

Eliciting parents' insights into products for supporting and tracking children's fine motor development

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ABSTRACT

Early development of fine motor skills is a critical milestone for children, which also helps the formation and maturation of other developmental areas like language development. While toys and daily artefacts could support children's fine motor skills, parents play a profound role in monitoring their developmental progress. Although there are several products to support fine motor development and help parents monitor their children's progress, the literature lacks a source that might inform the design of such products. As the first step of a bigger research project, we conducted semi-structured interviews with 13 parents to gather their insights into and expectations of such supportive products. We designed a sensor-embedded toy concept, ANIMO, aimed at supporting the fine motor development of 7 to 24-month-old children and assisting parents in tracking their children's developmental progress via a mobile app. We showed this concept to parents during interviews to facilitate the insight elicitation process. We present ANIMO, three themes summarizing parents' insights and expectations into products supporting fine motor development along with implications for their design.

CCS CONCEPTS

• Human computer interaction; • Interaction Design;

KEYWORDS

Design for children, Child Computer Interaction, Fine Motor Development, Toy Design

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1 INTRODUCTION

Fine motor skills, such as holding and grasping objects, are one of the fundamental developmental milestones for young children. The acquisition of these skills should be supported early on because children's developmental trajectories in the early years of their

lives are related to their cognitive and language development (e.g., [17, 21, 29]) Parents play a significant role in monitoring and supporting their children's early motor development [11, 35]. However, they might experience difficulties during this process due to various reasons [19]. The pace of motor development varies in each child. For example, while it is expected for a 7-month-old to do a raking grasp, some babies may achieve this skill later, or some babies can also perform harder grasps (e.g., pincer grip). Thus, parents might misinterpret normative information about their children's developmental progress and think that their children have a developmental delay. Furthermore, parents may lack the appropriate knowledge required for tracking fine motor development, or they may not be familiar with the tracking parameters (e.g., the force a child is exerting while moving an object) and what these parameters mean for motor development (e.g., how much force is considered as sufficient) [19].

Despite the importance of monitoring motor development, products designed to support this activity at home environment are sparse, especially for children under two. On the one hand, different toys on the market are designed to support fine motor skills (e.g., the Fisher Prize Linkimals¹ Zebra Walker²). Although these toys are helpful in supporting fine motor development while entertaining children, they do not offer parents a rigorous monitoring option. On the other hand, some mobile applications are designed to help families track children's development progress (e.g., Baby Spark³ and Wonder Weeks⁴). Unlike mobile applications, there are also some questionnaires that allow parents to track and evaluate their children's progress by observing their behavior and doing a checklist with different developmental milestones such as fine motor, gross motor skills (e.g., Ages and Stages Questionnaire (AQS)) [3]. Though these applications and questionnaires are useful in providing an overall understanding of children's development, they describe the development process by dividing data into standardized stages. Finally, even though these toys and monitoring apps could support fine motor skills, the literature lacks a source that might inform their design.

Addressing this gap, we aimed to produce design knowledge to help designers and researchers develop products that can support young children's fine motor skills (children under two) while encouraging parents' involvement in monitoring this developmental process. As the first step of a bigger research project, we conducted semi-structured interviews with 13 parents to gather their insights into and expectations of such supportive products. We designed a

¹<https://www.amazon.com/s?k=fisher+price+linkimaksor>

²<https://www.ubuy.com.tr/en/product/2M9AIHG-fisher-price-learn-with-me-zebra-walker>

³<https://babysparks.com>

⁴<https://www.thewonderweeks.com>

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sensor-embedded toy concept, ANIMO, aimed at supporting the fine motor development of 7- to 24-month-old children that assist parents in tracking their children's developmental progress via a mobile app. We showed this concept to parents during the interviews to facilitate the insights elicitation process. Through a qualitative analysis of interview data, we identified three themes summarizing these insights. We found that i) Being able to monitor a children's progress through numbers increases parents' competency and motivation in tracking, but it might also create anxiety, ii) Using different modules satisfies the need to support various fine motor skills, and iii) Adaptability to different skills, ages, and development stages makes a product desirable for parents. We also revealed three design implications: i) Account for parents' anxiety and frustration when providing feedback about motor development, ii) Support parents' involvement in the design, and iii) Consider the diversity in children's and parents' daily routines. We contribute to the design literature on motor skill development with these themes and implications along with a novel toy concept.

2 RELATED WORK

2.1 Fine motor development in children

Fine motor skills refer to the performance of manual actions like grasping, rolling, throwing, reaching, pinching by smaller muscles, hands, and fingers [1, 2, 21]. The development of these skills starts early on and continues through adolescence [1, 5]. Early motor skills are divided into different developmental markers linked with tongue and mouth movements, finger-hand movements, head and trunk stability.

The capability of performing fine motor skills and list of doing complex tasks increases between 6 to 24 months. Therefore, this age period is critical for supporting fine motor skills of young children [7]. Fine motor skills play a crucial role in children's daily activities such as dressing, eating, drawing, and self-care (e.g., [5, 6, 25]) Early fine motor skills are also related to children's cognitive and language skills (e.g., [17, 21, 33]). For example, exploring objects manually is associated with infants' word learning [33]. Similarly, a longitudinal study indicated that fine motor skills at 14 months are related to infants' object feature naming at 25 months. However, parents' vocabulary input in object feature naming also interacts with this process [21, 26]. Intervention studies indicate that training motor skills can be effective on later object exploration of infants [23]. Preschoolers' fine motor skills, together with their executive functions, contribute to their kindergarten achievement [8], and kindergarteners and first graders' fine motor skills are related to their math achievement [41].

In sum, developmental research suggests that supporting fine motor skills through object exploration with the help of parents is crucial for children's future cognitive and language development, which proves participation in the valued occupation of play, education, social interaction, and daily living [10,14].

2.2 Products designed to support and monitor fine motor development

Products designed to support fine motor development have been around for some time. Some popular examples are Montessori toys and Fisher-Price toys. Recently, smart toys embedded with sensing

capabilities have been introduced. These toys provide therapists and experts to monitor a child's developmental progress and enable them to detect developmental problems. For example, *Child's Play* [13, 38] is a system designed for 5-year-old children to monitor their interactions with objects and automated recordings about developmentally relevant activities through a wireless sensor embedded in existing toys. This system, a statistical pattern automatically characterizes a child's object play behavior, was tested with thirteen children by detecting object manipulation such as rolling, grasping, exploring, throwing, assembling, shaking, pulling objects with the help of own system's interface, *PlayInterface*, showing a retrospective review of play data [38]. Rivera and his colleagues [31] also designed a smart toy comprising two cubes with wireless sensors. The mobile computing platform measures the information coming from the cubes, which developmental specialists later use to detect a potential problem. They aimed to integrate this system into daily life toys so that professionals easily can enable early detection of possible developmental motor difficulties or problems by enhancing professionals' decision-support systems.

As for smart toys for non-professionals' monitoring of fine motor skills, *Easysketch* is a sketch-based educational interface that helps 3- or 4-year-old children draw basic things such as alphabet letters or numbers and provide teachers and parents with information on children's performance [20]. *Get that Cheese* [28] is a sensor-added smartboard game designed for preschool children to develop their fine motor skills. This board game supports the early detection of motor skill problems and follows their developmental progress [28]. Other games designed to support and monitor motor development by observing children's behavior in-game environments include *TaGGames* [18], *Furuto Cube* [32], *Chopsticks* [9], *Tangible Tabletop Game* [24,22], *StoryToy* [39], and *Polipo* [37].

Supporting younger children's motor development is crucial for their language and cognitive development. Although previous solutions advance the knowledge on how sensor-augmented toys could support fine motor development, they are primarily designed for children above three years old, or children who have cognitive problems or for clinical researchers to use at rehabilitation centers to detect problems in development. Furthermore, none of the previous studies in this field considers parents' involvement in fine motor development. These gaps in earlier designs signal a need to design products that can support fine motor development at early ages and encourage parents' involvement in monitoring this development. However, the literature lacks a source that can guide the design of such tools.

3 USER STUDY

3.1 Method

Our aim is to identify parents' expectations and insights into products for supporting fine motor development and helping them monitor their children's developmental progress. To this aim, we conducted semi-structured interviews with 13 parents. We recruited parents as participants since they are the decision-maker for children's lives, especially during the early years and their support and efforts throughout their developmental process are significant.

3.1.1 Participants. 13 parents (12 mothers, one father) from different households participated in the study. The sample includes mainly mothers due to their immediate interaction with their children during their early years (from birth to 18 months). The parents' ages ranged from 27-35 years old, with an average of 31. All have bachelor's degrees, they are from various, live in urban areas. All participants have at least one child aged between 7 and 24 months. We preferred this age range because supporting motor development at an early age is essential for future development trajectories.

We recruited participants via a recruitment poster posted on the Instagram pages of our research lab and from our personal network. We created a questionnaire via Google Docs for screening eligible participants, e.g., we excluded parents who have children above 24 months old. We also expanded our initial sample through snowballing. The study got permission from the ethics institute of our university. We received parents' verbal consent and approval of video recording before each interview session.

3.2 Interview Procedure

We finalized the interview procedure after running two pilot interviews to assess whether the questions help us gather parents' expectations. Parents are very sensitive when it comes to their young babies' hygienic conditions, so it is hard to conduct an in-the-wild study under COVID-19 restrictions. It was also not possible to send ANIMO to parents' homes or invite them to our research lab. All interviews were held via Zoom. Thus, we note that parents' comments were based on their perceptions of ANIMO rather than actual experiences with it. Each session was video recorded, and the average duration was 40 minutes. The interview consisted of four phases. First, we collected demographics about parents and their children (e.g., age, education level, marital status, gender, employment, number of children, etc.). Second, we asked about their children's favorite toys and their observations on how their children play and interact with toys. Third, we asked how they track their children's developmental process, the channels they use for information gathering, the topics they research, and the products they use while tracking. Fourth, we introduced ANIMO through a PowerPoint presentation. The researcher, as the designer of ANIMO, explicitly explained it in detail such as concept, module functions, context of use, etc. After the presentation, we would have conducted Q&A sessions if they had questions. We finally asked them to mention general comments about the concept, the features they like or dislike, and their suggestions for developing this concept.

3.3 ANIMO

ANIMO is a novel toy with sensors, which aim to support the fine motor development of 7-to 24-month-old children and help parents monitor their children's developmental progress in a more tailored manner through a mobile app. This concept has a number of features to realize this goal. First, it has modular pieces that can be attached and detached to respond to the needs of various children and maintain their engagement with the toy, addressing different kinds of fine motor skills such as pincher grip, palm grip, etc., which can be attached to the toy body in a different order (Figure 1left and middle). Second, it has two toy types (room toy and bath toy) in terms of usage context, functionality, and activities because, rather

than practicing one focused skill, adopting an integrative approach triggering other complementary skills might be beneficial for a child's fine motor development in general.

Furthermore, a water toy can be used during bathing to facilitate its adoption into daily routines (Figure 1right). This toy has three main modes: bubbling, splashing and waving. In bubbling mode, the faster the child spins the cap of the toy with their fingers, the more bubbles it produces, while the slower it does, the less it produces. The more force the child applies on the cap in splashing mode, the more different it splashes from the hole. In waving mode, when children start to rotate the water toy's cap with their palm, the toy creates waves on the water surface by giving some vibration to stimulate children differently. Third, the room toy provides both visual and auditory stimuli. Visual stimuli changes as types of child's interaction with modules on the main body. The intensity and color of light, for example, would arrange as the force children apply. The toy also gives auditory stimuli such as music or sound each time children interact with the modules to maintain their attention.

Finally, it has a mobile app to encourage parents' involvement in motor development (Figure 2). This app allows viewing data about a child's fine motor developmental process coming from the sensors on the toys' body and general child development literature. It offers personalized toy settings like music selection, the volume of the module, intensity of light, etc. It has a platform that parents can quickly access and ask questions to online experts about the general development of their children, usage performance of toys, etc. It provides parents with guidelines about the usage scenario such as order and selection of modules or managing play session time.

3.4 Analysis

We analyzed the interviews through qualitative coding [12]. Interview recordings were transcribed into text. The first and the last author coded the data, following a deductive approach by using questions as references.

For example, while coding the answer given to "What is your general thoughts about ANIMO?", we coded their likes and dislikes, the features they like/dislike, and the reasons for these. After coding the first two transcripts one by one, the authors discussed the compatibility of their codes. Upon having a mutual understanding, the first author finished coding.

4 RESULTS

We identified three themes summarizing parents' insights into and expectations of the products supporting fine motor skills of children and enabling them to monitor this developmental progress.

4.1 Being able to monitor a children's progress through numbers increases parents' competency and motivation in tracking but might create anxiety

Parents indicated that observing their children during play was a good time for monitoring their behavior. However, paying attention to children's motor behavior was perceived as difficult since parents



Figure 1: ANIMO with modules attached (left), Modules (middle), and bath/ water toy (right)



Figure 2: Some captions of the ANIMO mobile app relatively; login screen, child's information screen, side menu screen on the home page, after play data screen, settings screens, asking questions to experts screen, and general development info screen

tried to guide and engage them in play. They commented that observing children's behavior during play also affected the quality of the time they spend with their children. Hence, four parents said that receiving regular feedback through the connected app would likely to increase their motivation and ability to track children's development as this feature would help them focus on the play and the time, they spend with their children rather than the tracking activity. Conversely, they mentioned that being aware of children's development might have rebound effects. It was difficult for them to realize and acknowledge the fact that their children fail to achieve performing certain skills. Parents also mentioned that they were very sensitive about their child's development process in their daily life because it was very difficult for them to accept any negative comments or facts about their child. Thus, providing parents with this simultaneous feedback, as in ANIMO, might allow parents to assess their children's progress more objectively, at any time (either during or after the play). One parent explains this by stating the following:

"I think being able to get feedback is a nice feature because we as parents do not know how much force our child exerts when we think about how well children are playing, for example. This is not something we can feel by looking at it from afar or playing next to them. It is very nice to be able to detect this and unfortunately, no family can say that my child cannot do this. It is very difficult to confess the fact that your child is unable to do it."

While some parents were motivated to track a child's developmental progress through numbers, others stated that they might get stressed when they see the quantification of their children's development. Four parents indicated that receiving regular feedback from the app might have pressure on them when their children cannot execute some movements. One parent even said that they might even force their children to do the moves, which in turn might stress children.

"When my child is in the water, she must be under a hundred percent parental control anyway, at least I think so. It felt like I would interfere with my own child a lot. When I say 'interfere', I'm talking about my own negative side. She did this, didn't do that... It feels like I'm going to spoil the kid's taste a little bit so that she cannot make bubbles."

Four parents mentioned that receiving feedback via detailed graphics can be very useful for especially children with special needs. However, for parents who have typically developing children, it might create the feeling that there is a problem with their children. Thus, they would feel anxious about their children's development processes when seeing so many statistical and numerical elements in the app.

4.2 Using different modules satisfies the need to support various fine motor skills

Interviews revealed that all the parents were aware of the necessity to have different tools to support various motor movements

(e.g., pinching, grasping). However, four of them stated that they were reluctant to buy many toys specialized for only developing one skill because these toys would create clutter at home in time and that there is no guarantee that their children would play with these toys. On the other hand, seven parents reported using Do-it-Yourself (DIY) methods to support their children's motor development rather than using specialized toys for different fine motor skills. For example, activities such as making rattles that children can play with and squeeze by putting legumes such as beans in the plastic bottle, hanging the ribbons of various sizes, lengths, and thicknesses pasted on the table, and allowing babies to see to pull them. However, they found the preparation process of DIY methods a bit tedious because it had a long preparation and thinking phase. Thus, when introduced to ANIMO, parents liked the idea of using different modules for supporting various activities. They also indicated that being able to make different toys every time allows children to play for a long time because of the perception that they are playing with different toys. One parent indicated the following:

"I would like to have a specific product for fine motor skills. It is more comfortable for a parent to use something very multifunctional like ANIMO rather than designing individual activities at home. Let's suppose that we normally don't have a ribbon, put it through something with a pump, and take it from there with a gripping motion. These take much time, preparation, and require a lot of thinking. . . It is easier to use a product that has already been designed for this purpose."

4.3 Adaptability to different skills, ages, and development stages makes a tool desirable for parents

Parents commonly perceived toys as entertaining tools for their children. Two parents did not want to buy extra toys to support motor development because they did not think that it would be worth the price. Although all parents indicated that they had many gifted toys, children easily got bored because their attention and interest in the toys were easily broken. Thus, one parent indicated that their children might not want to use a supportive product, or the use period for such a product might be very short. In this respect, some parents stressed the importance of integration into children's daily routines. For example, regarding one of ANIMO's toys play in the water, they appreciated the idea of integrating the toy into an existing daily routine, i.e., bathing, indicating that it would be easier for them to encourage their children to play with the toy while having "fun" in the bath. Five parents further pointed out that this integration could encourage children to perform a daily activity when they feel reluctant, e.g., taking a bath. Furthermore, parents highlighted that being able to use a tool for another function when out of use might create a sense of adoption and personalization for their children, as in the case of ANIMO turning into a night lamp.

5 DISCUSSION

In this section, we discuss the implications of these insights for designing products to support motor development. While presenting these implications we give some suggestions and use some examples. We note that these do not represent an exact solution,

but rather serve as illustrative cases that should be validated by future studies.

5.1 Account for parent's anxiety and frustration when providing feedback about motor development

Insights from interviews show that parents are sensitive about the developmental routines of children. We observed that while some parents were very motivated to receive detailed feedback about their children's development, others were reluctant as they might get nervous when they see negative feedback about their children's developmental processes. In parallel with this, these parents did not prefer highly detailed feedback (e.g., how much force that children apply, how many minutes that they play with ANIMO) since they might use it to assess whether their children have a special condition. Another aspect that created anxiety in parents is receiving formative feedback, especially when the normative developmental paths do not always fit with their children's. For instance, a child in a typical developmental process is expected to be seated at the age of 7 months, while some children can experience this process earlier or later. Thus, designers should bear in mind that feedback about children's motor development is not neutral and can even create unintended outcomes. One way to avoid these unintended outcomes could be tailoring the feedback to the needs of different children. Another way could be presenting successful attempts as the default feedback while giving parents the option to enable more detailed feedback for failed attempts, reasons for these failures, suggestions for improvement, and so on.

5.2 Support parents' involvement in the design

Our analysis revealed that parents were willing to look for toys specialized in supporting motor skills. However, this might not be always a preferable method as purchasing many toys would create clutter at home and a feeling of wasted money, pointed by some parents. This problem could be addressed by designing toys with multiple detachable modules and by considering post-use function beforehand, as in the case of ANIMO, as this would allow parents to customize and adopt the toy according to evolving needs of children. An alternative solution could be creating DIY tools to support motor development by using everyday life materials such as beans, plastic bottles, ropes, etc. Though some parents reported in the interviews that they are already engaged in this practice, they complained about the long preparation and thinking phase. Here, we see an interesting opportunity for design research. It is worth exploring how can design (e.g., 3D modeling and prototyping tools) support parents' existing DIY practices for creating tools to support motor development.

5.3 Consider the diversity in children's and parents' daily routines

Children's daily routines influence the way they play with their toys and the way they interact with their parents. Since these routines vary in each child, parents preferred to have products that could be adopted to different use contexts (e.g., bedroom or bathroom) and integrated into their existing routines (e.g., having a bath).

This aspect was found significant in terms of motivating children to use a toy, thus, supporting their motor development, as well as extending the toys' lifetime. In this respect, we might suggest designers consider the diversity in children's everyday routines and tailor the toy according to this diversity. In the case of ANIMO for example, this is done through having two sensor-embedded toys specified for bathroom and bedroom use and through defining a post-use function (i.e., lamp). An alternative technique could be enhancing objects used by parents and children daily, such as clothes used for changing diapers or playing carpets with modules for motor development. In any case, conducting user research prior to design and knowing more about children's daily routines may be key for designing a product that can be integrated into these routines.

6 CONCLUSION AND FUTURE WORK

The development of fine motor skills at an early age is one of the fundamental steps that affect a child's other developmental functions such as language. In this WIP, we presented insights and implications that can inspire and guide the design of products to support fine motor development. By using a toy concept, which supports the fine motor development of 7 to 24-month-old children and assists parents in tracking their children's developmental progress via a mobile app, as a probe, we identified three themes summarizing parents' insights and expectations of such products. These include i) being able to monitor children's progress through numbers increases parents' competency and motivation, but might create anxiety, ii) using different modules satisfies the need to support various fine motor skills iii) adaptability to different skills, ages, and development stages makes a tool desirable for parents. Based on these insights we identified three design implications including i) account for parents' anxiety and frustration when providing feedback about motor development, ii) support parents' involvement in the design, and iii) consider the diversity in children's and parents' daily routines. The next step of this research is observing children's and parents' interaction with ANIMO (both the toy and the mobile app) to further improve this concept and refine design implications based on both user groups' experiences.

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