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Wobble: Supporting Social Play through an Open-ended Play Environment

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ABSTRACT

In this paper we explore how to design for different levels of social play such as solitary, parallel and group play. For this purpose, we developed an open-ended play environment that supports the three stages of play: invitation, exploration and immersion. This play environment, called Wobble, focuses on socio-dramatic play by triggering children's imagination. Wobble consists of multiple interactive light objects developed for children aged four to six years old. Wobble was evaluated with eighteen children playing in groups of three during a free play session. The results show a clear pattern of how children first approach the play environment in a solitary manner, then explore its interaction possibilities in parallel and eventually become immersed in group play. This pattern can be supported by various design properties as local feedback and spatial interaction rules.

Author Keywords

User-centered design; open-ended play; dramatic play; social play; stages of play; design research

ACM Classification Keywords

H.5.2 [**User Interfaces**]: Interaction styles (e.g., commands, menus, forms direct manipulation), User-centered design.

INTRODUCTION

Within the HCI community, research into play and games is an exciting and evolving field. Research in this field focuses on designing for playful user experiences that often have a societal or personal impact. Especially for children, play is an essential learning activity through which they practice new skills and explore imaginary worlds [1]. Play is generally considered to fulfill an important aspect in the development of children [9, 10, 19]. In play, children can develop an imaginary and temporary world with flexible rules and boundaries [7]. Children's play activity can take on a variety of forms. When involved in games, a structured form of play, rules and goals are predefined. When involved in an unstructured form of play, children have more freedom to create their own play. In our research we want to primarily support the latter form of play. Therefore, we focus on the design of play environments that support next to social and physical play also open-ended play [4]. In open-ended play, there are no predefined rules or goals. Players are allowed to create their own rules, goals and games [18]. A play environment can support open-ended play by offering flexible and dynamic interaction opportunities that are multi-interpretable depending on the imagination of the players [4]. In this way, open-ended play supports the creativity and imagination of the players.

In this paper we focus on dramatic play, which is still a rather unexplored type of play within the field of open-ended play environments. In dramatic play children engage in a pretend activity by dramatizing life situations, taking a role of someone else, or by bringing life to an inanimate object, i.e. making a doll talk [12]. In the ages of 4 to 6 years old children engage in dramatic play, while at the same time their interest towards social play scenarios increases [9]. The Play Observation Scale (POS) [12] identifies three levels of social play: solitary, parallel and group play. Additional research is needed to understand how an open-ended play environment can support these different levels of social play. For instance, by identifying design properties that can help designers create more socially engaging play environments. Therefore, in this paper we look in more detail at different levels of social play within dramatic and open-ended play.

In previous work, we have seen that in open-ended play the experience of interaction goes through three stages: invitation, exploration and immersion [17]. In the *invitation stage* the potential players are attracted to the play design through their senses from a distance. When players start to explore interaction opportunities and try to understand rules and affordances of the play design, players enter the *exploration stage*. Subsequently, in the *immersion stage* players are involved in ongoing engagement of the actual play experience. For example, players show strong expressive behavior while playing or focus on achieving a clear goal in the form of parallel or group play. The relevance of designing for these three stages has been shown [17]. We aim at further strengthening this approach by also taking into account the different types of social play.

We created a new open-ended play environment called Wobble (see Figure 1). Wobble is an interactive play environment, intended for children in the ages of 4 to 6 years old. The environment consists of multiple interactive objects in the shape of balls on a flexible stem. Children can interact with the balls and push them around. The objects sense their movement with an accelerometer and react to

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this with light feedback (RGB LEDs). The objects are connected with wires to an Arduino that controls the accelerometers and LEDs. Children can interact with each object individually, but the objects can also communicate with each other. Some balls in the system will softly pulsate and lights will jump from one ball to another. The play objects respond with light feedback when pushed, adding a sense of "living creatures" inside the balls. When a child subtly pushes an illuminated ball, it changes color, from turquoise to purple or the other way around. When a child pushes the ball a little harder the light will jump to another randomly assigned ball, as if the "living creatures" fly away. The play objects aim to trigger the children's curiosity and fascination (invitation stage). When exploring the play objects, the children may wonder about what can happen (exploration stage). Children are stimulated to develop their own worlds of fantasy while engaged in dramatic play (immersion stage).

In this paper, we explore the following research question: "*How do different design properties of an open-ended play environment support different levels of social play: solitary, parallel and group play; during the stages of play: invitation, exploration and immersion?"* To be able to examine this research question, we performed an explorative user study with Wobble. In the rest of this paper, we first discuss related work in the area of designing for play. Then, we describe the design process and concept of Wobble and relate this design to levels of social play and stages of play. We continue with a description of the set-up and methodology of our explorative study. After that, we present the results of this study addressing a verification of the concept, levels of social play and stages of play. The paper is concluded with a discussion.

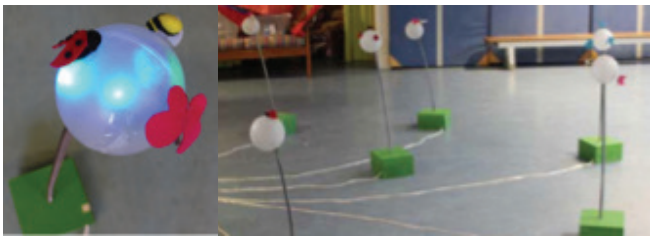

Figure 1: The Wobble prototype.

RELATED WORK

The research question for our study resulted from a literature study in play design research. Play has been described based on many different dimensions, including social, emotional, motor and cognitive dimensions, but also based on play contexts and structural properties of play behavior [8]. For the research described in this paper, work on socio-dramatic or pretend play, and on social play is most relevant. Below, we describe an illustrative, non-exhaustive overview of previous designs for play, and where relevant the related studies, in the areas of open-ended play, dramatic and social play and stages of play.

Open-ended play

ColorFlare [5] is an example of an open-ended play design (see Figure 2). ColorFlare consists of multiple handheld objects that can be rolled and shaken and reacts to these actions with different types of light feedback. Colors can be transmitted between objects to stimulate communication between players. The multiple interaction opportunities of ColorFlare can lead to the creation of a diverse variety of games [5]. This shows potential for designing for open-ended play, and we aim to elaborate on this research with a focus on both social and dramatic play.

Dramatic play and social play

Children at the ages of 4 to 6 years old are mainly interested in fantasy and pretend play. In this type of play "magic" often plays an important role. "Magic" can serve as an explanation for things that children are not yet able to understand [1]. Herein, "magic" can be the bridge between the play world of children and their cognitive development. Thus, the component of magic to support socio-dramatic play of children playing together is an important property to embed in an open-ended play environment for children.

There are a lot of commercial available products on the market that support dramatic play in children, i.e. baby dolls, such as the *BabyBorn* [3], kitchen and store toys, dress-up items and accessories and many more. However, these examples do not integrate technology. The *ActiMates™ Barney™* [2, 15] is an example of a play design that integrates technological advantages and focuses on dramatic play. The design is an animated plush doll in the shape of a familiar media character. Based upon how children bring life into inanimate objects mimicking social interactions, Barney fosters dramatic play by invoking such responses in children. Barney is an example of a quite concrete and structured play design that shows that dramatic play can be supported through integrating technology in a play design. Another example that focuses on dramatic play is the *StoryMat* [13] (see Figure 2). The design focuses on collaborative storytelling by offering a play space that is able to record and recall children's own narrating voices and the movements of the children's toys on a mat.

Figure 2: Two examples of related work: ColorFlare [5] and StoryMat [13].

Concerning social play, two theories have inspired our work: those by Parten [9] and Broadhead [6]. Parten [9] defined the degree of play participation in six sequential social participation categories: unoccupied behavior, solitary play, onlooker behavior, parallel play, associative play, and cooperative play. The theory developed by Broadhead describes the various social play behaviors in more detail. She created a methodology called the Social Play Continuum [6], in which social play behavior is measured by the level of reciprocity in language and action. The

Continuum describes four social domains: associative play, social play, highly social play, and cooperative play. These theories provide starting points for examining variations in play behavior ranging from more individual to more social behavior, and examining behavior in terms of children's actions and language.

An example of a design for social play is *FeetUp* [11], which encourages the practice of social skills. The design is a playful accessory embedded in the children's shoes. FeetUp provides audiovisual feedback when the child jumps or is off the ground. When multiple children have the same accessory, they have a common interest and can develop shared goals. When children share goals they have to explain ideas, argue, and negotiate, through which they practice social skills. These examples show evidence of how interactive play designs can support dramatic and social play in children. But these examples are not designed with open-ended play in mind, except for FeetUp, or combine their focus on social and dramatic play. The play designs that do focus on social play do not focus on specific levels of social play. Besides, the play designs focusing on dramatic play are still rather concrete and structured. In our study we will examine how to support dramatic play through a more abstract intelligent play design.

Stages of play

To date we are not aware of any other play design besides our own work that is designed explicitly with the three stages of play in mind. In a previous study we designed the *FlowSteps* [17] that focuses on the three stages of play. The design consists of multiple, flexible mats that provide light feedback when pressure is applied to a mat. It attracts players by randomly lighting up one of the mats (invitation stage). Players individually or together can explore possible interaction opportunities offered by the mats (exploration stage). Subsequently, players are able to create their own rules, goals and games by giving meaning to the output modalities of the mats (immersion stage). An explorative study conducted with the FlowSteps has generated insights on how to design for playful experiences during the three stages of play. The results show that the design properties that support playful experiences can vary for the different stages of play, e.g. some experiences are more important when players enter the immersion stage. In this paper we build further upon this work [17], by examining how an open-ended play environment supports different levels of social play during the three stages of play.

DESIGN RESEARCH APPROACH

We followed a research through design approach [20]. According to this approach, knowledge is generated by creating and testing prototypes throughout various iterations. Theoretical assumptions support the creation of a design, which is evaluated in context to verify underlying assumptions. Both aspects of design assumptions and user experiences are crucial in gathering qualitative and situational insights. The levels of social play, the three stages of play and open-ended play form the theoretical background and inspiration for the unique design of Wobble.

Design Process

Wobble was developed in three iterations. Each iteration consisted of developing or improving the prototype, evaluating it with children from the target group (see Figure 3) and reflecting on this. In the first iteration, the prototype (see Figure 3: left) consisted of three interactive flexible balls on a stick providing simple light feedback. The prototype was successful in evoking diverse interactions and open-ended play scenarios. However, an early evaluation showed that the prototype was still rather abstract for children from the target group (4-6 years old) and a more specific trigger for the development of dramatic play is needed. In the second design iteration, a new prototype (see Figure 3: right) with a larger amount of interactive balls was developed with light feedback as well as background sounds. This prototype offered a more specific context through its physical design, i.e. little felt insects were attached to the balls. A second evaluation showed that this prototype was successful in evoking diverse forms of interaction and play scenarios and in supporting dramatic play. For example, some children believed that the balls could be controlled by creating "wind" either by blowing or by waving with their hands. Furthermore, we observed that children played in different social settings with Wobble. For instance, children played solitary with one play object, or together with multiple objects, i.e. children pushed the lights from ball-to-ball together. These pilot observations showed that children engaged in different levels of social play. In a third design iteration the final prototype was developed, which consists of multiple interactive light objects. The final prototype was improved on sensor accuracy, physical construction, i.e. by aggravating the foot of the objects to increase stability, and fine-tuning the interaction rules, i.e. changing light color when subtly tapping the ball. Figure 4 shows an illustration of the final interaction rules.

Figure 3: Children playing with the first prototype (left) and the second prototype (right) of Wobble.

Design Rationale

Different design properties of Wobble support various levels of social play. Wobble consists of multiple independent objects that children can play with individually. In **solitary play** the child "engages in an activity entirely alone, usually three feet away from other children" [12]. In the design of Wobble, a child can play with one object in the system. The independent objects offer local interaction rules, i.e. subtly tapping the ball to change its light color. Children engage in **parallel play** when they "engage in activity beside, but not with other children, usually at a distance of three feet or less" [12]. The objects are grouped together at a distance of approximately three feet. This allows children to play in parallel with one independent

object while imitating each other's explored interactions. Different objects in the system provide different states of light and color feedback, i.e. always two objects are on, while 3 objects are off. The child can notice these differences, which can trigger the child to become somewhat attentive to his or her playmates and/or to start to engage in parallel speech ("the child verbalizes his or her own thoughts for the benefit of other children" [12]). In this way, the design incorporates properties that can direct children to parallel play situations. The child engages in **group play**, if he or she "engages in an activity with another child or children, in which cognitive goal or purpose is shared among all members" [12]. The interaction rules between the objects in the system can direct children to group play, as it invites children to play together with the multiple objects. For example, the children can push one illuminated ball to make the light jump to another randomly assigned ball in the environment.

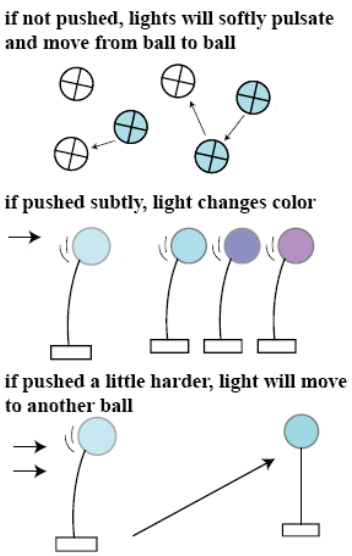

Figure 4: Final interaction behavior of Wobble.

Expectations

Based on pilot observations, we expect that the three levels of social play (solitary, parallel and group play) will be supported during the three stages of play in a pattern as illustrated in Table 1. When engaged in play with Wobble, we expect children to move from solitary, to parallel, to group play as children move from the invitation, to the exploration, to the immersion stage. Children will mostly approach the design in a solitary manner, when persuaded to play with the design in the invitation stage. In the exploration stage, children will move towards parallel play situations. When children enter the immersion stage, we expect children to become more engaged in group play, i.e. children will come up with shared games and goals in a group. This does not mean that other combinations of social play and stages of play will not occur, but we expect them to be less likely to occur. For example, in principle a design could elicit mostly solitary play in all three stages, because it provides less opportunity for children playing together.

	Invitation Stage	**Exploration Stage**	**Immersion Stage**
Solitary play			
Parallel play			
Group play			

Table 1: Expectations about how levels of social play will be supported during the three stages of play.

STUDY

We performed an explorative study as a first examination of how to support levels of social play within open-ended play. The set up of this study is rather small-scale, with a focus on collecting qualitative, detailed and rich information on how children play with Wobble. In this section, we describe the research question, set-up, methodology and analysis of our study.

Research Question

We aim to explore the overall research question: "*How do different design properties of Wobble support different levels of social play: solitary, parallel and group play; during the stages of play: invitation, exploration and immersion?*". To illustrate the play quality of Wobble, we also observe how children play with the design.

Set-Up, Methodology and Analysis

The study was conducted at a primary school in The Netherlands with eighteen children, eight girls and ten boys, aged 4 to 6 years old. Six groups of three children, some same-gender and others mixed gender, played in a free play session of 15-20 minutes with the design. Wobble was placed in a familiar environment: an unused classroom at the school. The children were divided in groups by their teacher based upon the likeliness of how well the children play together. All sessions were carried out according to the same protocol. A session started with guiding the children to the classroom where the design was set up. After entering the classroom, the test leader left the children alone with the design for about half a minute, to evaluate the *invitation stage*. Next, the test leader gave the children a short introduction and invited the children to explore the design. After five minutes, the interaction was further explained and the children were asked to come up with a game. When the children got distracted or started talking to the test leader their attention was brought back to the design.

The play sessions were analyzed using a qualitative research method [14]. During each session video recordings were made. All play sessions were coded for relevant events. In a

first round of analyzing the videos, the first author gained experience using the POS [10] to code levels of social play. In this analysis, we did not use the POS coding scheme in a quantitative manner (i.e. counting for how long children were involved in a type of social play). Instead, we observed in a qualitative manner how children played in a session and coded that with a certain type of social play. In a second round of observation, the first author coded the levels of social play in the three stages of play. A second independent researcher, after becoming acquainted with the POS [12], coded one video on levels of social play and stages of play. Both researchers discussed their findings until consensus was reached. In a third round of observation attention was paid to the specific design properties that support different levels of social play. The second independent researcher acted as a discussion partner for analyzing how different design properties support different levels of social play.

RESULTS

In this section, we present the findings of our study. First, we describe the game play during the free play sessions with Wobble. Then, we describe how particular design properties supported different levels of social play in the three stages of play. Note that all quotes from the children were translated from Dutch to English.

Game Play

Upon seeing the design, the children reacted enthusiastically and were curious to start playing with the design. Some children were a bit more hesitant, but the active lights of the design easily persuaded them to begin playing. During the free play sessions the children engaged in various forms of play. All children actively explored the design trying out various interaction possibilities such as pushing, clapping, waving or blowing to control the lights inside the balls. A large amount of children became engaged in dramatic play, e.g. one child made graceful 'wizard-like' movements trying to control the lights, saying: "*Pouf, pouf, pouf, turn on!*" Besides this, children came up with their own games, e.g. one group of children played a game like "*musical chairs*", in which each child tried to catch an illuminated ball. Most games involved rules about trying to turn the lights in the balls on or off. To a lesser degree, the children involved rules about different colors of light in their game play. Furthermore, the game play often involved a spatial element, wherein children went from object-to-object, e.g. children engaged in a game of pushing the blue light(s) from ball-to-ball. Children also played with the design without using the interactivity of the design, i.e. children explored the physical properties of the objects. Moreover, children were involved in conversations, communicating their actions and observations with each other, e.g. "*Look, if you tickle the ball it will wake up!*"

Although the game play differed between children, most children engaged in fairly similar play dynamics. At first children's game play was quite calm, but over time it became more active, e.g. running from object-to-object.

Figure 5: Children playing with Wobble.

Overall, Wobble supported diverse types of games engaging a variety of interaction possibilities. On top of the interaction rules of the design, the children created their own meanings, games, goals and rules in multiple ways. In this way, Wobble supported dramatic play and different open-ended play scenarios. Children seemed to enjoy playing with Wobble, expressing playful sounds during their play and explicitly stating they liked playing with the design.

Stages of Play and Levels of Social Play

An overview of findings on the levels of social play and stages of play is shown in Table 2. In the cells of this overview we describe the design properties that support different levels of social play (vertical) in different stages of play (horizontal). The three larger cells with bold text describe the main level of social play in that specific stage of play. The two large arrows show how children primarily move between these different levels of social play and stages of play. The smaller cells with grey text describe how other levels of social play are also supported in that specific stage of play. For example, in the exploration stage the main level of social play is parallel play. But solitary play and group play are also observed, though to a lesser degree. The small circular arrows indicate how children switch between specific levels of social play and specific stages of play. Below, we discuss our findings for each stage in more detail.

Invitation Stage

The video data shows that most children spread over the multiple objects in a solitary manner. Each child has a *personal object* when approaching the play design. Some children observed the objects at a very close proximity before daring to subtly push a ball. Another girl hesitantly walked step-by-step towards an object. Though, in some groups we observed a difference in this pattern. For example, in one group, two children initially tended to move together in the direction of one object in the system. However, when getting close to the object the children

chose to move to different objects in the system. Local feedback communicates to the children that the design offers local interaction possibilities for play. Therefore, *local feedback*, i.e. the lights, of the design supported the children's solitary play in the invitation stage. Besides this, solitary play is also supported by the *unfamiliarity of the design*. For example, we observed that most children seemed to need some time to process the play design, expressed in their calm behavior upon seeing the design. Though we observed some exceptions; for example, one boy who enthusiastically started to run in a playful manner between the objects upon seeing the design. Besides this, we observed that most children centered their attention on their own activity of approaching an object, i.e. children did not show true signs of being attentive to other children. Furthermore, in approaching the play design the children did not involve in conversation, and only rarely made statements such as: "*Wow, what are these objects?*"

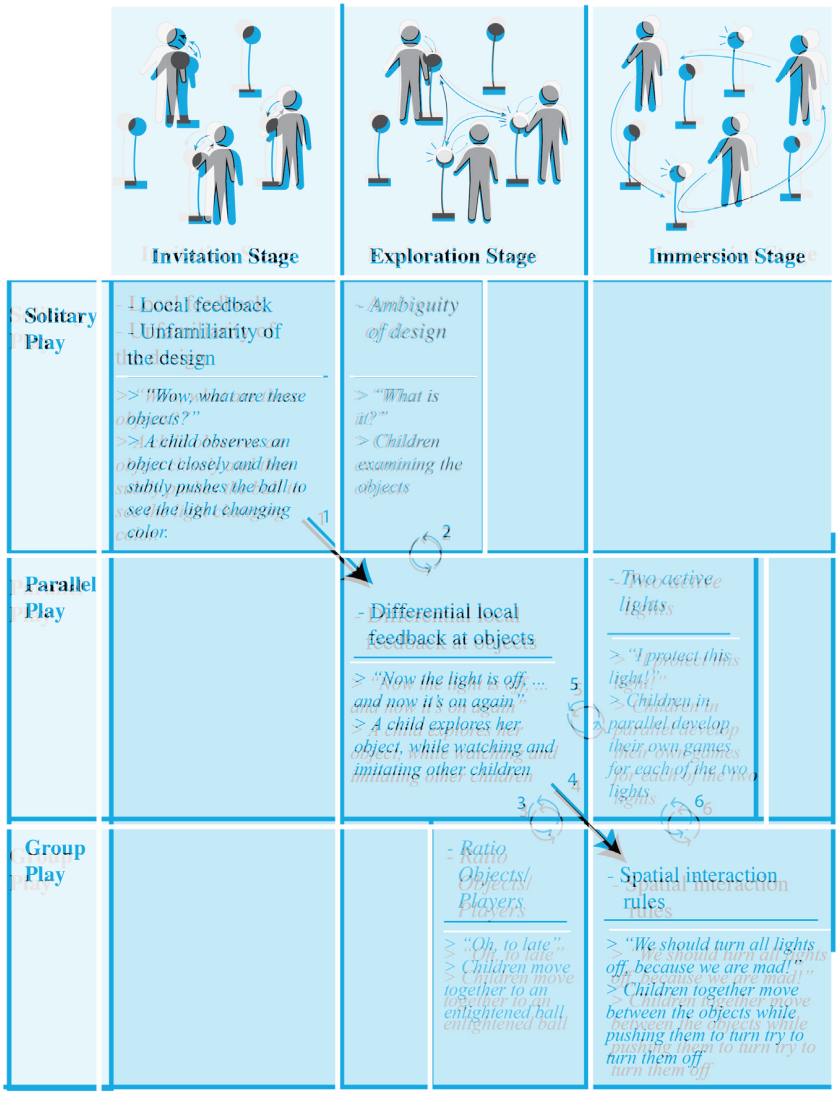

Table 2: Overview of findings: design properties supporting different levels of social play (vertical axis) in the stages of play (horizontal axis). The bold arrows (1 and 4) illustrate how children primarily move between these different levels of social play and stages of play. The small circular arrows (2, 3, 5 and 6) show how children can move between other levels of social play and stages of play.

Overall the play behavior of the children in the invitation stage is solitary. This is supported by the unfamiliarity and local feedback of the design, as well as the fact that each child has a personal object to interact with.

Exploration Stage

When children went from the invitation stage to the exploration stage, children mostly went from solitary play towards parallel play (see Table 2 - *arrow 1*). The different states of local feedback (at the same moment different objects displayed different local feedback) supported the children's parallel play in this stage. Due to the *differences in local feedback* of the objects, children's attention is directed towards each other. Children started to compare and noticed that their object could provide different local feedback in terms of light intensity and color in comparison to other objects in the system. We observed that the children almost directly became attentive to each other when entering the exploration stage. For example, a girl explored her personal object, while sporadically watching and imitating how other children interacted with their personal objects. Children also started to engage in parallel speech:

"verbalizing his/her own thoughts for the benefit of the other children" [12]. For instance, children started sharing their observations: "*Now the light is off ... and now it's on again*", "*I tickle the ball*" or, "*Turn on!*" In the exploration stage, children primarily played individually with their personal objects. However, sometimes the children switched from one object to another. Children tried-out a variety of interactions such as pushing, waving, talking or blowing to control the lights inside the balls. Furthermore, the children engaged in parallel, dramatic play. For instance, one boy knocked at a ball while saying: "*Knock, knock, who is there?*" Another girl examined her ball, after which she said: "*Oh I see, it is a big flower!*"

At the start of the exploration stage, children also engaged in solitary play for relative short periods (see Table 2 - *arrow 2*). For example, due to the *ambiguity* of the design a child became so fascinated by his or her personal object that the child just looked at it for seconds to half a minute. The child lost attention for the other children and did not engage in parallel speech. After this, the child again switched to parallel play.

As the exploration stage progressed, we observed that children sometimes engaged in group play for relatively short periods (see Table 2 - *arrow 3*). Group play in this design was supported by the *ratio illuminated objects versus amount of players* of the design. During the free play sessions, there were always two illuminated objects versus three players in the system. We observed that some children moved together towards an illuminated ball and explored its interaction rules, while engaged in communication. Children did have the general tendency to search for a personal object in the system, whereby children went back towards parallel play scenarios. The children rarely interacted together with one object in the exploration stage.

Overall, in the exploration stage children engaged in parallel speech and were attentive to each other, without sharing cognitive goals or rules. This parallel play was supported by different local feedback at the objects.

Immersion Stage

The video data shows that when children went from the exploration stage to the immersion stage, children generally went from parallel play to group play (see Table 2 - *arrow 4*). We observed that the *spatial interaction rules* persuaded the children to engage in spatial play scenarios, e.g. feedback divided over the balls caused children to move between the objects. Moreover, it triggered children to engage in mutual communication, e.g. children discussed rules, goals and games, and started their sentences with: "*We*..." Together, children started to develop rules, goals or games and in this way entered the immersion stage. For example, a group of children came up with a goal to turn all lights off: "*We should turn all lights off, because we are mad! Oh, you naughty balls!*" When engaged in group play, children directed each other by pointing.

Besides this, although less frequent, children entered the immersion stage in a parallel manner (Table 2 - *arrow 5*). This is supported by the *two active lights* of the design that afford to develop rules, goals and games in parallel concerning one of the two lights. For example, one child was involved in a game of protecting his or her own light, while another child, simultaneously, tried to push another light from one object to another object. Overall, children engaged for relative short periods in parallel play in the immersion stage. Often, children either started to engage in exploring the design again moving back to the exploration stage (see Table 2 - *arrow 5*), or started to engage in group play, in which children developed a shared goal or purpose (see Table 2 - *arrow 6*). For example, we observed that if a child in a parallel play setting came up with a game and communicated this game to other children, they tended to join the game, resulting in group play.

In the video data, we did not observe children moving in groups from the immersion stage to the exploration stage. When the children started to engage in group play, the children actually directly came up with a rule, goal or purpose. For example, a short conversation between two children playing with one ball: a girl said: "*Let's tickle the ball!*" upon which a boy responded: "*Yes, we should wake this light up!*"

Overall, in the immersion stage the children primarily engaged in group play. The children engaged in mutual communication and developed shared goals, rules and games supported by the spatial interaction rules of the design. In this way, children often shared a common goal or purpose in the immersion stage.

CONCLUSION

We were interested in exploring how different design properties of Wobble support different levels of social play: solitary, parallel and group play; during the stages of play: invitation, exploration and immersion. By examining how children play with the open-ended design Wobble we gained a better understanding of how to design for different levels of social play in the three stages of play. The results show that children in their interaction with an open-ended play environment generally move from solitary play to parallel play to group play, as children go from the invitation stage to the exploration stage to the immersion stage. Children primarily approach a play environment in a solitary manner, and subsequently explore its interaction possibilities in parallel at their personal object while being attentive to others and engaging in parallel speech. Children become immersed in a play experience while engaging in group play sharing a common purpose or goal.

Furthermore, the results show how the dynamics of the social play behavior of children develop over time and what specific design properties can support these levels of social play. For example, solitary play in the invitation stage is supported by the local feedback of the design, while group play is supported by the spatial interaction rules in the immersion stage. The results provide insights in how to design for variation in social play behavior of children over time and how to possibly persuade children towards a specific level of social play. Moreover, the results show that, in order to guide children's play to the immersion stage, designs should first offer interaction opportunities for

solitary and parallel exploration. This enables children to become immersed (involved in an ongoing engagement) in group play with the play environment.

This study was also a first exploration on how to design for open-ended play with a focus on dramatic play. Designing for this perspective taught us to explicitly take into consideration the abstractness of the design and consider using a specific trigger to stimulate the development of dramatic play.

We expect our findings can help other designers and design researchers in enriching their play designs to support different levels of social play. These findings should not be considered as the pattern children *should* follow when interacting with an open-ended play environment. Instead, we present these results as a design and thinking tool that provides insights in how to design for social dynamics in play. We also believe our findings can be adequate for other design scenarios with a focus on encouraging social interaction.

DISCUSSION

This paper presents a first step in exploring how to design for different levels of social play. Our current findings are based upon one case study and therefore must not be seen or used as final or fixed conclusions. More research into this direction is needed to further ground our results. For instance, future user studies could involve different age groups, as social play behavior tends to be quite age specific. The cognitive capabilities of younger children differ quite a lot from older children, which could influence their social play behavior. Besides this, the number of children influences the group dynamics. Different sizes of groups of children playing with the design can provide further insights into children's social play behavior. Moreover, the personality of children is also interesting to investigate further. For instance, Teele's Inventory of Multiple Intelligences [16] could be used as a tool to describe differences in personality characteristics of children.

Concerning the design of Wobble, some improvement points can also be addressed. The current objects are connected with wires. During the free play sessions some children got distracted by the wires for a moment and asked questions about their functionality. This did not disturb the children's play a lot as their attention quickly focused back on the design. But to avoid these issues we aim for a wireless solution in a next design iteration. Furthermore, the richness of the local and spatial interaction rules could be improved, to support more complex interaction.

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