Stimulating physical and social play through open-ended play

Tilde Bekker and Janienke Sturm
Dept. of Industrial Design, Eindhoven University of Technology
Den Dolech 2
5612AZ Eindhoven, The Netherlands
{M.M.Bekker, J.Sturm }@tue.nl

ABSTRACT
In this paper, we describe our design research on tangible play objects that stimulate social and physical play. We illustrate our work by describing a design case about an open-ended play object for children called the ColorFlare. The ColorFlare is an object that detects the player's movements and provides light feedback and that can communicate with other ColorFlares. A user test is described that examined how children use the ColorFlare to collaboratively create various (physical) games. We relate our research to definitions of embodied interaction: e.g. how do children allocate meaning to the interaction behaviour of the play objects and jointly create diverse games during the play sessions.

Keywords
Open-ended play, embodied interaction, social and physical play.

INTRODUCTION
We conduct research on playful interactions for various user groups, including children. We create concepts that provide motivating feedback to the users' physical activities, that allow players to choose their own game goals and rules, and that stimulate social interaction between players. In this position paper we will describe the relevance of the area of embodied interaction to our research on playful interactions. We will illustrate our work with one design cases. We will also present two questions we would like to discuss in the workshop.

DEFINITION EMBODIED INTERACTION
We will first provide some definitions of embodied interaction. Dourish provides the following descriptions in his book on embodied interaction:

"Embodied interaction is the creation, manipulation, and sharing of meaning through engaged interaction with artifacts' [7]

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He also mentions some trends in HCI research that are relevant for embodied interaction: "Both lines of development—social computing and tangible computing—are based on the same idea, that of embodiment. " [7]

Another definition is provided by Antle in her paper on embodied Child Computer Interaction: "Embodied cognition emphasizes how the particulars of human bodies acting in physical, social, and cultural environments determine perceptual and cognitive structures, processes and operations" [2]

Finally we mention the framework on tangible interaction by Hornecker and Buur [10] that covers topics related to social and tangible computing (which according to Dourish link to embodied interaction):

"The framework is structured around four themes […..]. Themes are:
• Tangible Manipulation refers to the material representations with distinct tactile qualities, which are typically physically manipulated in tangible interaction.
• Spatial Interaction refers to the fact that tangible interaction is embedded in real space and interaction therefore occurs by movement in space.
• Embodied Facilitation highlights how the configuration of material objects and space affects and directs emerging group behavior.
• Expressive Representation focuses on the material and digital representations employed by tangible interaction systems, their expressiveness and legibility."

The main aspects of these descriptions related to embodied interaction that are relevant for our work are that we create intelligent (tangible) objects with sensors, actuators and computing power, that provide feedback to players' physical activity. Multiple players interact with these objects, explore what response the objects provide and they jointly negotiate what meaning is given to the interaction opportunities of such objects. Our intentions are that these objects stimulate physical play. We assume (and have verified) that the feedback to physical activity stimulates physical play. Furthermore, we often create open-ended play objects, which means that the objects provide diverse opportunities for players to allocate meaning to the input

and output options, and thus negotiate and create their own game goals and rules stimulating social play. The open-ended design of the interaction allows players to create and share meaning when defining game goals and rules, for example building on experiences they have in other play situations. Finally, the objects can be used in diverse contexts, where we expect that the properties of the context may influence how the play objects will be used. Thus players will adapt their game goals and rules and interaction with the objects to the opportunities they find in the environment. Looking at the definition provided by Dourish [7] we design objects that provide multiple players diverse opportunities to create shared meaning in playful contexts. We follow a research through design approach in which we design different versions of Playful Interaction (PI) concepts, where the variations are used to study the influence of different design decisions on the users' behavior. We base the design variations on existing theories about behaviour change, exercise psychology and developmental psychology.

We have created various concepts and prototypes (e.g. for sport/like contexts and intelligent playgrounds) that examined how players can receive motivating feedback to their own behaviour, how they can be stimulated to have social interaction when playing with the concepts and how they can allocate meaning to diverse input and output options. We have conducted various studies to examine how children interact with PI concepts that provide feedback to their behaviour and allow competitive or collaborative play [3,4,5,9,14]. In this paper we illustrate our work with one design case.

RELATED WORK

For the purpose of this position paper we provide a very brief (and thus incomplete) reference to work by others who work on related topics, such as playful interactions for children. Various people work on tangibles to teach children topics such as programming [e.g. 8]. Our focus is on playful interaction without teaching a specific topic. Other people work on pervasive games for children [e.g. 13]. These often have fixed game goals and rules, while our concepts often do not. Furthermore, many concepts have been created to support storytelling [e.g. 6]. Our concepts do not really support storytelling, but allow creating various types of games. Finally, Matthews et al. [11] provide two design cases (interactive tiles and a physicalised playmat) that show overlap with our approach to designing open-ended playful interactions. In these two cases the artifacts are shared by the playing children. The design case in this paper has more mobile characteristics in that children can carry them with them and have a more direct manner of communicating through the personal objects of each child.

DESIGN CASE 1: ColorFlare

The aim of the project was to design intelligent play objects that stimulate social and physical play for groups of children (7 to 11 year old). Children of this age still like playing physical games and enjoy games with rules and game goals [1]. A user-centred design process was followed, in which children provided feedback to and tried out different concepts. This process resulted in the design of the ColorFlare.

The ColorFlare is an object that can detect whether it shaken or rolled. It provides feedback to its users by changing its colored feedback. Children can explore how the ColorFlare responds to their own movements. Furthermore, children can allocate meaning to the different types of feedback, thus creating their own game rules and goals. The ColorFlare was designed following a user-centred design approach where children provided input at various design phases.

The ColorFlare emits one of six colors at a time, chosen in random order. When it (see Figure 1) is rolled, its colored light changes to a different color. When it is shaken, the light starts blinking for five seconds. While the ColorFlare is blinking, it is able to transmit its color to another ColorFlare in the vicinity using infrared. The other ColorFlare then takes on the same color. The shape of the ColorFlare supports two purposes: it supports the sending and receiving function of the prototype and it causes the ColorFlare to move in a circle around the player, instead of in a straight line, which emphasizes the fact that it is intended to be a personal object.

Figure 1 **The ColorFlares in use**

User test

We carried out a user study to explore whether children were able to create their own games and whether open-ended play stimulates social interaction. Six groups of three or four children (19 children in total, 11 boys and 8 girls, age 7-11) played with the ColorFlares in a free-play session. The study took place at an after-school care center in Eindhoven.

After a short introduction of the test set-up, all children were given a ColorFlare and had the opportunity to freely

explore the ColorFlares and discover how they worked for a couple of minutes. After an additional explanation from the experimenter, the children were asked to play with the ColorFlares for approximately twenty minutes. During the play sessions video recordings were made which were used to analyze play behavior, in terms of the number and types of games that children created. For each test group we coded the number of games and for each game we coded which functionalities were used, what type of game was played, and which were the game rules and goals. The game categories were determined on the basis of our observations of the play sessions. For each observed game we made a short description of the main characteristics. Subsequently, games with similar characteristics were clustered. Finally, the following game categories were derived from these clusters: 1) Assignment, where the children create small assignments that one person can win, e.g. roll the ColorFlare and who is the first to get red, wins; 2) Tag, where the goal is to send your color to another child or all the other children; 3) Hide-and-seek, where either the children or the ColorFlares are hidden and have to be found; 4) Rolling, where the ColorFlares are rolled from one child to another; 5) Role-play, where children play a game in which they pretend to be someone or something else; 6) Guessing, where children had to guess for example whose ColorFlare would be the first to turn red; and 7) Other, for those games that do not fit in one of these categories.

After the play sessions the children filled in a Likert-scale questionnaire with approximately 30 questions, addressing aspects of immersion, positive affect, challenge, social interaction, creativity and physical activity. The first three modules were adopted from the Game Experience Questionnaire [12]; the other three modules we created ourselves.

Scenario – Tag

Dennis, Megan, Rob and Peter want to play a game with the ColorFlares. After some wild ideas have been proposed – and dismissed - Peter comes up with the idea of doing a game of tag. The goal is to pick a color and try and make all the other ColorFlares the same color. They start the game and run after each other, trying to send a color to somebody else, but also hiding to prevent from getting a different color. Dennis is the first to succeed in making Megan's ColorFlare green. Megan is now in Dennis' team and helps him to make the other ColorFlares green. Rob has made Peter's ColorFlare red, so they now form a team playing against the other two. It is a very exciting game, and in the end the green team manages to conquer the other two. Green wins!

Figure 2: Scenario of children playing tag with the ColorFlare

After a first phase in which children were mainly exploring the possibilities of the objects, each group created on average about six games. However, some groups only created three games, whereas another groups created as many as 12. In most of the games that were played, the interaction possibilities that the ColorFlares offer played an active role: many of those games made use of a combination of the rolling and the shaking/sending functions. For example, games in which children had to roll the ColorFlare to a specific color and then send their color to as many other ColorFlares as possible. Only in two of the 38 games the functionality of the ColorFlares was not used at all; in these games the children were just rolling the prototypes to each other.

All groups played various types of games. Most groups played games like tag, or hide-and-seek or made up small assignments for the group that could be won. The rolling and role-play games were played by only one group. Apparently, the functionality of the ColorFlare provides opportunities for many different games and game rules.

It was clear from the play sessions that the ColorFlares support social behavior. First of all, only two of the 38 games that were created were individual games. So, although the ColorFlare is a personal object, the games that were played showed a high degree of social interaction. The communication functionality of the ColorFlare stimulates children to create games in which they really have to interact with each other, either by deliberately trying to make contact or to actually prevent people from making contact. Apart from social interaction in the form of competition and cooperation, we often observed that children mimicked each other's behavior. Also, the open-ended character of the ColorFlare made the children discuss the games that they would play, for example to determine their rules and goals.

Our observations are supported by data from the questionnaire. For example, children indicated that they could use their imagination during play. Also, children indicated that they were able to create various games using the ColorFlares. Moreover, the children indicated that they looked at each other while playing and that they played most games together.

DESIGN CASE CONCLUSIONS

Our research is aimed at designing interactive objects for open-ended play. Open- ended play is a form of play where there are no predefined game goals and/or rules, where players can create their own games with their own goals and rules by allocating meaning to interaction behavior of the objects. This gives players the opportunity to bring their creativity into play.

In this article we described a study with interactive open-ended play objects, which react to players' movements by providing feedback using light and/or other modalities. We examine how the success of non-interactive open-ended play toys, such as Lego or an ordinary ball, can be translated to interactive open-ended play objects. This study showed the potential of interactive, open-ended play.

Overall, children enjoyed playing with open-ended play objects. The children liked being able to explore the possibilities of the prototypes and creating their own games. This was clear from their body language, the things they said and the questionnaires that they filled in. Many of the children asked whether they could keep the prototypes or where they could be bought.

Of course, although these observations show great promise, only a longitudinal study can show whether open-ended play will remain to be so much fun on the long run.

Our study showed that children were able to come up with diverse games with the prototypes. Also, they used the interaction possibilities offered by the prototypes explicitly in many of the games. Different types of games were created using (combinations of) different interaction opportunities. Our study indicates that the opportunities provided by more traditional open-ended play solutions can be extended to interactive open-ended play objects.

Future research will be aimed at doing further qualitative analysis of how children use the play objects: how they allocate meaning to the play objects properties, and how they use the objects dependent on the properties of the play environment. Furthermore, we intend to explore the effects of open-ended play on long term use. For instance, we will investigate whether offering multiple output modalities leads to better social interaction.

WORKSHOP QUESTIONS

We are interested in participating in the workshop to explore how the area of embodied interaction can inspire us, and to get a better understanding of the research area.

Some of the research questions related to embodied interaction that interest us are:

- How do children use tangible objects to create their own games?
- How do children allocate meaning to movements detected by sensors in tangible objects?
- How can object properties (both shape and interaction opportunities) influence social interaction between children?

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