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Tangible Interaction in Parent-Child Collaboration: Encouraging Awareness and Reflection

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ABSTRACT

Parent-child interaction during a collaborative activity can empower children if parents are able to envision their child's mental state and regulate their behavior. However, this ability is a great challenge for many parents. We designed a simple tangible 'Awareness Object' (AO) intended to raise parents' awareness of the roles they can play and help them shift their focus to the interaction with their child. We present results from 12 parent-child interactions with the AO. Our qualitative analysis reveals that the AO raised parents' awareness of their roles during the activity and led to various types of reflection by both parents and children. In addition, the AO increased children's involvement in evaluating their parent's role, which some parents found intriguing while others found inappropriate. We conclude that a simple tangible interface can enhance parent-child interaction. However, this interaction is sensitive and should be approached with caution.

ACM Classification Keywords

K.3.1. [Computers and Education]: Computer Uses in Education- Collaborative learning

Author Keywords

Parents; Children; TUI; Awareness; Reflection

INTRODUCTION

Parents play a key role in the social, emotional, and educational development of their children [18, 59]. As such, the parent-child relationship is an important component of children's learning ecology [36]. By adjusting their behavior,

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Figure 1. Parent-Child Collaborative Activity (Used with permission).

parents can empower children's learning process [35]. This requires awareness of the dynamic state of both the parent and the child [17, 37]. However, awareness is a demanding cognitive process that cannot be retained for long periods [52]. As parents' involvement in children's activities can have a drastic impact on their development, retaining awareness in parent-child interaction becomes an important challenge [5, 50].

Parents involvement in activities with their child provides an opportunity to empower children's skills, including communication, self-efficacy, and emotional development [2, 48]. By appropriate scaffolding, parents can further enhance children's potential achievements [35, 37, 49]. Vygotsky (1987), suggested that scaffolding should be adjusted based on the Zone of Proximal Development ('ZPD'), defined as the enhancement of what learners can achieve with the help of another person that they would otherwise be unable to achieve [65]. In the parent-child context, many studies show that when a child faces difficulties during an activity, parents' intervention should change from very involved (when the child shows frustration) to less involved (when the child demonstrates success)

[10, 11, 25, 39]. Appropriate parental scaffolding has been associated with two factors: (1) parents' ability to envision the child's mental state [17, 59] and (2) parents' ability to regulate their responses accordingly [50, 67]. Envisioning the child's mental state has been associated with reflection capacities and self-regulation abilities [52]. When these two factors are addressed, parents are able to adjust their response according to the child's need, allowing children to overcome challenges and achieve outcomes that would otherwise be beyond their reach. Therefore, the parents' goal is to fulfill these two factors, which could lead to a productive and intimate interaction [17, 59].

Understanding and adjusting behavior according to the child's mental state is challenging as it requires parents' awareness of both their own and their child's dynamic state [50]. Awareness is an essential cognitive process for understanding meta-levels of behavior [55]. Continuous awareness is a demanding cognitive process that cannot be retained for long periods [5], even when parents acknowledge its importance [51]. Lack of awareness may prevent parents from noticing their child's state, and in extreme cases lead to drastic negative consequences such as insecure attachments, anxiety, and different psychopathologies [5, 13, 14]. Two theories address relevant aspects of parent-child awareness: Parental Mind-mindedness and Reflective Function [30]. Parental Mind-mindedness describes the parents' tendency to attend to their child's mental state [37], while Reflective Functioning is the capacity to understand one's own and others' behavior in terms of underlying mental states and intentions [59]. Both theories highlight the parent's need to reflect and be aware of different implicit mental states. Continuous reflection and awareness during a collaborative parent-child interactions, require increased cognitive processing [37, 38, 54, 59].

In the field of HCI, Tangible User Interface (TUI) serve as a physical representation and physical manipulation of the digital world [29, 56]. Cognitive science investigate TUI as a mediator between the Internal and external representation [43]. This approach offers several unique advantages with regards to the challenge at hand. The physical nature of the interface facilitates social interaction and collaboration [28]; in addition, TUI can explicitly represent an abstract process and can contribute to awareness [53]; Finally, the physical representation can serve as a constant reminder for the processes it symbolizes [70]. The above advantages can contribute to continuous awareness.

Following these advantages, we designed a simple TUI called the Awareness Object (AO). The AO is a simple mechanical device that represents the parent's role in the context of parent-child collaboration. We based our design on the 'mentor-peer scale' as defined by Sadka and Zuckerman (2017) [51], the scale represents a range between two roles parents can fulfill during a collaborative activity with their child, a 'mentor-parent' and a 'peer-parent'. A mentor-parent role means the parent is focused on the child's learning process and will always follow the child's lead. In contrast, a peer-parent role means the parent is focused on the activity itself, striving to complete the 'goal' successfully and efficiently together with

the child, but usually by leading and not following the child's lead. Ideally, parents should shift their role between a peer-parent and a mentor-parent, and fine-tune their role based on the child's specific mental state during the collaborative activity. For example, during a typical activity, children experience a range of emotions including varying levels of frustration. Low levels of frustration can lead to overcoming challenges and thus increasing self-efficacy. High levels of frustration may lead to feeling of failure and a decline in self-efficacy. Parents that are able to be aware of the mental state of their child can fine-tune their role and adapt it to the child's level of frustration: taking the mentor role when frustration is low, and the peer role when frustration is high [10, 11, 25, 39]. Hence, increasing parents awareness can empower them to choose what role to take according to their child's needs and abilities [51].

Our design serves as a tangible representation of the mentor-peer scale using a simple mechanism that holds a vertical metal rod. Parents can move the rod from left to right through 20 possible steps. Our goal is to increase parent's awareness and self-reflection by manipulating the the rod as a pointer of the parent role (mentor or peer or in-between), in line with the guidelines recommended by the Mind-mindedness and Reflective Functioning theories.

RELATED WORK

There has been considerable research in the field of TUI for children. Within that active field, few have focused on TUI for parent-child interaction. Those who have, focused on three main themes: TUI for learning, storytelling and remote communication.

TUI for parent-child interaction in the context of learning drew inspiration from Piaget's conception that children are characterized as active learners when presented with a physical objects [45]. Little is known on how to design spatial environments to support cognitive development, however some researchers have shown that tangible systems enable physical action, which is a key component of cognitive development in childhood [1, 34]. Additional research on TUI for parent-child interaction showed that tangible objects incite curiosity, play, and learning [26, 58]. Parents can leverage the physical manipulation and physical representation of TUIs to 'bridge the gap' between what the parent thinks the child understands and the child's physical manipulation of the TUI that represent what the child actually understands [57].

Within the tangibles for storytelling category, most TUI's are multi-sensory environments that enhance playful communication while strengthening parent-child interaction [7]. These tangible systems enable children to freely share narratives with parents. This was shown as a powerful tool for promoting expression of the child's underlying emotions [6, 19, 22, 66, 69]. The open ended and tangible approach allows parents to be aware of different mental states of the child [66]. For example, the Linguabytes project is a storytelling tangible system for simulating speech therapy for children. Using playful materials, children can read interactive stories and do linguistic exercises. The collaborative affordance of Linguabytes serves

as a mediator for parent-child communication, leveraging the interaction to enhance communication skills [24].

Other TUI systems that emphasize interaction between family members are those that focus on long distance communication, helping individuals stay in touch with friends and family [47]. In a family context, and specifically parent-child interaction, physical objects and wireless communication are designed to create a human experience of co-presence [3, 8, 12, 20, 31]. For example, the e-seesaw design by Sun et al. (2016) [61]. The system includes two similar tangible seesaws: one for the child at home and the other for their parent at work. They are designed to support and enhance tangible social interaction and playfulness between remote parents and children. The tangible seesaws support parent-child communication by a simple minimal tangible manipulation. When the parent or child changes the position of the seesaw, the position of the paired seesaw changes accordingly. Their results indicated that the e-seesaw created a new form of communication between parents and children [61].

Tangible objects are also designed for raising awareness. In this case, their purpose is to make the actions of an individual obvious and explicit [46]. For example, Nipple Chair vibrates when it detects electromagnetic radiation, prompting reflection on the presence of previously undetectable power [16]. Another example is the Proverbial Wallet, a tangible object that provides haptic feedback to raise user awareness of their financial status. The object brings physicality to invisible concepts such as equity capital [32].

We believe it is possible to design an awareness TUI for parent-child interaction. By physical representation of implicit possible parental roles, we aim to encourage reflection on the mental state of both parent and child. Our approach is to design a simple TUI for collaborative parent-child activity, hoping to promote parents' self-reflection on his/her role as a mentor or peer during the activity.

DESIGN PRINCIPLES

We designed a simple TUI, a small mechanical object, that invites parents to reflect on their role during interaction with their child based on the mentor-peer scale. Our design approach of the object was in line with Norman's definition of a TUI as a mediator between the internal and external representation: 'knowledge in the head' vs. 'knowledge in the world' [43].

We wanted the AO to support real-time interaction while minimizing distractions to the parent-child activity. Therefore we decided to implement the AO without any digital components, using a simple spring-based mechanism that supports a metal rod and a button. We used 3D printed PLA plastic parts, a rubber band, two springs, and a 3.5 mm metal rod (see Figure 2). The top part of the base serves as a button and is coated with rubber paint for soft sensation (see Figure 2, A). The metal rod and the plastic ball at the top serve as a pointer for a tangible representation of the mentor-peer scale (see Figure 2, B). Parents move the position of the pointer to indicate their subjective opinion of their position on the scale. The rod movement was designed to provide mechanical auditory

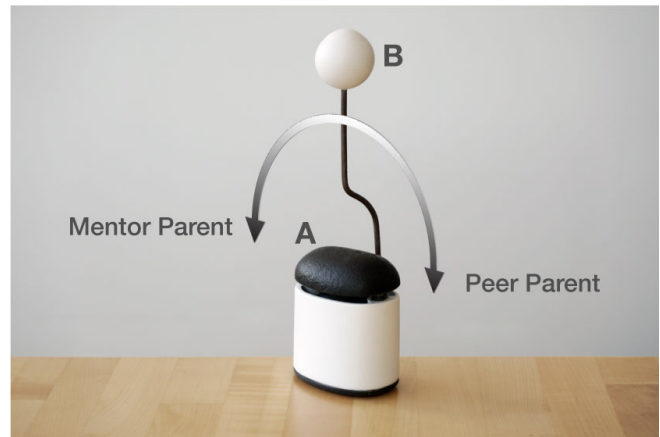


Figure 2. Awareness Object (AO). A - Button; B - Pointer; and the mapping of the mentor-peer scale.

feedback ('clicks') as the rod is being moved. There are 20 possible positions parents can choose along the 180 degrees of movement, ranging from extreme left (100% mentor parent) to extreme right (100% peer parent). Moving the pointer to either side creates tension via the rubber band, adding a mechanical haptic feedback. Since the physical presence of the AO can distract parents and children from the activity and from each other, we designed it to be peripheral through its a relatively small size (23X10X6cm) and neutral colors (black and white). Although the AO is designed for the parent, it is clear that children will also be interested in it because of its physical presence. We wanted to design a way for the child to take an active part in the interaction with the AO, and selected the button at the top of the object for that purpose. When pushed, the button activates a spring mechanism that releases the tension of the rubber, and as a result the pointer bounces back to the center of the object, making it clear for the parent he/ she needs to redefine their role along the scale.

Our design was informed by the following TUI benefits:

- External Cognition - Rogers (1996) [53] defines external cognition as the relationship between internal cognitive concepts (the mentor-peer scale), and external representations (the physical representation of the parent's position on the scale using the pointer). According to Rogers, external cognition has three advantages: *computational offload*, *graphical constraining*, and *re-representation*. *Computational offload* means an object should reduce cognitive effort by serving as a physical reminder of amorphous concepts during cognitive consuming activities [53]. *Graphical constraining* argues for similarity between the visual display and the amorphous concepts the object represents [53]. *Re-representation* means that the tangible design of the external object should aim to represent specific cognitive concepts [53]. In addition to Rogers, Hornecker (2005) argues that tangible manipulation of an object allows externalization of thinking processes about the concepts it represents [27]. Our design followed these recommendations, and therefore serves as external cognition for the mentor-peer scale.
- Tangible Facilitates Collaboration - Hornecker and Buur et al. (2006) argued that people's familiarity with physical objects and the affordances of those objects lower the

threshold for engaging with tangible objects [28]. This natural affordance prompts social interaction and implicit communication between collaborators [26, 28, 56, 62, 64, 71]. Collaboration is known as a core element in socio-cognitive development and emphasizes social interactions for generating new and creative thoughts and ideas [44]. Klemmer et al. (2006) emphasize that physical interaction with an object and the use of multiple access points lead to an interaction that is visible and inviting [33]. The visible presence of the AO ensures that parents and children will be aware of each other's interaction with the AO. The multiple access points invites children to have an active part in the manipulation of the AO.

- **Tangible Facilitates Continuous Representation** - Tangible objects are persistent and visible even when inactive or turned off. They have the potential to serve as a constant reminder of the tasks or processes they represent [68, 70]. Thus, the nature of tangible objects allow users to pursue ongoing activities while remaining aware of the presence of the tangible object. We designed the AO, and specifically the pointer, to serve as a constant and peripheral reminder of the parent's role throughout the collaborative activity, even when not directly used.

METHOD

Participants

12 parent-child pairs participated in the study (9 mothers, 3 fathers, 6 girls, 6 boys). All 12 families are from a medium-high socioeconomic status, live in central cities, and parents have an academic-level education. The children's ages ranged from 9-11 years old ($M=9.7$, $SD=0.7$) and the average number of children per family is 2.5 ($SD=0.9$). We chose this age group in-line with the recommendation of Druin and Tremblay (1999) who suggested that children at these ages are verbal, self-reflective, and master the ability to recognize emotions of adults [63, 15]. Participants were recruited from two sources: personal acquaintance with the researchers, and participants in the annual Scratch Day that takes place on our campus every year. In both cases, parents were contacted via email inviting them to participate in a study evaluating parent-child interaction during collaborative activity using a tangible device designed at the lab. We followed ethical guidelines including IRB, parental consent, children consent, and parental approval for pictures and videos. Following Read's (2015) guidelines



Figure 3. When the button is pressed, the pointer bounces to the center.

for research with children, we explained to the parents and children about the research field of the lab, what the research is about, and why they were chosen to participate in the research. Specific parents also gave approval for picture and video inclusion of them and their children in the paper and video. In a preliminary conversation with both parent and child we emphasized that they can withdraw their participation at any time. As part of our IRB ethics guidelines, parents and children were fully debriefed after each session.

Procedure

Three sessions were held with each parent-child pair at their home. All sessions were videotaped and recorded. The first session served as an introduction to making activities. When the researcher arrived, he introduced himself and explained that the purpose of the first session was to evaluate parent-child interaction during collaborative activity. Both parent and child were informed the sessions would be filmed for research purposes. After parents signed the consent forms, the collaborative activity was introduced: a co-making activity kit described in an instruction card. The activity kit in this session involved the construction of a simple mechanical automata and a paper circuit. The goal of this first session was to introduce the parent-child pair to the activity kit, so in future sessions the making activity would not be a novelty.

The second session was conducted a few days after the first one. The researcher explained that the purpose of the session was to evaluate a new object for parent-child interaction. The researcher introduced the AO, introduced the scale from a theoretical perspective, and demonstrated how the object and specifically the pointer represents the mentor-peer scale. This demonstration was accompanied with a written explanation about the scale, to make it easier for parents to relate to the theoretical concept of the scale. The mentor role description in the written explanation was as follows: 'The mentor-parent role is to support the child's learning process by asking leading questions and allowing the child to make mistakes along the activity'. The peer role description was: 'The peer-parent role is to become the child's partner, complete the activity successfully, and avoid mistakes along the activity'. Special emphasis was given to the adaptation of the parental role according to their child's changing need and ability during the seven-stage collaborative activity. Then, the parents practiced moving the AO's pointer to the side that represented, in their opinion, the role they just played during the activity. The child practiced pushing the black button, and was informed he/she should push it at the end of each stage during the activity (completion of an instruction card). Pushing the button reset the pointer to the start (middle) position. Following the demonstration how the AO can represent a parent's role, the researcher made sure parent and child understood the mentor-peer scale, and the collaborative activity began. The activity was guided by instruction cards (seven cards for seven stages). During the activity the researcher sat behind the parent and child, observing the interaction.

At the end of the parent-child activity the researcher conducted a semi-structured interview with both parent and child. The specific choice of a semi-structured interview allowed for flexibility during data collection while remaining grounded in a

particular framework [21]. The interview opened with general questions for both parents and children about the collaborative activity (e.g. *'how often do you do share activities?'*; *'describe a challenge you had during the activity'*), and continued with questions for parents about the AO (e.g. *'can you share how the experience with the AO was?'*), and ended with questions evaluating the AO's effect on their awareness (e.g. *'did the object raise your awareness of different roles during the activity?'*).

Two months after the activity, a follow-up semi-structured interview was held with 10 out of 12 parents at their home (two families were abroad). The time that passed since the first activity allowed us to assess the parents' reflection and insights without the novelty of the activity. In addition it allowed us to assess whether the interaction with the AO had any effect on parents awareness beyond the actual collaborative activity. We conducted the follow-up interview without the children, to allow parents to express their thoughts freely. Our goal was to share with parents some of the themes that emerged in the data analysis (activity observation and post-activity interview), and to further explore those themes with follow-up questions. We opened the follow-up interview with a reminder of the collaborative activity with the AO, then we followed-up with questions regarding the different situations raised in the parent-child collaborative activity (e.g. *'how did you feel when the child evaluated your role?'*).

FINDINGS

We present data from qualitative analysis of 12 parent-child pairs who performed a collaborative activity with the AO. The activity was followed by two interviews: the first, a post-activity interview with both parent and child, and the second a follow-up interview with the parent only. Qualitative methods were used as they can provide a 'rich description of complex phenomena' and are ideal for 'conducting initial explorations' [60]. The analysis process included two stages. First, all videos and interviews were transcribed and read several times by the primary coder to gain a general sense of participants' thoughts before coding. The collaborative activity from the first session was briefly reviewed to verify that all families performed the activity successfully. Second, we performed 'Thematic Coding' [4] on the videos of the collaborative activity with the AO and interviews transcriptions. A primary coder reviewed the transcriptions and identified possible common themes. The initial themes were presented to an additional researcher and discussed, keeping themes that reached consensus. Following theme definition, the primary coder and a third rater both coded all data separately (including more than 200 parent-child interactions with the AO and a total of 22 interviews). A Kappa coefficient analysis [4] revealed an 88% inter-rater reliability. Disagreements were further discussed until they were settled. The final analysis revealed four themes. The first theme relates to the different levels of awareness raised by the AO. The other three themes concern the AO's influence on parent-child interaction, including: Different types of interactions parents and children had with the AO; Different levels of joint reflection parents and children had on parental role; and Different attitudes parents had towards the child's evaluation of their role.

1. Awareness raised by the AO

Our analysis indicated different levels of parents' awareness towards their role in the interaction with the child. 8 out of 12 parents felt that the interaction with the AO raised their awareness and in some cases it led them to reconsider their behavior:

'It's difficult to understand the mental state of your child. For example, I tend to take over. During the activity the AO helped me realize that maybe I should be more of a mentor parent rather than a peer parent'. (Mother 2)

'It helped me be more aware of my role. It helped me understand how I acted and if I was more of a peer or a mentor'. (Mother 10)

'It made me be more aware of my part in the activity. It helped me understand what role I took, whether I was a peer or a mentor'. (Father 9)

In one case, a mother and a child discussed the AO while referring to it as a living creature:

'It's a great tool to remind me. Every stage I had an opportunity to raise my awareness in real time. He's cool, I like him'.

Child: 'Do you like the creature?'

Mother: 'Yeah, he clarifies and makes you precise. He's very present during the activity, but if you want to take it to the next level maybe for the next activity I wouldn't need him'. (Family 2)

Of the eight parents who mentioned that the AO raised their awareness, two indicated that the AO made them over-aware, to a level that was distracting:

'I would rather do the activity without it. It reminded us that we are in a research. Instead of having natural dynamics with my child it made me over-aware and it made my child be aware of things that maybe I don't want her to be aware of'. (Mother 5)

'I felt it managed me. I was more preoccupied by it than with the interaction with my child. It made me act unnaturally. It was annoying'. (Mother 4)

The four parents that the AO did not raise their awareness mention that the AO didn't change their level of awareness. Some pointed out they were already aware of their potential roles regardless the presence of the AO:

'No, it didn't raise my awareness. I was already aware of it. Even in the first activity, without the AO I was already aware and always thought whether I should help and how'. (Mother 12)

'I think I'm already aware of it. If I would think I need to change something in my interaction with my child I would have use it'. (Mother 3)

During the follow-up interview we told parents that the AO was used by different parents in different ways. They were asked again to assess whether the AO raised their awareness or not. Parents' answers in the follow-up interview were

consistent with their answers in the post-activity interview. Some parents provided additional insights on the effect the AO had on their awareness:

'When I'm under pressure I'm less aware of my deep behavior and the AO helped me be aware when I took over the activity'. (Mother 7)

'The fact that it made me reflect on my role raised my awareness. If the purpose of this tool is only to raise awareness and not to evaluate what happens afterwards - it helped. If you want a person to self-reflect, it's a great tool'. (Mother 12)

One mother mentioned that the activity with the AO influenced her during future interactions with her child:

'It was interesting and great. The activity with the AO initiated a thinking process. I definitely thought of it during the activity, but also afterwards. I find myself thinking of it from time to time. There are many situations when the child does something and you need to decide what role you should take. Either you do it with him or you let him make a mistake. As a parent you need to be very attentive. In my case I don't want my children to make too many mistakes because that will cause them to be frustrated and give up'. (Mother 11)

Another mother mentioned the AO raised her awareness of the importance of making decisions when interacting with her child:

'A few days ago my child asked for my permission to sleep over at a friend's house. Deep inside I didn't want her to go. But I didn't want to tell her not to go. Instead I told her to ask her father. He agreed and I felt really bad because I didn't want her to go. If I had had the AO for that case, he would have reminded me that I have to decide whether I'm a peer or a mentor. In that case I would have chosen the mentor role and explained why I don't want her to go. That would have helped me'. (Mother 7)

2. Parent-child interaction with the AO

Our analysis of the parent-child interaction with the AO revealed three themes.

2.1 Parent-child interaction with the AO

A theme that emerged from the data was how parents and children interacted with the AO. Some of the parents focused on the tangible interaction with the AO; others invited their children for joint reflection; and some forgot to use the AO. In all families, more than one type of interaction was observed during the activity. Children reacted in various ways to the parents' interaction with the AO: they either accepted or ignored parents' invitation for joint reflection. In some families children were the ones who initiated joint reflection. In a few cases the parent and child did not interact with the AO and continued with the activity flow. In 10 out of 12 families, more than one type of child response appeared during the activity.

2.1.1 Parents interaction with the AO

Tangible interaction with the AO was characterized by moving the pointer to indicate parents' role in the activity. Parents typically showed self-reflection considering the specific position indicating the degree of each role. In some cases, parents move the pointer without sharing or verbalizing their thoughts:

Mother moves the pointer to the peer side, and child turns a page to the next stage of the instruction card. (Family 5)

In several cases parents verbalized their thoughts while considering the position of the pointer:

'This time I was more mentor' while moving the pointer to the mentor side. (Mother 12)

'Extreme peer' while moving the pointer to the peer side. (Family 1)

In other interactions, parents invited their children to joint reflect on their role while moving the pointer:

Mother: 'So...how was I this stage?'

Child: 'You were almost like in the last stage'. Child presses the big button and moves the pointer to the mentor side.

Mother: 'I'll tell you what I think...'

Child presses the big button.

Mother moves the pointer further to the mentor side than what the child decided. (Family 2)

In a few cases parents forgot to use the AO. This typically occurred when parents and children were focused on the collaborative activity and were enthusiastic about moving to the next stage.

Child succeeded in gluing the paper to the cardboard.

Mother: 'Very good! What's the next stage?'

Child: 'I don't know, let's see' and passes to the next stage of the instructions. (Family 5)

In cases where parents forgot to use the AO more than twice, the researcher reminded them about the presence of the AO.

2.1.2 Children's response to the parent's interaction with the AO

Children reacted in different ways to their parents interaction with the AO. In some cases children didn't respond to their parent's interaction with the AO even when invited to do so by the parent:

'I don't know, I feel I was both mentor and a peer, what do you think?'

Child shrugs. (Family 10)

In most cases children responded to parents' reflection upon their role. Children typically shared their opinion after being invited to do so by the parent:

Father moves the pointer to the mentor side and faces the child: 'OK?'

Child: 'But you made mistakes'.

Father: 'OK, but...um...' tries to move to the next stage in the construction cards.

Child insists: 'Hey, but you corrected my mistakes!'
 Father: 'Yeah, but...' keeps trying to shift child's awareness to the activity.
 Child grabs the pointer: 'Wait, but this side is the peer and that side is the mentor'.
 Father: 'But I thought you more than...ummm...'
 Child gives up and reads the instructions from the construction cards. (Family 9)

Mother moves the pointer to the peer side of the scale:
 'Do you agree?'
 Child: 'Um...yeah'.
 Mother: 'Maybe more?' and point towards to the peer side of the scale.
 Child: 'Um...you...it was like...'
 Mother: 'You told me what to do during the last stage'.
 Child: 'Yeah, but you also corrected me. So I think you placed it right'. (Family 7)

Some children also offered their opinion when not specifically asked by the parent, initiating joint reflection:

Mother moves the AO to the peer side of the scale.
 Child: 'You are right'.
 Mother: 'Why am I right?'
 Child: 'Because you helped me out.' (Family 3)

After father moves the pointer to the mentor side of the scale.
 Child: 'Do you think?'
 Father: 'Yes'
 Child: 'O.K.'
 Father: 'You think I'm wrong?'
 Child: 'I think you were a peer, but never mind, it's about what you think'. (Family 8)

Some children even initiated interaction with the AO. By moving the pointer children often expressed their opinion regarding the parents role.

Child presses the AO and asks: 'What were you? Were you a mentor or a peer?'
 Mother thinks for a while: 'I'm a peer' and moves the pointer to the peer side.
 Child: 'Not a little peer, a total peer' and moves the pointer to the extreme peer side.
 Mother nods in agreement: 'Yeah, I'm a total peer'. (Family 11)

In some cases children initiated interaction with the AO, while disrupting the flow of the activity.

While the mother is cutting the paper:
 Child: 'I think you should have put the pointer like this' and moves the pointer to the extreme peer side.
 Mother: 'Really?'
 Child: 'Yeah, next time put it...' and points towards an extreme peer.
 Mother: 'I'll put it according to how I was...' (Family 2)
 Child: 'Do you want me to show what I think of you? You are...' reaching his arm towards the AO.
 Father: 'Wait, not yet. Let's finish this stage' and tries to



Figure 4. From top to bottom. Child presses the button at the end of the stage. Father reflects upon his role. Father and child react to his choice (Used with permission).

gently move the child's hand from the AO.
 Child moves the pointer to the mentor side.
 Father: 'Really?!'
 Child: 'Yeah, I think that...'
 Father interrupts: 'We'll talk about it later'. (Family 1)

2.2 Parent-Child Joint Reflection

In all families, parents and children had different forms of joint reflection on parent's role. Some conversations were informative, where parents and children discussed the nature of the different parental roles:

Child: 'Mom, what's the difference between a peer and a mentor?'
 Mother: 'A peer is someone who is an active participant in the activity, right?'
 Child: 'And a mentor is someone who helps'.
 Mother: 'Do you want me to be a peer parent or a mentor parent?'

Child: 'Be both, find the balance. There are two sides to a coin'. (Family 2)

In other conversations parents and children agreed on the parent's role:

After mother moves the pointer to the peer side of the scale she asks the child: 'What do you think? You told me what to do'.

Child: 'So did you, it was half- and half'.

Mother: 'Half- and half?'

Child: 'Yeah, I did this part' while pointing towards the construction kit.

Mother: 'Well, I still think that I don't let you make mistakes during the activity'.

Child: 'You are right'.

Mother: 'I don't like making mistakes'.

Child: 'Me neither'. (Family 10)

In contrast, some conversations led to conflicts where parents and children disagreed about the parents role:

During the post-activity interview:

Researcher to mother: 'What role do you think you took during the activity?'

Child moves the pointer all the way to the peer side of the scale.

Mother: 'No! That's not nice, you slander and smear'.

Mother moves the pointer back to the middle.

Child moves the pointer back to the peer side of the scale.

Mother moves the pointer back to the middle and keeps moving to the mentor side of the scale: 'I was here'.

(Family 7)

2.3 Parents' attitudes towards children's awareness of their parent's role

The interviews revealed that parents had different attitudes towards their child's awareness of parental roles. Seven parents enjoyed hearing their child's perspective on their parental role and behavior. However, three parents were concerned by the child's high awareness to their parental role. Two parents expressed ambiguous attitudes.

The seven parents who enjoyed their child's awareness to their role, experienced it as a very positive experience, and as a new way of parent-child communication:

'I had a great time hearing indirectly what she thinks. The AO helped her describe what she thought in a very summarized way. Sometimes when I ask her what she thinks (of me), as a 9 year old, she has a hard time describing her thoughts due to lack of vocabulary or the fact that sometimes it's hard for a 9 year old to describe what she thinks of her dad. Here, it was very easy for her to describe what she thinks, especially when she disagreed with me. I wish I had this tool at her age or even older'. (Family 8)

Some highlighted the possibility of using the AO as a tool for evaluating children's perceptions of the relationship with the parent and revealing 'invisible' inner emotions towards the parent:

'I think that even if the parent decides what role he took, it's a good thing to consult with the child, because then you have a chance to understand his temporary inner mental state. Let's say the child is mad at me, even if he doesn't express it for various reasons, he will perceive my behavior in a negative way. This (the AO) can indicate and then I can use it as a tool to understand...I would ask him 'why do you judge me so harshly?' and try to dig from here. There is the opposite situation, where I judge myself harshly and the child thinks it's not that bad. In some aspect it can confirm to myself that I'm ok'. (Family 7)

On the other hand, some parents thought there are negative aspects to child's high awareness of parental behavior. One mother was worried about the outcomes of her child's awareness of her role:

'I wouldn't want my child to be aware of this dynamic. It's like behind the scene of a parent, and you need to let him...you know...(switching to a language the child doesn't understand) I don't want her to think about it in every activity I do with her (Switching back to the language the child understands). If you use it (the AO) during interaction of two equal people it's fine. But since you use it during parent-child interaction...you know...we live our daily life afterwards and I do other things with her...' (Family 5)

Others focused on their negative emotions:

'It raises negative emotions when sometimes there is a difference between how I perceive myself and how my daughter perceives me'. (Mother 12)

Two parents raised ambiguous thoughts:

'At some point it was annoying when he criticized me. But although it was annoying it doesn't mean I need to change it. I think it's good that he has his own opinion and that he argues with me. I think it's important to allow your child to speak up and say what he thinks...but, I don't think it's always a good thing. It's ok when we are playing. I'd rather it happened in a game context than a fight. I wouldn't use it when there are there are things we have to do, like homework'. (Mother 6)

'After I asked my child for her opinion, there was some kind of a dialogue. I was curious to hear what she thought. But not really. I didn't actually ask her: 'what do you think?', I remember it made me feel embarrassed'. (Mother 3)

As evident from these findings, some parents were comfortable with the joint reflection while others were not. From an ethical perspective, we took several measures. Before each session we verified that parents understand they can withdraw from the activity at any time with no negative consequences. In addition, parents were given the chance to retrospectively exclude their data from the research (none chose to do so). In cases where parents were uncomfortable with the joint reflection part, we performed a follow-up conversation with the parents to verify that the inconvenience was resolved after the activity ended.

DISCUSSION

We presented a qualitative study using the Awareness Object (AO) designed to enhance awareness and self-reflection among parents during a collaborative activity with their child. The AO design was based on TUI principles to represent the mentor-peer scale, making parents more aware of the possible roles they can play during a collaborative activity with their children. The qualitative analysis showed that the AO influenced parent-child interaction in several ways. Our analysis indicated that in most families the AO raised parents' awareness of the roles they can play during the activity. However, a few parents felt that the AO made them 'over-aware', and some parents mentioned the AO did not raise their awareness. Moreover, in most families the AO led to different levels of joint reflection on the parental role. In addition, the affordances of the AO led to more active involvement by children who wanted to express their view of the parental role during the activity. Some parents found the children's involvement intriguing and even followed up with joint reflection, other parents found it inappropriate and even embarrassing.

These findings indicate that even a simple interactive object with a meaningful representation has the potential to expose theoretical concepts (mentor-peer scale) and elevate parent-child interaction in collaborative activity. By leveraging TUI frameworks that present tangibles as facilitating external cognition, collaboration, and continuous awareness, we showed that the simple mechanical object was able to support parents continuous awareness of inner processes and alternative roles. In addition, the implementation of elements from Mind- mindedness and Reflective Functioning theories enhanced parents' reflection. Findings from parents' self-reports indicated that they were minded towards their level of involvement in the activity based on child's mental state and needs. Parents also considered the AO as a tool for addressing sensitive issues and for revealing the child's emotional state. In some cases parents awareness persisted beyond the collaborative activity, during future activities with the child. This implies that a single interaction with the AO has a potential to influence future parent-child interactions. Future studies should evaluate the extent of the effect.

Our findings imply that a minimal TUI awareness intervention such as the AO can contribute to parent-child interaction. As suggested by Vygotsky (1978), awareness can allow parents to offer more appropriate scaffolding for their children, empower their skills and lead them to greater performance [65]. Notably, the few parents who reported that it did not raise their awareness, perceived it as a useless tool. This finding is in line with principles of slow technology, a design philosophy that suggests technology and tools need to actively promote moments of reflection. When it is used without the relevant context, it might become awkward and be perceived as a useless tool [23].

Although the object was designed for the parent, we included a button as a marginal interaction for the child. We designed the button to prevent the child from feeling excluded from the interaction with the AO. However, the strong affordance of the AO invited children to move the pointer even though it

wasn't their designated role. In addition, the fact that the AO motivated parents to explicitly reflect upon their role, together with the nature of tangible objects as encouraging collaboration, contributed to raising children's awareness and invited them to express their opinion even when not directly invited by the parent. Some children showed high initiative and began an interaction with the object before completing the collaborative activity stage. These unique interactions provided fertile ground for diverse parent-child conversation on issues that are usually 'backstage' in parent-child interaction. As such, they allowed a new communication channel for parents and children, where children are invited to express their opinions and discuss their parents roles. Another important aspect mentioned by the parents in this context, is the AO's physical representation of the parental role. Parents indicated that it presented an opportunity for children to express themselves and their thoughts about the parent via the simple physical moving of the pointer. This is important for children who are less likely to express themselves verbally, especially on such a sensitive subject. Some parents indicated that this was not likely to happen without the AO and that this could be a tool for understanding their child's emotions towards them.

Interestingly, parents had different approaches towards the joint reflection with the children. Some parents were enthusiastic and perceived it as an opportunity for opening new communication channels with their child. The ability to discuss sensitive emotional issues related to the parent-child relationship was very appealing to most the parents. Those parents were happy to embrace the discussion even when the child's opinion conflicted with their own. Other parents found the joint reflection inappropriate. They mentioned that these 'hidden' processes of the parental role should not become explicit or open for discussion. Some parents even said that children's awareness of the parent's role is not a topic they would like to directly communicate with the child. They felt uncomfortable discussing it in front of the child and even found it embarrassing.

The Mind- mindedness and Reflective Function theories help us understand these results. The strategies and interventions recommended by these theories report on increased awareness and self-reflection by parents. As we reported in our findings, the AO can also be effective in helping parents increase awareness and self-reflection. Clearly, a short intervention with such a simple object cannot be compared to the influence of a long term expert-led intervention. However, our results show that physical objects, or TUIs designed according to appropriate theoretical principles, can serve as the starting point of a process that empower parents to develop their self-reflection and in some cases even lead to joint reflection with their child. Future work should further explore the potential of more advanced TUI's in parent-child collaboration.

Another theory can further explain the considerable differences in parents' approaches towards the joint reflection with their children. Newberger's (1989) Parental Belief System, presents four levels on which parents tend to think about their child and understand his or her behavior. On the first level, parents understand their child in terms of their own experience.

On the second, they perceive their child in terms of social and conventional norms. On the third level, parents understand their child as a unique individual. On the fourth level, parents perceive the child as a complex and changing psychological system and their need to balance between competing needs of the child, parent, and family [9, 40, 41, 42]. The Parental Belief System recommends that dialogues concerning parental roles should be adapted to the parent's level of the Parental Belief System. Parents that are not at the appropriate level would not be able to discuss such issues: 'trying to get them swallow a Smithfield ham in one gulp' [9, 59]. This implies that empowering parents' to reflect on their parental role is not ideal for all parents; some will welcome an open dialogue and will be able to consider external evaluation of their parental roles, while others will find it inappropriate because of their Parental Belief System, values, and preferences. TUI's designed for parent-child interaction should take these critical aspects into consideration, and allow parents to customize the level of reflection to their abilities.

LIMITATIONS

Our qualitative study has several limitations. First, our families sample was rather homogeneous in terms of socioeconomic status and level of education. Second, the specific scale we chose to represent with the AO in this study, the mentor-peer scale [51], is driven by our own interest. Other scales of potential parent roles can be relevant as well. However the scale we chose is of high relevance to parent-child collaborative activity [10, 11, 25, 39]. Third, in three cases parents or children did not interact with the AO more than twice during the designated times. In those specific cases, according to the study protocol, the researcher gave a single gentle reminder in the form of: 'I remind you to use the AO at the end of every stage of the activity'. This external intervention by the researcher could have affected the natural parent-child interaction. However, as an 'in the wild' qualitative study, there are many potential interruptions, and the relative influence of a single reminder in very few cases could not have a major influence on the results. Another limitation is the possible contributing effect of the instructions given before the activity on parent's increased awareness. The instructions were a necessary part of the study's procedure, as the AO is abstract and has no meaning without instructions about the scale and concepts it represents. We therefore cannot distinguish the effect of the object's physical presence from the possible effect of the instructions given about the theoretical aspect of the parent-mentor scale. That said, in the post-activity interview most parents specifically mentioned the physical object and how it helped them raise their awareness during the activity. They mentioned the physical presence of the object as a tool for joint reflection with their children, and emphasized it enabled indirect indication of their child's thoughts and inner-state. These reflections by parents strengthen our confidence that the object's presence had an effect.

CONCLUSION

Our study suggests that parent-child interaction and specifically parent-child collaboration hold great potential for HCI researchers and designers. In this paper, we showed that even a

simple mechanical object, when designed according to appropriate theoretical principles and TUI guidelines, can enhance parents' awareness and reflection during parent-child collaborative activity. Our findings also reveal that parent-child interaction is extremely sensitive, and parents' ability to cope with reflection vary. We further showed how our findings connect to relevant theoretical frameworks, including Mind-mindedness, Reflective Function, and the Parental Belief System. HCI researchers that design for parent-child interaction should be aware of the relevant theoretical aspects, and specifically take parental belief systems into concern. We specifically see promise in TUI designed for parent-child interaction, as TUI has inherent relevant benefits, including tangible representation, external cognition, and enhanced collaboration.

In sum, we highlight the following aspects from our finding: (1) Tangible properties can increase awareness and reflection in parent-child collaboration. (2) Tangible properties increase involvement and interaction of both parent and child. (3) Not all parents can successfully cope with joint reflection with their child about parental roles. Some parents successfully leverage it towards reflective conversation, while others are not open for discussion about it and feel it's inappropriate. (4) Based on Parental Belief System theory, the object should allow parents to customize the level of reflection to their ability.

SELECTION AND PARTICIPATION OF CHILDREN

Families participating in the study were recruited from two sources: personal acquaintance with the researchers, and participants of the annual Scratch Day. We chose families with children at the ages of 9-11 because they are verbal, self-reflective, and are expected to be able to conduct open and natural interaction. The research was conducted at the families home. Parents signed consent forms for them and their child, and children gave verbal consent. Parents were informed they can withdraw at any stage without any negative consequences. Both parent and child were introduced to the researcher, the research field of the lab, and the purpose of the research.

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Figure 5. Parent-Child Joint Reflection (Used with permission).

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