Peekaboo: Enhancing parent-child communication by promoting eye contact during family car rides

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1 ABSTRACT

Parent-child communication is crucial for the emotional, social, and cognitive development of the child. It thrives through shared activities and meaningful conversations in which both are fully present. Car rides offer a valuable opportunity for such interaction, yet mobile phones often compromise these moments of connection. We explored the potential of enhancing parent-child communication in the car by facilitating eye contact, which has been shown to directly stimulate brain systems that elicit strong emotional responses. We introduce the design study of Peekaboo, a tangible interactive dashboard device that consists of a mirror, an electric motor, and a camera. Using a human-centered design approach, the interaction presented is intentionally brief and situated within the driver's natural line of sight, minimizing any gaze deviation from the road. We believe this study demonstrates the potential of minimal gestures to encourage eye contact and improve communication between parents and children during car rides.

CCS Concepts: • **Human-centered computing** → **Interaction design process and methods**.

Additional Key Words and Phrases: Parent-child interaction, TUI, Family quality time, car rides, eye contact

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2 INTRODUCTION

Parent-child communication has been shown to be important for the development of a child's emotional, social, and cognitive development [20, 37, 45]. Parents play a central role in the establishment of healthy communication with their children, which has a profound effect ranging from a child's well-being and self-esteem from an early age [46], to social functioning and academic performance [14, 15].

Healthy communication comes from shared activities and meaningful conversations, where parents and children give their full attention [12, 18, 34, 41]. During social interactions, eye contact was found to be the key to expressing willingness for interaction, attentiveness, and serves as a cue to continue conversations [10, 31–33]. Eye contact was found to directly activate brain systems that evoke strong emotional responses that affect perceptual and cognitive processing [26, 28]. Therefore, it affects people's interactions and affection for each other [2, 29].

However, while on their phone, parents and children miss the opportunity for healthy communication. Studies show how screens, especially mobile phones, have become a significant challenge for healthy communication between parents and children, in particular how these devices affect healthy communication between parents and children by distracting their attention, causing disengagement from present interactions [3, 11, 21], and leading to emotional unavailability, divided attention, and reduced engagement [25, 36, 48]. This becomes even more difficult during adolescence [6, 22, 25].

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Fig. 1. Peekaboo: A TUI to encourage eye contact between parent and child during a car ride

Although eye contact has been found to increase comfort and facilitate communication, people are not always aware of how eye contact influences interaction [31], this effect is further intensified by the strong visual demands of mobile phones, which require constant eye contact with the screen.

The context of family car rides offers a unique opportunity for meaningful communication between parents and children. Driving children during the week is a familiar routine for many parents, often along with work and other commitments [24, 40]. The car can also serve as a dynamic social space, offering opportunities for interactions beyond transportation [9, 27, 35]. Its intimate setting allows for a range of conversations, while the car itself serves as a supportive space without bias [50]. Moreover, it appears that the structure of the car journey, where beginning, middle and end is defined, provides a natural framework for the unfolding of discourse. This enables the car ride to become a unique setting for sharing feelings, personal stories, exchange of perspectives, and becoming an opportunity for meaningful communication between parents and children [8, 35].

This paper explores the potential to encourage parent-child communication during car rides by enhancing opportunities for eye contact between them. As eye contact has been found to evoke strong emotional responses, but does not occur naturally and is even more compromised with the distractions of mobile phones, we want to explore the possibility of a smart object to encourage glances and ultimately eye contact to foster more meaningful interactions between parents and children while in the car. We present the human-centered design process of Peekaboo, a TUI that is positioned on the dashboard in front of the passengers seat and consists of a mirror, an electric motor and a camera. Peekaboo moves swiftly once to capture their attention, but does not distract the driving, encouraging an eye contact between parent and child.

3 RELATED WORK

Related works include technological interventions to promote parent-child interaction, technologies that enhance social interaction during car rides, and embodied technological interventions aimed at encouraging eye contact within social interaction.

3.1 Technologies for parent-child interaction

Previous works showed how technological interventions can utilize and leverage everyday activities towards promoting a positive and healthy relationship between parents and children in various contexts. For example, in the context of shared cooking, Kitcheff is a tangible kit designed to promote a playful cooking experience while encouraging physical closeness between parents and children. The TUI system consists of a smart recipe box and wristbands to encourage collaborative cooking. A preliminary study with five families showed the TUI enhanced control, visibility, teamwork, engagement, and physical closeness during the cooking process [38]. Another example in the context of parent-child collaboration, is the Awareness Object, an analog mechanical tangible object, designed to raise parents' awareness of their roles by reflecting upon their role and physically representing the role they believe they took, using the tangible object. A study of 12 parent-child interactions revealed that the Awareness Object promoted reflection by both parents and children, enhancing parents' understanding of their roles and increasing children's involvement in evaluating these roles. While some parents found this involvement intriguing, others found it challenging, highlighting the sensitivity of such interactions and the need for cautious implementation [43]. In the context of home education, Awayvirus is a tangible toy designed to promote children's hygiene awareness and foster collaboration with parents. The object was design based on surveys, semi structured interviews with parents and professionals. In a limited evaluation with one parent-child pair, the design, consisting of tangible blocks and educational cards, showed the potential in increasing children's interest in learning hygiene habits while encouraging active parental involvement through playful interactions with the kit [42].

These works demonstrate the potential of TUI's to enhance parent-child interactions by fostering engagement, reflection, and collaboration. The confined space of a vehicle and the daily time spent together create a unique opportunity to explore how technology can facilitate meaningful connections by leveraging technology to promote eye contact during family car rides

3.2 Technologies that enhance social interaction during car rides

Various technological interventions have focused on enhancing parent-child interaction during car rides. Mileys is a location-based in-car game designed to connect children with their family and surroundings rather than isolating them with entertainment devices. By integrating augmented reality, virtual characters, and location-based information, Mileys encourages engagement inside the car between family members and outside the car with the environment. Developed iteratively, the game's design evolved through prototyping and evaluation, uncovering insights and challenges in promoting meaningful in-car interactions [50]. Another example is "RiddleRide," a design concept for a multiplayer quiz app that offers an entertaining and educational experience for backseat passengers. The system was developed based on a probing study conducted with 20 families. It delivers voice riddles through the built-in sound system, with each question read aloud, enabling all passengers to take part and allowing children who cannot read yet to join in the fun. [47]. Another design concept related to car rides was introduced by Wu et al. (2020). Through a user-centered design approach, they developed an experience that features a mobile application which is pre-set by parents and suggests

Table 1. Human-Centric Design Study

Participant #	Age/Gender	Study
P1	41M	Need find - Parent
P2	40F	Need find - Parent
P3	50F	Need find - Parent
P4	43M	Need find - Parent
P5	F40	Need find - Expert
P6	F50	Need find - Expert
P7	F43	Need find - Expert
P8	M24	User testing 1
P9	F23	User testing 1
P10	F20	User testing 1
P11	F26	User testing 2
P12	M23	User testing 2
P13	M21	User testing 2
P14	M26	User testing 2
P15	F27	User testing 3
P16	F22	User testing 3
P17	M22	User testing 3

games or audio content tailored to their children's preferences as well as travel plans, and road conditions. Additionally, it includes an augmented reality (AR) interactive window to facilitate interaction and a set of tangible blocks. Children in the backseat can manage the media in the car using the screen-free tangible blocks.[49].

These studies highlight the potential of car rides to foster meaningful family interactions, emphasizing the importance of thoughtful design to ensure positive user experiences while minimizing distractions. In this work, we leverage technologies that promote eye contact, enabling an unstructured and open-ended interaction between parents and children.

3.3 Embodied technological interventions aimed at encouraging eye contact within social interaction

Previous studies have previously leveraged human's natural tendency to interpret social cues to facilitate social interactions. Such embodied interventions aim to facilitate a more positive environment, influencing non-verbal cues such as eye contact. For example, Sadka et al. (2021) developed robotic bar stools designed to subtly facilitate positive human-human opening encounters by encouraging eye contact [44]. Another example by Morag et al. (2020) introduced a table spinning top designed to encourage collaboration for minimizing the distractions of mobile phones use during family dinner time [39]. When the spinning top detects phone usage, it begins to spin, and family members must touch with their fingers the base together to make it stop. One key finding from the study was that this activity encouraged eye contact among family members. In the context of public spaces, Balesrini et al. (2016) presented the Jokebox, a technological prototype that requires two passers-by strangers to coordinate actions to hear a joke. The technology encouraged strangers to establish eye contact and often resulted in follow up interactions [4].

These works highlight how thoughtfully embodied-based designed HCI technologies can promote eye contact, fostering stronger social bonds and more meaningful human interactions. In this paper we integrate these three research directions into the design of an interactive technology aimed at facilitating eye contact between parents and children during car rides. This approach leverages the unique potential of the car environment to foster meaningful family interactions.

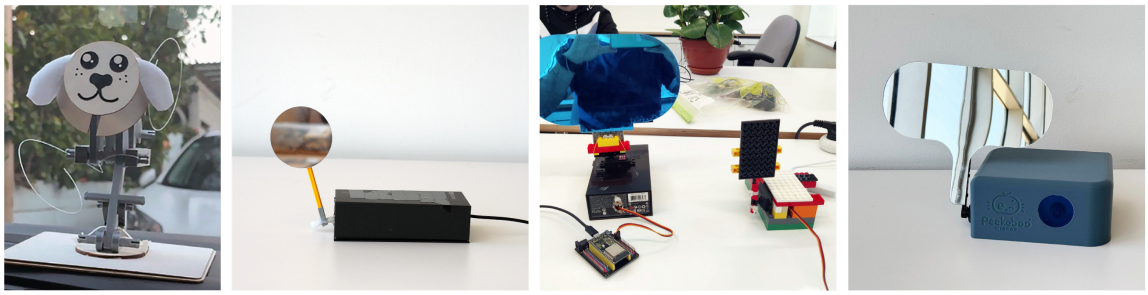

Fig. 2. Sample of rapid prototyping from left to right: A dog-like object in a car setting, testing movement and sizes of mirrors, and the overall design of Peekaboo

4 DESIGN

The design process described below follows Design Thinking and Human Centered Design (HCD) approach [7, 13, 23], where understanding human needs take precedence before developing a solution. In this study, we began by identifying our users' needs and validating them through previous research and consultations with relevant experts. We then proceeded to an iterative design process that involved rapid prototyping and user testing. This study included 17 participants (see table 1).

4.1 Need Study

Our need study begun with interviews of 4 parents of children ages 9-12. The interviews revealed that mobile phones are the main distraction, limiting their communication and quality time with their children. A parent said: "Once they are on their phone, they don't hear or see anything else" [P2], "I really want him to let go of the phone but it is very hard" [P1], "They become passive and it is very hard to engage with them" [P3]. In addition, we interviewed three experts, a developmental psychologist, a psychologist, and a speech therapist to further explore the need for enhancing parent-child communication. A psychologist shared that in therapy parents complain about how their children are disconnected from their social environment. The developmental psychologist shared how habits are hard to break: "It's hard when a child is used to eat in front of his phone or fall asleep with his phone, The most effective approach is to transform the situation into a screen-free environment and enrich it with human interaction" [P5]. The speech therapist emphasized the importance of quality time between parents and children for the development of healthy communication and how eye contact is important: "If we want the child to learn how to communicate with others, we need to remember to make eye contact when we are with them and really be with them" [P6]. From this we concluded that we need to focus on prompting moments of communication between parents and children.

The decision to focus on a driving context was based on interviews with parents who shared that their afternoon and evenings are very hectic and even when together, it is hard for them to spend one on one time with them: "I remember being shy and only sharing my parents in the car on the way to an afternoon activity, it was just me and my mom in the car" [P4]. We looked further into the context of family car rides and found that this context is supported by previous studies that suggested that family car rides are a great potential for quality time [9, 27, 35]. Parents drive their children weekly to and from afternoon activities, the rides that are short, usually with 1-2 children in the car. In addition, previous work has shown that car rides provide a setting where parents and children can converse with one another, play games or sing songs [5, 35, 40].

With the understanding that we want to focus on car rides and promote meaningful moments between parents and their teens while in the car, we created a persona for the parent in which we voiced her challenges and struggle, her motivation to engage her child while driving, and the child being disengaged because of his phone. We then outlined a brief journey and identified several key points relevant for intervention: entering the car, during the drive, and leaving the car. We wanted to learn more about the context and when is best to introduce the intervention. From previous studies we understood that the greeting is of importance for healthy communication [1]. Positive greeting can be essential to the interaction that comes right after [16, 17]. We also found that positive or negative social cues in the first moments of the interaction, affect psychological aspects such as mood, sense of belonging and motivation, and lay the social foundations for the following interactions [29, 30]. However, observing two car rides of families taught us that the moment of entrance into the car is very hectic and most times accompanies with eye contact which fades later into the drive. We then decided that we will focus on the ride itself. This step was concluded with the understanding that we want to create a smart object that will encourage eye contact between parent and child in a car ride.

4.2 Iterative Prototype Design

Our first prototype was a dog-like toy. We were looking for an object that people are familiar with having in their car. We placed in on the dashboard in the center between the parent and the child. When moves, the toy plays sounds and lights. After placing it in a car we decided it was too distracting for the drive. In addition we felt that the toy drew too much attention and interfered with possible dynamics between parent and child, not only creating an unsafe ride but also enhancing a playful tone, rather than the intimate atmosphere we aimed for. We revisited the literature and found that due to the significant influence of nonverbal communication on social interaction, even minimal technological modifications on social cues can meaningfully affect the following social interaction [39, 44]. Based on these findings, we decided to design an object that can influence the social cues between parents and children, specifically focusing on eye contact, through minimal movement. We created a simple object with a dog face (see fig 2) that we could activate remotely from the backseat with a string. This round of testing focused on the desired feedback for positive behavior in the car, meaning a conversation. Learning the importance of positive and negative feedback on behavior change [19], we decided to move the object whenever they spoke in the car. In addition, we wanted to test the position of the object on the dashboard. Based on user testing with three participants, we concluded that the object should be positioned in front of the child on the dashboard to minimize distraction for the parent and enhance engagement for the child. In terms of feedback, we understood that we want to facilitate a conversation, not impose or intervene with it. We realized that the intervention should capture attention in a subtle manner without interfering, allowing for a more natural interaction between the parent and child.

For our second prototype, we chose to eliminate the dog-like appearance to better accommodate older children. We decided to included mirrors as we wanted to explore the possibility of encouraging eye contact as a communication facilitator. Building on the concept of rear-facing car seat mirrors for infants (thus the name Peekaboo), we sought to explore the potential of a front mirror designed to promote eye contact between the passenger and the driver—an interaction that usually only happens when they are facing each other. We began by testing various mirror sizes and examining the optimal angle needed to establish eye contact between two individuals facing forward. We continued to design the minimal gesture of the mirror. The idea was to evoke a glance in hopes that it establishes eye contact. We decided on two possible movements for the mirror: vertical (up and down) and horizontal (sideways). We invited four participants to test these movements in a lab environment. They were seated next to each other and asked to imagine being in a car. The driver was instructed to "drive" while the passenger pretended to be on their phone. We remotely

adjusted the mirror using both movements in different sequences and gathered their feedback on which movement was most noticeable yet least distracting. All participants preferred the up-and-down movement. One participant commented, "It made me slightly look at him" [P5].

Our third prototype included the 3D fabrication of a box, a motor and a handle to hold the mirror. We iterated with several designs a series of prototypes for the box containing the electronics and arm supporting the mirror. To ensure the movement remained steady and stable, we shortened the arm (see figure 2). We also iterated with the eye recognition software and adding a camera to the box, adjusting the size and the position of the camera. We invited 3 more participants to the lab and positioned them in front of a big screen with a large simulation of a ride (see figure 3. We wanted to check the timing of the movement of the mirror and introduced few options, from few seconds after the rides starts, a minute into the drive and 2 minutes into drive. From observing and asking the participants' opinions, we decided to have the mirror move one minute into the drive. We also experimented with several design solution on how to secure attachment of Peekaboo to the dashboard, until achieving a rounded shape that aligned seamlessly with the dashboard.

5 MID FIDELITY PROTOTYPE

Our mid-fidelity prototype is composed of a mirror, an electric motor, and a camera placed on the dashboard in front of the passenger seat directed toward the passenger. A computer vision algorithm is activated through the camera. After a minute towards the ride, if the camera does not detect the eyes of the child, the mirror performs two vertical swift movements to subtly draw passengers attention. If the child lifts his gaze, the detection of the pupils becomes positive and the mirror stays steady at an angle that enables eye contact between the parent and the child. Pilot testing evaluated the mirror's movement to ensure it is noticeable enough to capture the attention of both parent and child without distracting the driver. Parents naturally glance occasionally, and the mirror allows them to quickly check on their child. The system is designed to move only once per journey, promoting interaction without imposing it.

Fig. 3. User testing Peekaboo from left to right: checking the angel of mirror, testing movement of the mirror in a pretend driving context

5.1 The System

The system includes a Raspberry Pi 4 microcomputer with an Arducam 1080P Wide Angle USB camera and a high-torque 20Kg servo motor. The camera is positioned in the center of the box for optimal facial capture. The servo motor is connected to a plastic arm that is attached to the mirror. For vision analysis, we used MediaPipe and OpenCV libraries, utilizing a face mesh detection system that tracks 468 facial landmarks with emphasis on eye recognition tracking. The system calculates gaze direction using bounding boxes around each eye to compute Iris position ratios. Upon detecting a 60-second absence of eye contact, the system activates the servo motor controller to perform calibrated mirror adjustments, implementing non-intrusive attention-recapturing movements while maintaining optimal viewing angles upon gaze reestablishment.

6 DISCUSSION

Peekaboo was designed to enhance eye contact between parents and children in the context of car rides. The design and implementation of Peekaboo were performed in accordance with previous HCI literature and psychology studies, which emphasize the importance of parent-child communication and the constant daily challenges that limit communication. It also leans on previous design work that indicated the importance of eye contact and the possibility to enhance it using smart objects and TUIs. Our design process revealed that mobile phones are the main significant distraction, limiting communication and quality time. Users and experts inputs suggested driving context as an opportunity for meaningful moments between parent and child. The solution designed for that specific context required the researchers to fully understand its limitations and unique setting, for example to observe the different points of interaction and to understand when and how the intervention will take place. Strong design guidelines were integrated into the final prototype, emphasizing the importance of allowing eye contact, fostering meaningful moments of connection without forcing the interaction, and prioritizing safety. The design approach specifically targeted enhancing communication during car rides while maintaining both safety and engagement. Future work should include a safe driving setting for both parents and children to evaluate the TUI.

7 LIMITATION

The context of car rides must be thoroughly analyzed to ensure that any technology used does not introduce safety risks while driving. We recognize that Peekaboo encourages eye contact between the driver and the passenger, which may imply that the parent is diverting their gaze from the road. Although diverting the gaze is already well integrated into driving habits, we recognize the fact that creating eye contact with a passenger differs fundamentally from checking side and rear mirrors. The use of mirrors is an integral and rehearsed part of driving, whereas making eye contact involves a social and emotional interaction that could pose additional cognitive demands on the driver. To address this, Peekaboo was designed to work within the driver's natural line of sight, ensuring minimal deviation of gaze from the road. The interaction promoted by Peekaboo is intentionally brief. We acknowledge that this further requires careful testing in a controlled setting to fully assess its impact on safety and driver behavior.

8 CONCLUSION

In this work, we outlined the design process and proposed a technological solution aimed at encouraging eye contact between parent and child during car rides. This solution is grounded in theoretical frameworks and design guidelines supported by prior Human-Computer Interaction (HCI) studies that have demonstrated their effectiveness.

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