities in which jumping played a key role, such as breakdancing or gimnastics. FeetUp also encouraged kids to share their personal activities with others, thereby creating social challenges. The WSK encouraged free-play amongst school-aged children (7-12 years) and teenagers (13-17 years). It was so simple to understand that children could start using it inmediatly. The explorative options of the accessory, such as the list of 30 sounds to choose, enabled them to find personal connections with the accessory, creating personal experiences and expressing themselves through fantasy, rhythmic or body play. The ambiguity of some sounds sparkled the imagination, since they were challenged to provide some playful meaning for it. In this sense, the sounds of everyday objects were more playful than the sounds of musical instruments, since the former provided imaginary playful objects. Girls and boys were both engaged in free-play. However, girls devoted more time to the explorative phase of playing, while boys moved to action more directly. Social play was apparent, but the quantitative analysis was not conclusive.

How do these results contribute to free-play research? Most studies of free-play technologies have not turned to real-life experiences to inform the design process. In this dissertation, however, grounding playful accessories in real-life experiences of free-play has been persistent throughout main stages of design, from conception to evaluation. Thus, this dissertation has introduced a research/design paradigm to understand, in a deeper way, free-play technologies, and to design and evaluate these technologies in a way that truly fit in and encourage this type of play. Given that free-play is a chaotic activity (Callois, 1961), the crux of this paradigm is to conduct natural research methods to have participants involved in all – or in most of - the stages of the design of new free-play technologies. By 'natural' we mean research methods commonly used in ethnography, such as first-hand observations and conversations, because these methods enabled us "to understand 'the member's point of view'"(Dourish, p.542), are conducted in settings "in which the activities of interest occur" (Blomberg and Karasti 2013, p.88), and place an "increasing emphasis on the social organization of activity" (Dourish, p.542).

Question 2. Are there new design opportunities to create interactiveobjects that encourage free-play? If yes, what are these opportunities?

Building on the design of the three PAs, this dissertation has opened up a number of design opportunities to create objects to encourage free-play. Examples of these design opportunities are to (a) exploit the relevance of playful 'wearables' to encourage free-play on the move, when structured entertainment is not an option or a difficult one; (b) use individual objects that fit in with the natural process of social play, including the transition from solitary to imitation, observation, parallel play, and finally to associative and cooperative play (Parten, 1933), and (c) capitalise on the relevance of no digital network amongst participants to allow them to create their own play network, defining their own rules and goals.

How do these results contribute to free-play? Rather than conceiving interactive free-play from the point of view of augmenting playgrounds and/or playful objects, this dissertation proposes augmenting everyday clothes with Playful Accessories (turning them into PA could be an alternative) to encourage free-play on the move. The body of the children is the most important (along with their creativity) element in their free-play, and the hectic lifestyle led by many kids urges us to ask ourselves the (fundamental) question of how free-play technologies (can) fit into their lives, question that plays a key role in the transition from technologies to massive products. The three Playful Accessories discussed in this dissertation can be seen as practical examples of these design opportunities, which might be regarded as far-fetched, and creative uses of digital technologies enabled by emerging interaction paradigms, such as wearable and ubiquitous computing, which, in light of recent technological developments, are likely to be important in the near future.

Question 3. How can we conduct Participatory Design with childrento empower them to contribute in the design of playful technologiesfor them?

This dissertation has introduced the embedding approach in an attempt to empower children in the design of playful technologies with and for them. This approach embeds PD studies in their everyday activities conducted in communities of practice, by slightly modifying them with the intended experience. In this way, they are involved in the PD studies by using their skills, interests and habits. Thus, the PD activities are meaningful to them, and they have the proper context within which to expand their creativity and contribute effectively to the design process.

How do these results contribute to PD? First, the embedding approach is novel. While ethnography has often been used as a means to inform PD (e.g. implications for design, source of inspiration), this dissertation has introduced a way of intertwining ethnography with

PD by using core tenets of the former. Second, the embedding approach has proven to be effective with children and older people. Third, the embedding approach concurs with the current trend towards community-based PD.

4.3 Discussing the contributions in a broader sense

The research approach proposed in this dissertation concurs with the move towards integrating ethnographic methods with all the stages of interaction design (Blomberg and Karasti, 2013). This is a challenge, and we have addressed it by embedding the design research in the everyday life of participants, as opposed to conducting ethnographic observations of design activities with participants, which predominates in current research.

Within the current research scenario of free-play technologies, which has been reviewed in the related work of the papers presented in this dissertation, the context limits considerably the experiences encouraged, since user studies are often conducted in unfamiliar or restrictive environments for children, such as laboratories, and/or with time restrictions, tacit commitments, and with fixed play partners. By contrast, the paradigm proposed by this dissertation provides a different perspective into current research and has resulted in a number of publications, as well as being supported by a number of studies covering the whole design process, from ideation to design and evaluation.

The techniques and methods employed along the PhD period cover a wide range of scientific tools, from tests of significance to field notes. There have also been specific contributions to methods, related to PD and with evaluation. This variety and selection of techniques, and methodological contributions, gives strong support to the findings, especially if one appreciates that free-play is a complex activity.

This dissertation has adopted and adapted concepts and approaches from several disciplines to advance on the understanding of free-play technologies and school-aged children. As for disciplines, studies of developmental psychology, ethnography and HCI, are areas which have a contribution to this thesis.

The design study was conducted by following a PD approach using ethnographic principles and methods. The idea of integrating ethnographic methods in the design process is taken from previous studies on PD (Disalvo et al., 2013; Blomberg and Karasti, 2013). This appreciation of the relationship between the special theme of the dissertation and the wider field of knowledge is an indicator that the results are grounded in a more comprehensive theoretical body.

Having discussed the conclusions, there are reasons to believe that whereas they can sparkle new research and design methods and ideas, they have a solid scientific basis. Yet, this dissertation does not claim that the work presented here is free of limitations. The most relevant ones – at least, those that we see now - are discussed below.

4.4 Limitations

It might not be possible to extrapolate the results provided in this dissertation to other free-play studies. Methods, techniques and design opportunities are strongly related to (a) the technologies presented to encourage free-play amongst school-aged children, and (b) the everyday contexts of the participants involved in the study. User experience is strongly context-dependent, and further research is needed to see the relevance of our findings in other research contexts. Nevertheless, the evidence obtained with three different case studies, carried out in two different cities and in two countries, and the different uses of the technologies, makes the contributions relevant for these specific contexts.

The observations of free-play might have been interpreted in different ways, and one should be aware of this potential bias, as the researcher is a tool. Nevertheless, having a number of observers in each activity, conducting reliability tests and understanding the relationship with research done in other related areas, gives strong support to the contributions.

No longitudinal study has been conducted in order to test, for example, the prototypes during a more extended period of use. This seems to be of special importance, given that free-play is a dynamic activity, as our results have shown, at least, in terms of free-play patterns and players. Looking at free-play over time could be a very interesting the topic for future studies.

Even with these caveats, the contribution made by this dissertation suggests that there is space for continue exploring design concepts and research methods to find proper objects encourage free-play, and it is required in order to get the impact the industry with feasible free-play products.

Future work perspectives are summarised next.

4.5 Future work

I plan to address the question of how to move from research to commercial products. I aim to make free-play technologies that improve free-play and are suitable for the market. The prototypes developed and presented in this dissertation, when discussed with industry partners, were seen as too technically complex for clothing industries and out of the scope of toys industries. In my future work, I aim to strengthen my research by working along with industry partners.

Working toward this end, this dissertation has provided a set of new design opportunities, especially the use of ambiguity as a resource to play and the use of individual play objects to encourage social play, that I would be interested in validating in the design of new technologies for free-play, as these opportunities seem to hold great potential for generating more concepts and products.

An important element of this validation process will be to conduct long-term user studies, in both open/public and more private contexts. Towards this end, autonomous prototypes should be developed (only on and off button should be required to use it). This can contribute to understand how interactive textiles can contribute in the everyday life of child development.

With respect to PD, I would like to continue validating the embedding approach presented in this dissertation, in other contexts of research beyond playful interaction, to contribute in the research of the intersection of PD and ethnography.

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ANNEX I. Research activities surrounding this thesis

1. Freeplay technologies research, complementing the content of this PhD

In addition to the papers presented in the body of this dissertation, three papers have also been published in international peer reviewed conferences or workshops and one master thesis was supervised. I outline the content of the papers related to Chapters 2 and 3.

(Rosales, 2010) is a position paper that presents the dilemma between structured games and informal play, to define free-play in the developmental psychology context. It introduces the relevance of free-play to prepare children to face adult life and define personality, including developing physical and social skills. It presents work related with objects encourage free-play using sensing and reacting technologies. For kids between 3 and 6 years old, objects that focus on physical play, and for children between 6 and 9 years old, objects that focus on social interaction.

(Rosales et al., 2011b) presents Feetup, augmented shoes that blink and beep when jumping. It presents the participatory design study, that lead to the design of the prototype, and also point at, the challenges PD of managing children's creativity into products that would be possible to develop. This preliminary PD study motivate further research on how to adapt PD techniques to children's skills which is expanded in Chapter 3. It also presents an explorative evaluation technique, which describes the relation of the experiences children in first session with FeetUP with Free-play values. According to that preliminary evaluation, FeetUp motivate spontaneously children to physical play, open-ended rules play, fantasy play, collaborative play, and were engaging.

(Rosales et al., 2011a) stresses the relevance of creating new objects for free-play by building on the routines, objects and activities related with free-play to assure its successful integration on the everyday life. Thus, based on observations of around 240 kids during free-play sessions presents the concept of Playful Accessories. Playful accessories, propose the development of free-play technologies that takes advantage of those boring moments, when, for the benefit of free-play, there is no access to structured play, but kids are looking for something to play with.

An MSc project (Tirado, 2012) explores the use of digital technologies for stimulating physical activity during collective free play through the use of FeetUp in three different coordination conditions. This explorative study was carried out with four kids in after school center in Barcelona, Spain.

1.1 Collective creation of games using free play technologies

Rosales, A. (2010). Collective creation of games using free play technologies. In proceedings of Interaction Design and Children (pp. 335–339). Barcelona, Spain.

Available at: http://dl.acm.org/citation.cfm?id=1810607

Abstract

From the age of six children are developing important social skills, often through play. However, many children now spend most of their leisure time interacting through screens, rather than developing face-to-face social skills, which are also important for adult hood.

Using augmented technologies to stimulate children in the collective creation of games could contribute to developing these social skills. Related work with augmented technologies for play does not take into consideration the evocative power of the objects to be augmented. We aim toidentify objects, which are particularly evocative, and makethem interactive through augmented technology. We will also draw on the basic rules of traditional folk games to create toys, which genuinely stimulate social skills.

We present two early prototypes designed to investigate both the way in which children perceive feedback from different sensors and actuators and also their ability to construct their own games with those objects.

Categories and Subject Descriptors

H.5.1 [Information, interfaces and presentation]: Multimedia Information Systems - Artificial, augmented, and virtual realities.

General Terms

Human Factors

Keywords

Augmented technologies, interactive toys, folk games, social skills.

A. Introduction

Currently children spent most of their leisure time in front of screens [1], [16], [18] TV, video consoles, computers and so on; in addition, the market is full of entertaining and stimulative technologies for structured games, such as tabletop games, video games, and the Wii. Thus, there are little opportunities for children to have face-to-face interactions playing with other children and to creating their own games. Having face-to-face interaction, combined with the ability to create their own games helps children develop their social skills (quite important in adult life). We propose the use of evocative objects, objects that inspire different histories, context, meanings or uses for children, augmented with technologies as a way to encourage children to move away from screens, have face to face interaction and participate in the collective creation of games with their friends.

A.1 Infancy and development

At this age, a child's skills are in the process of developingand can be accomplished with adequate stimulation [20]. Good stimulation can prepare children to face adult life with the appropriate skills to get what they would like being and behave integrated in the society [11]. Besides that, social skills development contribute on define child personality. Digital technology has become an important influence in the last years and could also be used to influence the development of social skills.

6-9 Years development

6-9 years old children are in the process of developing quite important skills related with social activity in addition to physical skills and rational operations.

Through verbal communication they experience an explosion of social relationships; relationships with friends and classmates become the center of their attention. They are starting to state their own points of view, accept to negotiate, make agreements, deals and accept to cooperate. Rules become an important subject in their life because they are learning how to deal with them. [11].

Figure 25: LED ball

Many projects have been developed using technologies for free play; some of them are appropriate for 3-6 years old activities: Pathway [14], Space Explorer [15]. Most projects have been focused on stimulating physical play, while social activity have been regarded as a parallel aspect to develop: Interactive Tiles [9], Morels [6], Flash Poles [17], Battle Tank [1], Led Ball [17].

Around the age of 9, children should start making longer sentences, follow a long sequence of rules or instructions, should be able to pay attention during longer periods of time, an should have a certain experience on how to deal with failure, frustration, tolerance, self acceptance and collaboration. All these are crucial social skills for the future adult. Some projects have been designed to stimulate social interaction by providing open-ended scenarios: Morels [6], Boxology [4] Ferris02, LED Ball [3], see Figure 25.

Alternative proposals should be developed to contribute on the general understanding of the subject. We aim at researching free play activities done by 6-9-year-olds and developing appropriate toys that will cultivate those social skills starting to evolve at this age.

Face-to-face Interaction

Recently, children are being subjected to a lack of face-toface social interaction partially caused by a saturation of screen based entertaining formats [1], [16], [18]. Children spend their leisure time interacting with screens: watching TV, playing with consoles, or chatting on the computer, which reduces the time to be spent in face-to-face interactions. Some of those activities do imply interacting with other children: participating in social networks, communicating through chat clients, playing games in computer networks or online, using collaborative tools. However, when their interactions are almost exclusively being mediated by technology, it is their face-to-face communication skills the ones that have to suffer.

A.2 Play

Play is not only the core activity for children; it is the main activity in a young individual's development [13]. The attitude of the child is setup for play; he (or she) will have a whole set of situations to discover and skills to develop for their future adult life and play makes it easier.

Play is the imaginary, illusory realization of unrealizable desires but appropriated through play [10]. By playing, children develop social, physical and cognitive skills [5]. Free and unstructured play is essential for helping children reach important social, emotional, and cognitive developmental milestones as well as helping them manage stress and becoming resilient [5].

Free Play

Play refers to a range of voluntary, intrinsically motivated activities that are normally associated with pleasure and enjoyment. Some instances of play have clearly defined goals and they are structured by rules (in which case we refer to it as "a game"), whereas other forms of play exhibit no such goals or rules, it is considered to be "unstructured" and referred to as "free play".

During free play the child uses all of his (or her) potential to entertain himself. He starts from scratch and uses his own interest, motivations and surroundings. Furthermore, while engaged in free play with other children, the group will use the sum of resources and ideas to play together.

Many authors have contributed to define free play: free play is voluntary, spontaneous, involves a pretend element, it is engaging, fun and pleasurable [8]; it is collaborative [7] and involves physical movement [19] and it is always open-ended [3].

There are many projects designed to stimulate play by using sensors and actuators on different kind of objects. Some of these projects have decided to augment playgrounds, like Flash Poles [17], Boxology [4], or Pathway [14], while others make use of shared objects: the Led Ball [3], Space Explorer [15] and Morels [6] or closely relate to individual objects, such as Spookies [19], Battle Tank [1], or Heart Beat [18], see Figure 26.


Figure 26: Heart beat

Games

On the other hand, a multitude of entertaining and stimulative games is available on the game market. It includes sports, tabletop games, video games or the Wii. Structured games are fully designed, the child has to reach a specific goal following the rules and the pre-set game path. The challenge is to discover a way to reach the previously set goal.

Toys

A toy is an object that inspires people to play; they are the center of children's play. In a child's hand, an inspiring toy transforms: a child will imagine a story, a context, a purpose and several uses for it. The toy becomes a link between what he imagines and the external world. He will subsequently explore his surrounding environment by making use of the toy.

Sometimes, it is worthless to integrate technology into toys, for example when the advanced possibilities will never be used. The affordance of a simple ball is very strong; a child will not need nor want to play with an augmented ball. [12]. Others attempts of augmented balls that are meant to motivate children to play, such as the Pinball Football [2], or the LedBall [17], have no clear results indicating that children prefer to play with a normal or augmented ball. Ballons are structured toys; children have learned culturally how to use them; a ball is used to kicking, for dribbling and score goals.

We believe there is a lack of well-defined criteria to select the object to be augmented. Sometimes simple objects, such as bag or a stick, could become a toy for a child. Those objects have no predefined meaning, uses, or goals, which allows them to evoke different states; these objects let children imagine diverse situations, uses, and context. A stick could be a sword, a bridge, witch, castle, horse, walking stick; and in children's hand could be even more things. Evocative objects afford better free play because it let the children spontaneous involve their personal feelings, thoughts or context, and finally let them imagine and create their own games.

In the Boxology [4] project, they choose boxes because they found that boxes inspire children to play, and this would make augmented objects playable. Cardboard boxes affords free play, voluntary use, spontaneous exploration, and make children imagine a multitude of stories to play.

Folk Games

Folk games are ancient games, transmitted from generation to generation through oral culture. Similar games are known in several cultures with different names: the "tag" game in USA, known in Spain as "corre que te pillo", or the "hide and seek" in English known in Spanish as "Escondite". Since most of those games are learned by oral culture, rules are not completely setup. In addition, they are continuously transformed during the game by its players.

We have heard about Freeze tag, British tag, Chain tag, and so on, all of them free versions from the basic tag game. With its unstructured rules, face-to-face interaction, free body movements and open-ended goals, folk games stimulate free play and spontaneous development of social skills. Folk games, inspired in casual, physical games often played by kids have been used to investigate how to encourage the improvising of new games [6], [18]. Through the collective creation of games, children deal with the problem of bringing ideas, building concepts, getting support for it, negotiating and reaching agreements, and this way they develop social skills for adult life.

B. Proposal

Our proposal explores the use of sensors and actuator technologies in objects - that are to be identified - building on their evocative power to inspire free play. This would stimulate the collective creation of games that may contribute to the development of a child's personality between the age of six and nine. We suggest an alternative approach to continue research on this topic by building on the evocative power of certain objects and using folk games rules systems as inspiration.

From six to nine, children are starting to discover that they have individual thoughts and that they have their own personal point of view [11]. This discovery involves an active exploration of their own opinions and learning how to accept, negotiate, make agreements, deals or cooperate with other people. Invaluable social skills are developed in this stage and we believe digital technology could be used properly to contribute on this development.

Based on the related work, we conclude that stimulating the collective creation of games, social interaction and openended games is a relevant topic that can contribute on children´s ealry development and that augmented technologies could be used for it. Augmented playground or toys take advantage of children´s natural ability and interest to interact with new technology and encourage them to play [17]. Sensors and actuators technologies used to make thinks react interactively, actively feedback and motivate children to play. Furthermore, evocative objects, augmented with technologies and connected in a network to exchange stimulus, could stimulate children´s interaction to create games together.

Evocative objects are unstructured objects that haven't been designed for play, and/or could be used for several purposes, such as a stick, or a bag. Since there are no specific rules about how to play with a stick, a costume or bag, these objects allow children to imagine diverse uses. Adding technology to connect sensors and actuators in a network of these evocative objects, could stimulate children to interact with each other and create ways to use them in their games. This would also allow the invaluable social experience that lets them develop social skills essential for adulthood.

Folk games are ancient games transmitted from generation to generation through oral culture. Those games are relevant to our research firstly because they are played in face to face interaction, where social experience becomes an important issue and secondly because children develop and contribute their own rules to the pre-set rules of the game. Since the games are transmitted from generation to generation, rules are not used based on written information and they are not completely closed; often children start to make versions of the original idea, getting involved in a process of collective creation of games. The study of how contemporary children play folk games and they ways in which they transform them could guide the development of new toys for open-ended games.

For weal or for woe, children have changed dramatically the way they spend their leisure time. We should understand which are the folk games still played by children, what is the way in which they are played nowadays, and how playing has contributed to the collective adaptation of those games.

After further research in the area of the evocative objects and folk games played by present children, the project would focus on how to enhance those objects with technology and get long-term stimulus for social interaction. Our goal is to find and understand both the ways in which sensors can motivate children and their perception of actuators and augmented objects and subsequently discover the best ways to augment objects and inspire children to play.

C. Early prototypes

Two early prototypes have been developed for us to start familiarizing with the technologies and children's habits for play. Both are individual objects to be used by a number of players at the same time. Our objective is to observe the ways in which children react to specific sensors and actuators (accelerometer, LEDs, speaker, infrared sensors and receptors), whether there is interest in exploring the objects or not; if they are likely to start playing with them and to observe the way in which they use an individual object simultaneously used by other children around. We want to see if they start playing together and which are the games they play. This experiment would provide the basis for proving the initial hypotheses and guide our research in this line.

The first prototype is a glove that allows interaction without touching. Its creation was inspired by the evocative power of costumes and by folk games, such as "the duel", "tag", "hide and seek". However, we hope that in a child's hand the glove would be used for many other different games. Each child will have a glove augmented with infrared led and receptors, speakers and a micro-controller. This way, one player will have the power to send an infrared signal to another and generate a sound that both the first player and the second can hear. The second player could try to avoid receiving the infrared signal or try to get it, hiding or showing the sensor with his body.

The second prototype is a movement display designed to make a player aware of another's movements. The prototype is inspired by the use of one's own body to play and by folk games that involve freezing moments such as “Stop”, or "Freezing Tag". Each child has an accelerometer attached to their hips, a super hero like shield with LEDs display to show whenever he / she moves, and a microcontroller.

The first next steps would constitute of testing the prototypes with children to receive first feedback about their collaborative creation of games, and then continue the iterative design.

D. Conclusion

Valuable works have been developed on the theme of free play and its relation to early age development; our proposal and early prototypes continue this research line and deal with social interaction development by using evocative objects and folk games as source of inspiration.

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1.2 FeetUp: a playful accessory to practice social skills through free-play experiences.

Rosales, A., Arroyo, E., & Blat, J. (2011). FeetUp: A Playful Accessory to Practice Social Skills through Free-Play Experiences. In IFIP Conference on Human-Computer Interaction INTERACT (pp. 37–44). Lisbon, Portugal.

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Abstract

In this paper we describe the design process of an interactive accessory to play anywhere and anytime while encouraging free-play and practice social skills. We explain the design process, the resulting conceptual design of FeetUp and the preliminary user's evaluation. FeetUp is a playful accessory that takes advantage of children's interest to jump, or perform body stunts. These activities generally include lifting both feet, and FeetUp gives audiovisual feedback whenever this happens to encourage free-play related with jump activities. Preliminary user's experience shows how FeetUp, encourages freeplay.

Keywords: free-play, children, playful, augmented technologies, social interaction, wearable.

A. Introduction

Children are in continuous training and their way of being will be strongly influenced by all their current experiences [12] [8]. By playing children mimic other's experiences and learn about it [10], this way they build their own values and develop new skills.

Many authors have discussed the correlation in children's life between their increased interest on screens (either television, videogames, computer, mobile phone, or others) and their lower physical activity and/or social interaction [1], [11], [14]. More interest on screens prevents them from experiencing valuable face-to-face interaction important for practicing social skills, which could be developed through free-play. Free-play can be open-ended, spontaneous, physical, collaborative, engaging, fun, pleasurable, and usually involves a pretend element [17].

Several projects have explored the use of objects to encourage free-play [1], [9], [4], [16]). Some of these objects are designed to stimulate physical play, and regard social activity as a, secondary goal. Other objects have been designed to stimulate social interaction by providing open-ended scenarios [9], [7]. However, in most cases the object to be augmented lacks well-defined selection criteria, or its interaction affordances does not add value to free-play. E.g., the interaction design proposed by Ridén for an augmented rubber ball was not useful [16]. The authors noticed that "the interaction enabled by its flashing lights was not used at all" and they concluded "the force of affordance of balls is very strong for children".

Our approach focuses on understanding children's interest, habits and routines related to evocative objects and free-play activities. We use this knowledge as initial requirements to design and create evocative objects that encourage social interaction through free-play. In this paper we present FeepUp, an evocative object designed to encourage children's to play using their bodies to jump, roll, perform handstands or any other stunts collaboratively with their friends. We describe the design process, the resulting conceptual design of FeetUp, including the object design, its interaction rules, and the physical setup. Finally we present preliminary results indicating that FeetUp encourages free-play and discuss opportunities for future work.

B. Design process

The design process started by two ethnographic studies aimed at understanding, the relationship between free-play and children's routines, in order to identify the implications for design [5]. This sets the framework for designing playful objects to promote free-play by involving children in the design process [6] through brainstorming, iterative prototyping and evaluation.

B.1 Children and free-play

In a preliminary ethnographic study, we used traditional methodologies, such as observing children in their natural play settings as observer-participants note taking, and then categorizing the collected information [2].

We followed children's between 6-9 years old while playing in Barcelona during 24 sessions in parks, school patios, and their homes. We documented children's relation with free-play, what they do, and what objects they use during free-play sessions. We registered our observations in a notebook, and then we categorized the observations, to extract relations between objects, activities, games and social interaction related with free-play.

From this process emerged that the most common object in children's activities or games is their own body. They naturally played games related with physical challenges with their body. We identified several free play challenges they typically find in their body, such as playing against gravity, aim, coordination or visibility, attention, strength, etc. Each challenge is related to many activities or games. For example, while playing with gravity, they enjoy handstands, handholding, hanging, hand walking, somersaults, tumbles, or carrying each other.

B.2 Children's routines

A second ethnographic study identified opportunities on children's routines for free-play. We documented the routines of 8, 2 to 4 members families, all of them with at least one kid aged between 6 and 9, as participant-observers [2]. We immersed in their spare time activities and conducted unstructured interviews [2] with parents.

The study indicated that children's routines lack spare time or free time. Family routines are full of duties, and children's time has to be planned according to them. In addition to attending school, practicing sports, and doing extracurricular activities, children are also participants in many of their family's tasks, like going to the supermarket or visiting their aunt's house or following their brother's activities. However, free-play can also happen in parallel to other activities, like playing while shopping, during a family visit, or on the road.

Objects designed to stimulate free-play should be small enough to be taken along while going out, and practical enough so that children can always carry them. Objects could also be embedded into smart clothes and offer additional value as suggested by Steffen [15]. As children wear clothes all the time, they can act as playful objects to allow children to play whenever they have an opportunity, whereas at on the road, on a waiting room, or at the store.

B.3 Brainstorming with children

The Current design trends suggest that children should be part of the design team in order to voice their opinions and inform the design with their own interest, emotions and feelings [6]. For the design of FeetUp, children collaborated with researchers, providing ideas for interaction and providing useful information about adequate ways to stimulate free-play. At the beginning of the process we presented children with sketches of 5 imaginary powerful accessories. (See Figure 3).

We explained to children that these objects were powerful ("magical", and "limitless"). In order to evoke children's imagination, we asked them to describe and explain the sketches: what the pictured kids where doing, and how the pictured devices would work.

This process provided many interaction design ideas for many playful accessories, and also provided valuable insights to identify the most adequate accessories to stimulate body challenges in diverse playful situations. For the final selection, we considered only playful accessories that could be developed with existing hardware. We selected three playful accessories that elicit numerous opportunities to practice social skills and allow them to imagine several situations and evoke possibilities for play making use of body challenges. The selected projects include FeetUp, Statue, and Gloves The two other projects were developed at later time.

B.4 Wizard-of-Oz and Imaginary Experience

We started the iterative design process with early prototypes, to validate the concept, and verify if the prototype could be used for what it was designed for. Several sessions allowed children to test every new improvement, and re-arrange the pieces to fit their bodies and interests. The first iterations demonstrated the ideas with a combination of wizard-of-oz and partially functional prototypes to test and validate the initial concepts. At the beginning, part of the functionality was implemented and the rest was operated manually activated sensors. This method was used to illustrate how some of the accessories would work, facilitating the user to imagine experiencing and playing with each accessory. This gave us important insights to evolve the design according to how users imagine this will be working and what for.

B.5 Iterative Prototyping

We improved the original design according to users' feedback and introduced several new functionalities that emerged from interacting with the objects themselves. For every test we invited a new user to a playground to play with the prototypical accessories and drew conclusions about how to improve the design, considering how users spontaneously used the device? What for? And how users expected the device to work?

The results of every new test guided the following iteration in the design. This process finished when the prototype was fully implemented and the concept was validated with individual users. Trough validation, users confirmed that they managed to practice diverse activities with the accessory and imagined games where they could use it. Important improvements emerged from user's ideas about how to arrange sensor to properly detect jumping, how to arrange the actuators for visibility, or the kind of feedback they expect to have in the games they where imaginary playing.

C. Conceptual design

FeetUp is a playful accessory embedded in a pair of children's shoes that provides audiovisual feedback whenever the user jumps or is off the ground. (See Figure 10). FeetUp is similar to popular shoes that light while walking, but FeetUp demands additional effort as kids have to jump to get the feedback. Since games and playful activities have to have some degree of challenge [3] [13], increasing the difficulty to get the feedback opens a gap to make more interesting plays around it.

FeetUp stimulates children to play against gravity, one of their most frequent activities related to free-play. Giving feedback while jumping lets each child share his jumping achievements with his colleagues, and when several children have the same accessory, they have the same interest in common and they can have shared goals. While sharing goals they must explain ideas, argue, negotiate, and make agreements, thus they are practicing quite important social skills.

There is no digital network between users, but the common interest is the excuse for them to create a network of shared goals, represented as simple activities or more complex games. They have to propose how to use this shared feedback to play together with this new shoes. The system incorporates a simple rules system so that children have the opportunity to create their own system of rules, challenges and goals based on the basic, but consistent information they receive.

C.1 Object Design

For the object design we considered the use of an existing object children already wear and have with them all the time. Thus we choose a pair of shoes that can be used anywhere, and offer limitless opportunities to play. The audiovisual feedback is directly embedded in the shoes themselves to maximize its visibility.

C.2 Interaction rules

The interaction system reacts to only one factor; children jumping. The shoes rules give feedback when children are jumping; they blink and play sounds when both feet are not touching any surface.

C.3 Physical Setup

The setup includes 4 touch sensors, 2 microcontrollers, and 2 emitter and receiver radios, 2 LED arrays, and 2 piezo speakers. The setup includes two pressure sensors placed on the insole inside each shoe (one in the base of the heel and another on the sole), thus allowing us to detect when each foot had been completely lifted from the floor. A microcontroller in each foot reads sensor data, validates that both sensors have been de-activated, and sends a radio frequency signal read by the other device. When both microcontrollers confirm that all pressure sensors have been de-activated, they trigger the LEDs in the surface of the shoe and make a sound alert with a piezo speaker.

D. Evaluation

A pair of children tested the final prototypes playing with the shoes in a playground during 30 minutes, in a preliminary evaluation of the project. Researchers did structured observations, to identify how the FeetUp accessory yielded the characteristics commonly present in free-play. Observers took notes during the session, and at the end of it, answered some open questions.

Observers described 7 concepts related with free-play behavior [17], including spontaneous, voluntary, collaborative, open-ended and engaging play, being physically active and with a pretended element. Some observations are described in the following list:

- They enjoyed discovering the accessory and understanding how it worked; they discovered that it blinked when jumping. They spontaneously started to play challenges related on how to cheat the shoes and discovered how to cheat it by making it blink without jumping; moving their feet while sitting, or tiptoeing.
- They exchanged their discoveries, and motivated each other to start new challenges. They paid attention to their partner activities and made comments about them, while collaboratively helping each other.
- They were free to do whatever they wanted in the park. However, they voluntarily moved-on to other jump related activities, and got involved in making the lights blink by dancing, hanging, sliding, or jumping.
- They played games using simple goals, games they were used to. Later they started to adapt the activities to better see the lights of the shoes, to keep the lights blinking longer, or to make the activity more and more difficult in an open-ended encouraging game.
- They engaged in the experience, preferring to play with the accessory rather than playing with games in the park where the testing took place, and the activity occupied all the time they usually spend in the park.
- They were active and had continuous physical activity during the test.
- They described the accessory as "magical shoes" and they imagined that the shoes could give the super-powers and allow them to control others shoes, or other people. However, the accessory was no used as a pretend element.

Fun and pleasure values, also fundamental in free-play [17] were not considered, as they will be observed using an extended framework in future work.

Children used verbal and non-verbal communication while discovering the accessory, while imagine what they could do with the powerful shoes, and finally while playing. With verbal communication they described their hypothesis about the shoes, described their achievements, express satisfaction or frustration, and give support to his friend. Non-verbal communication challenged them to imitate each other, or establish new challenges. This indicates that they where practicing social skills.

Some inadequate ergonomics of the design generated frustration and disappointing experiences in children. This was due to the size and intrusiveness of the devices' hardware, as is also mentioned by Steffen [15].

E. Conclusions and future work

We have presented the design process of a playful accessory to practice social skills through free-play. FeetUp is a playful accessory to play against gravity; it encourages children to perform jumping challenges.

The ethnographic studies gave us important insights to create a conceptual framework which argued that children could benefit with playful clothes, playful bags or playful accessories and that these objects can support their innate need for playing.

The participatory design process, and the activities proposed to involve children in the design process, allow us to involve children's insights, during the entire process and make informed design decisions to fit their interest and preferences.

Future work includes, testing the prototypes with larger groups of children, and evaluating the accessory using a specific framework to identify how FeetUp encourage fun and pleasure. Future work will also consider 1) Developing conceptual designs and prototypes for other physical activities often performed by children in their games. 2) Comparing the results of the evaluation of each design. 3) Define guidelines to design objects to stimulate practicing social skill.

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1.3 Evocative Experiences in the Design of Objects to Encourage Free-Play

Rosales, A., Arroyo, E. & Blat, J., 2011. Evocative Design Process of Objects to Encourage Free-Play for Children. In Ambient GamingWorkshop at the International Joint Conference on Ambient Intelligence.Amsterdam, The Netherlands, pp. 1–4.

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Abstract

In the near future technologies will be even more present in every day objects, which should add a playful value for children, to make use of their natural interest to play while being socially and physically active. We have moved towards this direction by building on free-play experiences identified through a face-to-face ethnographical study conducted over 4 months. The study shows that, beyond the increase of screen based entertainment, children have scarce opportunities for free-play (leading to them being more sedentary). Moreover during free play, they combine the interest of an individual activity, with a personal challenge, while collaborating and competing. Based on these findings we propose augmenting accessories with sensor systems giving feedback while doing specific body challenges. We have developed and tested two prototypes based on this concept: shoes that blink while jumping and a fanny pack that blinks while moving.

Keywords

free-play, social skills, motor skills, multi-experiences, ubiquitous, augmented technologies.

A.Introduction

It is expected that technologies will be even more present in everyday objects in near future. Technologies for children could be introduced in clothes, accessories, simple toys and playgrounds, and some of them can be used to sparkle children's creativity, stimulate face-to-face interaction and free-play to promote social and personal skills, for instance. Researchers have been working around these issues, mostly creating brand new ideas, but alternative approaches could lead to innovative products for final users. We have taken the route of understanding successful free-play experiences through ethnographic lenses to build on successful free-play experiences. This way, technology would add a new level to the existing free-play experiences.

Free-play encourages children to practice social skills, as they have to come up with new ideas together, they have to express, negotiate and collaborate with each other. Free-play occurs when kids spontaneously get together to play, when they are physically active, specially when they choose what to do, and do not have a concrete objective or a rigid set of rules [1], [3], [6], [4]. In spite of this, many factors increase or decrease the opportunities for free-play [8], such as the high interest of kids for screen based entertainment, the increasing number of extracurricular activities or a hectic life style [3].

In this paper we describe the evocative design process of free-play oriented interactive objects. The first phase of the process includes the use of ethnographic methods for understanding children's relation with free-play in specific living contexts. Through this phase we identified objects and activities related with free-play as well as routines and spaces that might influence their free-play. We chose to elicit new ideas with ethnography methods as it provides "a way of getting a first hand view of the ground realities of everyday life" beyond what people say or do and can be captured through surveys or focus groups [1].

The second phase of the process includes applying the evidences emerged from the ethnographic phase in the conceptual design of new objects to build on successful free-play experiences.

According to this process we have created Playful Accessories; clothes that act as playful objects, that children wear all the time and that encourage free-play in unexpected moments.

B. Evocative Design Process

Ethnographic Studio

The ethnographic study was carried out throughout 4 months observing around 240 kids playing in parks, schoolyards and homes in three districts of Barcelona (Spain). The observations were conducted to understand objects, activities and routines related with free-play.

We collected contextual evidences in real life situations using participation-observation, note taking, and informal interviews [1]. We analyzed the data through Grounded Theory [9]: we read our field notes, generated an initial list of open codes, and grouped them into initial categories. The four main categories that emerged include:

- "Let's jump!": Kids in this age get involved in physical challenges, playing with strength, speed, gravity, coordination, etc. Beyond playing with a airplane, a ribbon or with a pebble they are facing physical challenges.
- "I've got no time to play": The daily routine is full of curricular and extracurricular activities and gives no room for free-play.
- "I'm bored": There are a lot of boring moments, such as going to the supermarket, or visit grandparents. However, being bored can be opportunity to sparkle children's imagination and boredom is more easily overcome with a suitable object within reach.
- "Can I play with you?": While playing with body challenges such as scooter races or climbing a wall, kids mix this individual activity, with collaborative and competitive social patterns.

Design Concept

Based on ethnographic findings we have defined the design concept of playful accessories to encourage free-play.

We aim at designing playful accessories that give feedback to children's actions to encourage free-play. These sensor-augmented accessories can react to specific body's actions and movements, and, according to the ethnographic study, kids are highly interested in body challenges.

Moreover, this playful added value on everyday clothes or accessories can be put into practice by children in unexpected situations or in the different and multiple I'm bored moments happening every day (identified in the ethnographical study). The free-play is encouraged – even if there is no time to play.

We also seek that the augmented accessories offer a combination of individual activities and personal challenges with the possibility to collaborate or compete with others, which is a key social pattern identified during our observations of free-play in real-life settings.

Our proposal takes advantage of current sensing technologies to create smart clothes adding a relevant value Steffen [5] by add a playful one for smart clothes for children.

Prototypes

We have designed, developed and tested two Playful Accessories: Statue and FeetUp.

Statue: is a fanny pack that blinks and makes sound whenever the user moves. Statue stimulates children to play games related with being a statue or moving without being noticed, which are commonly played by children, according to our ethnographical observations. It is inspired in many folk games, which include being statue. According to our evaluations, the accessory added a new condition in their everyday settings that encouraged transforming their frequent games. Social interaction emerged by slightly modifying the rules in a social dynamics that challenged power, leadership and creativity, they also practiced body language, imitations and small talks.

FeetUp: is a pair of shoes that blinks and makes sound whenever the user jumps, or is off the ground. FeetUp stimulates children to play against gravity, one of their most frequent activities during free-play. According to our evaluations, with FeetUp each found his/her personal style to play with the accessory; doing ballet, capoeira, handstands and so on. This led children to associate with someone with whom they had a common interest, shared their knowledge and tried to improve their performance together, generating challenging social experiences.

C. Conclusion and future work

We suggest using ethnographic methods to study children's relation with free-play in specific contexts, where children's life happens. Ethnographic explorations may be used to build on existing evidence of factors that facilitate or restrict the opportunities for free play to design evocative objects that encourage free-play.

According to our ethnographic explorations we propose add a playful value to clothes or accessories children wear all the time, to make use of their playful attitude and their infinite interest to improve body challenges.

We have designed 2 playful accessories: FeetUp and Statue. Both are wearable objects that encourage free-play in unexpected situations everywhere and all the time.

Future work includes compare the evaluation of both accessories to understand how the different features of each design influenced the experience, and define a set of design opportunities, that can be taken into account in the design of future objects to encourage free-play.

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2. Supporting R&D projects in diverse areas

During the period of this thesis, the author worked on a number of emerging media technologies in three main areas, playful interaction, eLearning and HCI studies with elderly.

These activities have been carried out within the framework of R&D projects, where the author has been playing different roles, including ethnographic explorations, participatory design studies, product development and evaluation which entailed different activities related with HCI studies. Some of the activities of those roles include:

- User studies
    - Understanding the needs of both the project and end-users
    - Establishing methodologies
    - Planning the activities
    - Recruiting participants
    - Conducting the studies
- Product development
    - Designing user experiences
    - Creating interactive prototypes
    - Developing new interactive textiles products
- Research Management
    - Participating in project meetings
    - Coordinating industry, user-groups and research partners
    - Reporting activities in formal documents (deliverable reports or publications)

The list of projects with their corresponding areas is presented in Table 8.

Table 8: List of R&D projects

Project Name	Subject	Technology
Learn 3 http://gti.upf.edu/learn3/	eLearning	Interactive Textiles
EEE http://gti.upf.edu/eee/	eLearning	Interactive Textiles
Barcelona World Race – The Game http://gti.upf.edu/the-game-barcelona-world-race/	Playful Interaction	Web
Life 2.0 http://www.life2project.eu/	HCI with elderly Expanding Wellbeing	Web
Worthplay http://worthplay.upf,edu	HCI with elderly Playful Interactions	Web - Touchscreen
Tertulies Actives http://tertuliasactivas.org/	Playful Interaction	Mobile

As a result of this involvement in projects, the author of this dissertation have been the coauthor (in some case, main author) of a number of papers or research reports whose full list is summarised next.

(Rosales et al., 2012) is a preliminary study which discussess the impact of ethnographic techniques in two PD studies with elderly participants. The studies compare traditional PD techniques such as focus groups, interviews and usability test with real life and meaningful activities. The main findings include the difficulties for participants to contribute through focus groups, interviews and usability tests, due to their limitation to visualize the complete process, self censorship, self criticism, rather than problems on the intended interface. Otherwise, the use of real life and meaningful activities, elicit spontaneous participation, and lead to rich and focused discussion of the topics.

(Rosales et al., 2013) discusses the main results of the ethnographical research on everyday digital game play by older people carried out in Àgora in the framework of the WorthPlay project during three months. The work and analysis of the results conducted so far does not allow us, at this stage of the project, to generate the intended first version of the human taxonomy of worth-playing digital games by older people, as doing so requires more reflection on the activities conducted and a deeper analysis of the related literature. We consider that a more realistic date for the first version of the taxonomy to be defined is the end of November 2012, when the first version of the game will have been developed. The goal of this deliverable is therefore to present an account of the work carried out thus far and the main findings which have originated from this work. This deliverable also intends to guide the co-design process and the evaluation plan, both of which will help us to define the first version of the taxonomy. 170 older people, with different profiles in terms of gaming, ICT experience and use, were involved in the ethnographical work, which consisted of in situ observations and conversations and other different activities, such as playing sessions, covering a wide variety of games and devices. The findings of the ethnographical research have been grouped into two main categories: motivation to play (or not), and playability. A further subsection deals with gameplay on different devices. The final section summarises the findings and opens a discussion on game play and games worth playing by older people, framing the future work to be conducted in the WorthPlay project.

(Rosales et al., 2014b) gives an account of the objectives, procedures and results of the second (and final) round of evaluation of the WorthPlay platform, which enables older people to both create and play games. Four playful activities were designed and conducted in different situations of play with around 70 older people, with basic and more advanced ICT skills, interested and not in games. The evaluation focuses on the experience of older people as a) players and b) game creators, and on c) changes in their game acceptance. The results show our participants had fun, reported learning and showed creativity while playing WorthPlay games. The results also indicate that older people can create games through the WorthPlay platform, which presents a radically new view of older people in games research, and that creating or designing games brings empowerment and social recognition benefits. Finally, the results indicate significant changes in the acceptance of games amongst our participants before and after playing (and creating) WorthPlay games. Thus, these findings give a strong support to the concept of game put forward, designed, developed and evaluated in this project.

(Hernández-Leo et al., 2011) presents the Signal Orchestration System (SOS), a system that augments the physical environment with digital signals indicating orchestration aspects. The SOS facilitates its integration with digital educational spaces to allow transitioning activities from digital to physical spaces. The prototype has been used in two different experiments in the context of a real course applying adaptations of the well-known Jigsaw collaborative learning flow pattern. The results show that the SOS enables a flexible dynamic orchestration of the collaborative activities.

(Hernández-Leo et al., 2012) goes further in the SOS with the second version of the system. In this paper we present an Orchestration Signal system, composed of wearable Personal Signal devices and an Orchestration Signal manager. Teachers can configure color signals in the manager so that they are transmitted to the wearable devices to indicate different orchestration aspects. In particular, the paper describes how the system has been used to carry out a Jigsaw collaborative learning flow in a classroom where students received signals indicating which documents they should read, in which group they were and in which area of the classroom they were expected to collaborate. The evaluation results show that the proposed system facilitates a dynamic, visual and flexible orchestration.

(Righi et al., 2012) presents key results of an ethnographical study we conducted with 55 older people (aged 59-80) over 18 months while participating in online communities. The results show that trust is very important for this user group. Privacy and concerns about misuse of personal information are important elements of trust for them, and closed social circles and everyday trusting strategies are key ingredients of their virtual and face-to-face trust building processes.

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