Prototyping for Investigating Affective Objects with and for Children

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Abstract. If designers give users the means to create or experience interactive prototypes with them, users can contribute and form realistic expectations and experiences. That is especially relevant in case of novel interactive solutions and children as users. In 2017, two prototyping workshops concerning affective objects were organised with children and designers across Europe: one in Germany in a summer camp, the other in Italy during a science festival. The former workshop helped designers inspect children's expectations for affective objects. The latter workshop helped designers assess other children's experience with the prototypes created by the former children. The paper presents the prototyping workshops with in total 81 children, aged 11 to 16, and reflects on what designers learnt from them.

Keywords: children · prototype · cards · affective object

1 Introduction

Emotion communication is mostly done non-verbally, through facial expressions, body postures or objects that are extensions of our bodies. *Affective objects* are interactive objects that enable users to communicate emotions. Affective objects are often created by teams of adults, and experienced by children[1] later in the design process. At the same time, the design community also advocates for a more active role of children in the early design of interactive objects, with diverse degrees of participation [7]. Lately, the community has stressed how children should be involved as design protagonists so as to "shape" and "reflect on technological development" for them [13].

Various techniques can be used to include children in the early design; prototyping is one, which can be used in different design stages and for different goals. For instance, Moser et al. [18] used non-interactive prototypes to investigate expectations for "future" games with and for children. Buchenau and Fulton Suri [2] used experience prototyping to make diverse users actively experience design alternatives with designers.

Starting from that body of work, this paper pursues the idea to include children into the early design of affective objects for them through prototyping.

[1] A child is a person below the legal age of majority.

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If designers include children into the making of prototypes, children can express their *expectations* for affective objects. If designers enable children to interact with early prototypes, children can *experience* novel design ideas of affective objects for them. The paper reports on two such prototyping workshops with designers and children, organised across diverse ages (from 11 to 16), cultures and countries. In one workshop, in a Germany forest, children make their prototypes and designers investigate children's expectations of affective objects for children. In the other one, in a school in Italy, other children experience those prototypes and designers investigate their experience.

The exploratory interrelated *research questions* of the workshops are two: (R1) What affective objects do children create or engage with? (R2) Can prototyping enable children to communicate their ideas of affective objects?

The paper begins with an overview of related work and background concerning the design of interactive objects with children, especially in relation to emotion communication. Then the paper continues with its core matters. It presents the workshop in Germany, with 55 13–16 years old children from Germany, Czech Republic and non-EU countries, and the follow-up workshop in Italy, with 26 11–14 years old children from different cultures as well. In its conclusions, the paper reflects on the results of the workshops in relation to the above research questions.

2 Background and Related Work

Emotions play an essential role in our interpersonal relationships. Besides the body, objects embody meanings, memories, thoughts and, more generally, emotions [5]. In [19], Scheirer and Picard defined the term "affective object", "which has the ability to sense emotional data from a person, map that information to an abstract form of expression and communicate that information expressively, either back to the subject herself or to another person".

Children aged 11–18, who are pre-teens or teens, face considerable emotional changes [3]. Emotional communication becomes crucial and important in facilitating their social interactions and well being, in general. Nowadays, there are various affective objects for children, especially teens and pre-teens. Their design process is managed in different manners. If affective objects are for children with special needs, they are generally created by interdisciplinary teams of adults and then evaluated with children, who are not involved in their early design, e.g., [8]. In other settings, children are also involved in the early design of interactive objects for them. Then prototyping with children can be used to help designers develop affective objects for children.

Workshops that investigate *expectations* for affective objects are not many, especially with pre-teens or teens [12]. In general, workshops with children tend to create prototypes, mainly non-interactive, e.g., videos [15], like in the workshops in [21] and [18]. The latter investigated children's expectations for games by creating non-interactive prototypes with children from different countries. A similar idea is pursued in the first workshop in this paper, held in Germany,

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which investigated children's expectations for affective objects by creating interactive prototypes. There are several toolkits that designers and children can use together for ideating, conceptualising and prototyping interactive objects. Card-based or other paper-based generative toolkits are used for ideating and conceptualising objects, e.g., the Tiles cards for ideating Internet of Things (IoT) interactive objects [17]. As for the prototyping stage, the research and commercial communities offer several toolkits, with sensors and actuators, e.g., micro:bit [16] and LittleBits [14]. See, e.g., [1]. The first workshops employs card-based toolkits for the ideation and conceptualisation phase, and integrates them with programmable blocks, such as LittleBits kits, in the prototyping phase.

Later on, the interactive prototypes can be used to gain direct insight into children's *experience* with them. Experience prototyping, in the original acceptation of the term [2], "is any kind of representation, in any medium, that is designed to understand, explore or communicate what it might be like to engage with the product", and which promotes "active participation" of designers and users. Children's experience with interactive prototypes can be investigated, e.g., through ranking instruments with children older than 8 years, as suggested in [11]. This idea is adopted in the second workshop of this paper, held in Italy.

3 Workshop in a Summer Camp in Germany

3.1 Participants and Setting

A workshop was organised with designers and children to investigate children's expectations of affective objects for them. It lasted c. 2 hours in the evening and asked participant children to ideate, conceptualise and prototype their own affective objects. It was conducted in a German forest during a youth summer camp, within a semi-open location with long dining tables. All children participated voluntarily and were told about the workshop goals. Their parents or referent adults approved of their participation, after being informed about the workshop goals and methods.

Group	F	M	Nationality	Group	F	M	Nationality
G1	7	0	Mixed	G5	0	8	Mixed
G2	0	7	Mixed	G5	0	8	Mixed
G3	6	0	Czech	G6	0	7	Mixed
G4	6	0	Mixed	G7	0	7	Mixed

Table 1. Group Composition.

Tables for groups were located on both sides of a central table, working as hub, with the design material, e.g., Littlebits toolkits. Another area had

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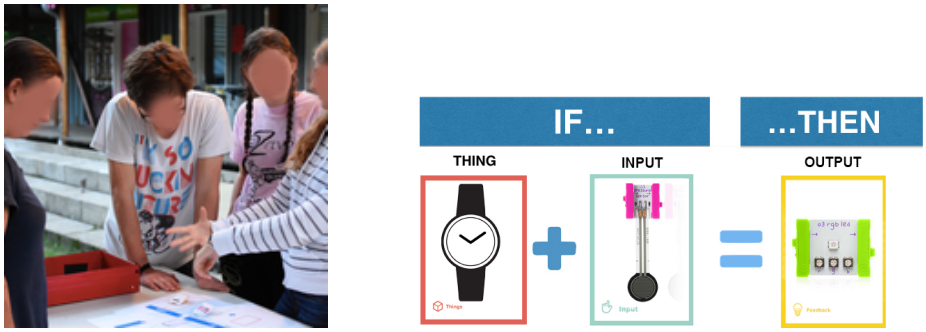

Fig. 1. A photo concerning a group working on affective objects in Germany (left) with the conceptualisation framework (right).

a theatre-like stage for the final presentation and sharing of affective objects, placed in front of the hub table.

The workshop involved a total of 55 children, 26 females and 29 males, aged 13–16. Children were from Czech Republic (31), Germany (18) and non-EU countries (3). Common languages were German or English. In total, 8 groups were created by the camp organisers according to camp organisation constraints, with separate female groups and male groups, but with mixed groups in terms of nationality. See Figure 1 for a group. Table 1 specifies them all.

The workshop also involved design facilitators, one per group, trained to the goal and methods of the workshop. There was also a design moderator, who usually remained at the hub table for delivering material and feedback to the group elected representative.

Table 2. Affective objects.

Group	Affective object	Group	Affective object
G1	Affection Watch	G5	Cheer-up Pillow
G2	Hungry fork	G6	Sadness Bottle
G3	Confusion Stone	G7	Happiness Clip
G4	Happiness Candle	G8	Laughing Bracelet

3.2 Workshop Format and Material

The workshop was organised in an *ideation* and a *conceptualisation* phase, a *prototyping* phase and a *sharing* phase.

In the ideation and conceptualisation phase, paper-based generative toolkits are often used. Tiles cards are paper-based generative IoT toolkits [17]. They

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can be downloaded from [20] and changed according to users' needs. The Tiles cards include so-called primitive cards, which inspire combinations of IoT components such as everyday things, sensors, actuators. The workshop adopted and adapted those Tiles cards: cards concerning objects in the campus, a pillow; input cards for LittleBits sensors or switches, e.g., a pressure sensor; output cards for LittleBits actuators, e.g., LED lights.

However, Tiles or similar cards, alone, may be insufficient with inexperienced participants for conceptualising IoT objects. Thereby, designers also use further generative toolkits for guiding children towards the prototyping phase. In [10], researchers used a common conceptualisation framework for making children reflect about the intended interaction with their object before prototyping it. Their approach was adopted in this workshop, which used an ad-hoc conceptualisation framework. This has simple if-then rules to fill in with object cards, input cards (if-part) and output cards (then-part) for sensors and actuators. See Figure 1.

During the workshop, firstly, children discussed about the assigned mission: creating affective objects that communicate one's mood or emotions. Then they chose what objects to make interactive: either everyday objects, represented on adapted Tiles cards, or natural elements of the forest location, e.g., a stone. At the same time, they chose input and output cards, adapted from the Tiles primitive deck for the available Littlebits sensors (for input cards) and actuators (for output cards). Children were asked to reflect about such cards together and place them in the correct area of the conceptualisation framework.

For the prototyping phase, children moved to the hub for collecting prototyping sensors and actuators. The moderator handed the toolkits out according to children's questions and what specified in their conceptualisation framework.

In the sharing phase, children moved to a theatre-like stage. There each group in turn enacted their prototype to explain its ideation, in a silent-theatre performance. This was chosen because of the multi-lingual environment, so as to enable all participants to equally share their ideas and engage in the process. While one group was presenting, with the help of facilitators, the others were trying to understand the exact idea behind the object, and what emotions the object was communicating.

3.3 Results

This section reports on the results of the workshop in Germany. The affective object prototypes, created by children, are listed per group in Table 2 and described below. Other results are reported in relation to the two main questions of the paper, given in Section 1: concerning children's expectations for affective objects, firstly, and the workshop organisation, secondly.

Data come from children's artefacts, i.e., their conceptualisation frameworks and prototypes, besides designers' documentation, i.e., photos, videos and independent observations. In particular, at the end of the workshop, designers compared their documentations, and organised them in relation to children's expectations for affective objects and the workshop organisation.

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Description of Affective Objects. The Affection Watch should count each affectionate touch (e.g., hugging, caressing), create happiness, and display how frequently its user gets in physical contact with others. The Hungry Fork should express negative emotions due to hunger: when the button on the fork is pressed, and lights the red LED which is embedded into the user's t-shirt, the user expresses the fact that hunger stresses him/her and he/she needs food from others. The Sadness Bottle should reveal its user's sadness through a blue LED when the user hugs it and touches it; hugging, as care giving, is translated into an affective object which communicates the sadness of its user. The Cheer-up Pillow is an assistive object for coping with negative emotions: when pressed, it makes a massage by vibrating and, when the slider is used, it also blows fresh air on the face. See Figure 2. The Laughing Bracelet responds to laughs and magnifies its user's positive emotional state: the loudest the user laughs, the loudest the bracelet responds. The Confusion Stone, when held in hand and squeezed, should recognise the user's state of confusion (a negative situation), and warn the user and others with a buzzing sound. When the Happiness Clip is touched, it lights up and makes a buzz sound to represent the happiness of the user. Similarly, when the Happiness Candle is put on its platform, it should measure the happiness of the user and show it with numbers on its digital display.

Results Concerning Affective Objects. Children's prototypes and designers' documentation were given to three researchers: two from interaction design, one from industrial design. Researchers inspected them in relation to children's expectations for affective objects, by considering the following analysis criteria: (1) the used physical objects and their affordance; (2) emotions conveyed by affective objects. Researchers worked independently, after agreeing on the criteria and a common report format in two initial meetings. Researchers met again for comparing their results. Results were discussed; in case of low agreement, they were revised. The final results are as follows.

Researchers judged if children's prototypes used only everyday objects, or also natural elements from the surrounding natural environment (forest); the affordance of the used physical objects. Only 1 out of 8 prototypes (the Confusion Stone) used an object from nature. Affordance was judged low in the following sense: only $37,5\%$ prototypes (3 out of 8) used physical characteristics of the physical object. In general, according to researchers, children tended to choose objects that they were using daily and represented on cards (e.g., pillow, fork, bottle) rather than reflecting on physical objects and their affordance.

Criteria concerning emotions were taken from the emotion design literature [6]: valence, for judging the valence of emotions (positive, negative) that objects meant tackling: sharing, for judging whether emotions were communicated to the user only, or also to others; utilitarian value, for judging whether affective objects had purely utilitarian value (e.g., being fed) or not. As for the valence criterion, half affective objects were judged related to negative emotions and half to positive emotions, across male and female groups. Interestingly, the Sadness Bottle, concerning a negative emotion, was created by the G6 group

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with refugees from non-EU countries. As for the sharing criterion, results were as follows: in the case of 2 objects, one made by a female group and the other by a male group, emotions were communicated to their users, only; in all the other 6 cases, emotions were also communicated to others. As for the utilitarian value criterion, only 2 objects, by two out of the four groups of males, were purely utilitarian; all the others 6 were not, according to researchers.

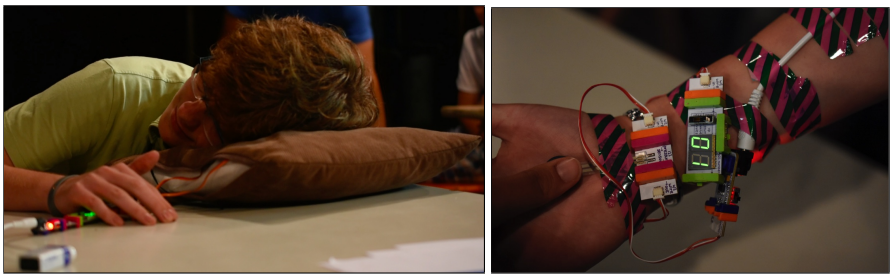

Fig. 2. The Cheer-up Pillow and Affection Watch.

Results Concerning the Workshop Organisation. Data concerning the workshop organisation come from designers' documentation. According to this, all children managed to create their prototypes in the alloted time and with the given material; designers mainly helped in the scaffolding of children's ideas.

Moreover, paper-based generative toolkits helped children create realistic expectations and keep the design aligned with the assigned mission. Most impotantly, they helped children structure their ideas and hence facilitate the communication with designers. For instance, designers gave all groups feedback concerning the chosen sensors and actuators in relation to the if-then rule, inserted into the conceptualisation framework, before groups of children started prototyping their affective objects.

4 Workshop During a Science Festival in Italy

A later workshop was organised with designers and other children in a school in Italy, on the occasion of a science event, with the main aim of investigating children's experience of the affective object prototypes that were created in the former workshop.

4.1 Participants and Settings

The science event organisers and teachers invited children to the event, and the workshop had 26 participants, aged 11–14. There were 15 males and 11 females. Participants were selected by the science event organisers and school

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Castiglione della Pescaia, Italy, May 29, 2018 (published at http://ceur-ws.org).

personnel; all children participated voluntarily and were told about the workshop goals. Their parents or referent adults approved of their participation, after being informed about workshop goals and methods.

The school is multi-cultural, and 38.46% of participating children had different cultural backgrounds than Italian. Demographics data were collected through a survey by the science event organisers, concerning children's age and gender, besides cultural origins (if different than Italian or not).

Four designers were also present, besides a moderating teacher. One of the designer was the design moderator present in the former workshop in Germany. Children were divided by their teacher in groups of 5–6 children, heterogeneous for cultural backgrounds. Each group participated separately in the workshop.

Fig. 3. Children experiencing the Cheer-up pillow

4.2 Workshop Format and Material

The workshop was split into three phases, with dedicated physical areas; a brief *introduction* to the prototyping of affective objects; the *sharing* of the former workshop experience; the collection of children's *preferences* for affective objects.

The first phase served to introduce children to sensors and actuators for prototyping affective objects. Each group, in turn, moved towards the related area with two designers. A designer showed children examples of simple affective objects, and invited children to reflect on how the objects used sensors and actuators; the other designer mainly acted as observer and note-taker. This phase served to expose children to the prototyping of affective objects.

The second phase was for sharing the results of the workshop experience in Germany. Each group in turn moved to the sharing area, with a long table for displaying the affective objects of the former workshop. In this area, children found the moderating designer of the former workshop and another one, mainly acting as observer and note-taker. The moderating designer acted as narrator and "bridge" between the two workshops. She explained children's origin and ideation of each object, and how to interact with it. Then children were invited to touch and use it, and ask questions about it.

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In the final phase, children ranked affective objects with a survey form. Each object was represented on a sticker. Each child chose three stickers to rank his or her three preferred objects in the survey form. This has medals for the first position (the first preferred object), the second position (the second preferred object) and the third position (the third preferred object).

4.3 Results

As in the case of the workshop in Germany, results concerning the workshop in Italy are given in relation to the two research questions of Section 1: concerning firstly children's experience of affective objects, and secondly the workshop organisation.

Data come from children's survey rankings, besides designers' documentation—photos, videos and independent observations. Like in the first workshop, designers compared their documentations, and organised them in relation to children's experience with affective objects and the workshop organisation.

Results Concerning Affective Objects. The survey rankings of affective objects were analysed by gender. The Happiness Pillow was ranked first by 81% of participants. The result is independent of gender: 82% females and 80% males chose it. The Affective Watch was second for 38%: 45% were females and 33% males. Males and females differently assigned the third place: 45% of females chose the Laughing Bracelet; 33% of males chose the Hungry Fork.

Those results are backed up by designers' documentation, concerning the behaviour of children with objects or their verbatim comments. According to that, the Happiness Pillow was very engaging, e.g., children kept on squeezing it. The Affection Watch created physical contacts among participants (such as holding hands). This seems to have engaged more females than males. In turns, males seemed to be more interested in the functioning of objects, e.g., they questioned the moderating designer about the employed sensors or actuators.

Results Concerning the Workshop Organisation. According to designers' documentation, children generally grabbed how to interact with protypes, after being exposed to their prototyping int the workshop introduction phase; during the sharing phase, little explanation was needed by the moderating designer, who mainly reported the generation of the objects and what they were meant for. The fact that the designer was previously exposed to children's ideas enabled her to quickly interact with children about prototypes.

The interactivity of prototypes also engaged children into experiencing them, e.g., children asked to interact with all prototypes. While interacting with the prototypes, some children spontaneosly voiced their opinions about them, e.g., they criticised some prototypes, or suggested novel application scenarios. For instance, the Sadness Bottle was criticised because of the chosen physical object (its material and shape); a group of participants came up with an idea of a soft object that could be hugged, whereas "a glass bottle cannot". While trying out

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the Confusion Stone, another group conceived a novel usage: the stone could help children express their stress or fear and ask for the help from others "very far away".

5 Conclusions and Reflections

This paper presented two workshops for including children in the design of affective objects. Prototypes were the main communication medium within and across workshops, among children and with designers. The former workshop was held in a Germany multi-cultural summer camp and mainly served to investigate children's expectations for affective objects. The latter workshop was in a multi-cultural school in Italy, on the occasion of a science event; children experienced the prototypes of the former workshop, and expressed their ideas about them.

Data were gathered and analysed for both workshops from complementary perspectives, e.g., children's and designers'. The reported results enabled us to answer the main research questions of the paper: what affective objects do children create or engage with? Is prototyping adequate for communicating children's ideas? This section ends by reflecting on the specific results related to the research questions: firstly, affective objects; secondly, the prototyping of affective objects itself, as a communication means among children, and with designers.

5.1 Reflections on Affective Objects

According to the results of the workshop in Germany, the majority of children (7 groups out of 8) used everyday physical objects, and not nature elements, as if children had grabbed "the first available thing". Overall, such results seem to indicate that children were not constrained and yet not guided towards their choice of physical objects. Thus the workshop results do not give clear indications concerning children's expectations of physical objects for affective objects. As far as emotions are concerned, some indications emerge from that workshop. Children realised as many affective objects for positive emotions as for negative ones, and mainly for communicating emotions to others, independently of gender. The group with refugees made a bottle that shows others their sadness, thereby externalising and sharing their status. Only male groups made affective objects with utilitarian values (half of them). That may be explained with the age range of participants (aged 13–16) and reflect a gender difference.

The later experience workshop in a multi-cultural school in Italy used the affective object prototypes created by children in the former workshop. According to its results, two objects were preferred by all children: the Cheer-up Pillow was the first choice, independently of gender; the Affective Watch was the second, preferred by females. A possible reason for children's preference for the haptic pillow was that it created a haptic sensation, which was unexpected in a pillow and hence appreciated by children. As for the Affective Watch, it was leading children to touch each other rather than creating a simulation of touch, which might be the reason why it engaged more females than males.

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5.2 Reflections on Affective Object Prototyping

In each workshop and across workshops, prototypes were the main communication means. According to the reported results, interactivity facilitated prototype sharing and engagement in the former workshop. It also enabled participants in the later workshop to rapidly experience prototypes in an ecological setting and engage with them, in line with previous findings albeit with adults [2].

The material for the workshops included ad-hoc paper-based ideation cards and a conceptualisation framework, besides prototyping kits. The material helped in rapidly guiding children towards their creation or experience of prototypes. Moreover, the material facilitated children's communication with designers, and hence it helped designers convey children's ideas across workshops. At the same time, the material might have partly limited children's expression, e.g., in the former workshop, children always tended to use everyday objects, represented on cards. Children's imagination could also have been hampered by the limited range of available sensors and actuators. In the future, an intermediate workshop might be introduced between the two workshops with children, to continue prototypes with more advanced micro-electronics kits and fully realise children's expectations and experience of affective objects, e.g., a making workshop with university students, like in [4].

The presence of the same designer across workshops was also relevant to convey the ideas behind object prototypes more completely, in line with the results reported in [9]. Future workshops with children should thus maintain such a choice.

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