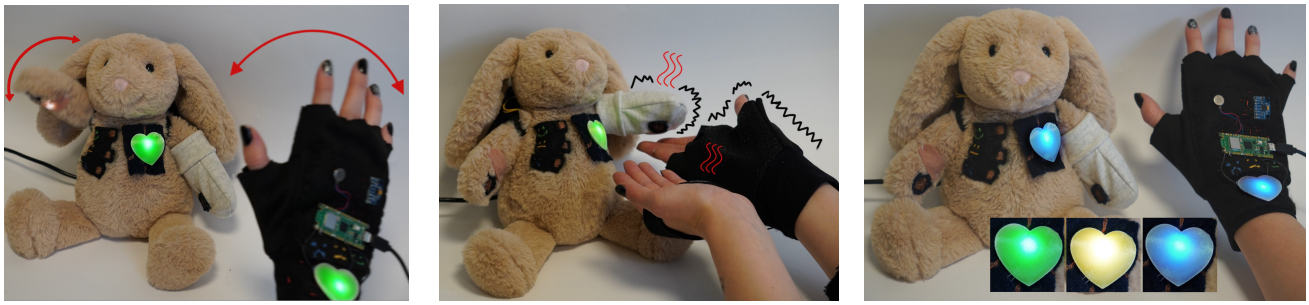
ChiParCo and ParChiCo: Connecting Children and Parents Remotely With Tailored Tangible Communication Tools

Anna Sophia Calmbach*
s8ancalm@.stud.uni-saarland.de
Saarland University, Saarland Informatics Campus
Saarbrücken, Germany

Sophie Kunz*
s8sokunz@stud.uni-saarland.de
Saarland University, Saarland Informatics Campus
Saarbrücken, Germany

Alice C Haynes
ahaynes@cs.uni-saarland.de
Saarland University, Saarland Informatics Campus
Saarbrücken, Germany

Jürgen Steimle
steimle@cs.uni-saarland.de
Saarland University, Saarland Informatics Campus
Saarbrücken, Germany



(a) Waving (b) Hand-holding (c) Emotion-sharing

Figure 1: The three interactions afforded by the prototype-pair ChiParCo (interactive plush bunny) and ParChiCo (interactive glove).

ABSTRACT

Parent-child separation can detrimentally affect a child's well-being. While digital technologies enable remote communication, they often lack effective means for young children to initiate contact, engage physically, and express emotions. Pioneering work on tangible devices for communication offer promising solutions, but current research minimally explores devices tailored to the differing needs of parents and children during separation, and fewer evaluate their designs with functional prototypes. Building on design suggestions from previous work, we implement a functional pair of prototypes for remote parent-child communication: ChiParCo, an interactive plush bunny for children, and ParChiCo, an interactive glove for parents. The pair provides three interactions: waving, hand-holding and emotion-sharing, which combine physical, synchronous and asynchronous, as well as emotive communication. In a qualitative user study with parent-child dyads (n=10), we investigate the form factors of the prototypes, participants' perceptions of the three interactions and what design implications we can draw from their feedback.

CCS CONCEPTS

• **Human-centered computing** → **Haptic devices**; **User studies**.

KEYWORDS

tangible interfaces, remote parent-child communication, qualitative user study

ACM Reference Format:
Anna Sophia Calmbach, Sophie Kunz, Alice C Haynes, and Jürgen Steimle. 2024. ChiParCo and ParChiCo: Connecting Children and Parents Remotely With Tailored Tangible Communication Tools. In *Interaction Design and Children (IDC '24), June 17–20, 2024, Delft, Netherlands.* ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3628516.3655803

*Both authors contributed equally to this research.

IDC '24, June 17–20, 2024, Delft, Netherlands

ACM ISBN 979-8-4007-0442-0/24/06
https://doi.org/10.1145/3628516.3655803

1 INTRODUCTION

The parent-child relationship is a strong bond and one of the most important factors in a child's development [6, 27]. However, many children experience separation from their parents due to myriad reasons [2, 12, 13, 47]. This parent-child separation is often unavoidable, yet may weaken the bond between parents and children and negatively impact the children's mental health and psychological

development [6, 14, 54, 55]. Modern communication tools offer parents and children the means to communicate when separated, with the phone being the main form of connection [5, 31, 48, 63]. Yet, research has shown that current technologies fall short of meeting the needs of intimate remote parent-child connection [5, 31, 48, 58, 63]. Conventional communication methods lack the possibility of emotional expression, especially considering the limited ability of young children to express their emotions verbally [5, 58]. Moreover, children have a short attention span and thus parents have a hard time keeping them engaged during phone conversations, leading to reduced contact [5, 58]. Further, current communication devices oftentimes require a co-located adult to help the child interact with the remote parent, which is especially troubling in cases where the two adults are in conflict [58, 63]. Another neglected factor is the importance of physical touch in the parent-child relationship, for instance, in the form of good-night hugs [10, 48], which current communication technologies do not adequately afford.

Pioneering work has shown great potential for tangible devices to address these factors for remote parent-child communication [9, 48, 51, 53, 57, 62]. However, few of these works have explored tangible devices that are tailored to both parent and child [9, 53, 57], despite previous work highlighting their differing needs [10, 44]. Additionally, only limited work has been done investigating such devices with functional prototypes during user evaluations [9]. Parents are in need of a mobile, non-obtrusive system to use in their everyday schedules [44], through which they can be aware of their child's current mental state [31, 48]. Further, asynchronous methods are needed to address scheduling conflicts [31, 58]. Children, on the other hand, require an engaging device that supports non-verbal and emotional communication [5, 44, 53]. Additionally, it was found that communication devices for children should be easy to use and allow for child-initiated contact [5, 31, 48, 62].

We contribute to current research by developing two tailored, tangible prototypes for remote parent-child communication through an iterative, user-centered design process. These consist of a child's side prototype and a parent's side prototype that are tailored to their respective needs:

> **ChiParCo, an interactive plush bunny,** is an approachable, tangible interface for children that acts as a proxy for the parent. It provides emotional support, enables physical interactions and child-initiated contact.
>
> **ParChiCo, an interactive glove,** is a mobile, wearable device for parents that caters to the needs of their busy schedules and enables intuitive, physical and gestural interaction.

Our prototypes afford simple, tangible interactions designed to be easy for young children to engage with. The prototypes include physical, synchronous and asynchronous interactions as well as support for emotional awareness in the context of parent-child communication over a distance. Our design centers on three interactions:

> **Waving:** an asynchronous gestural and tangible interaction, accommodating differing schedules, while being an engaging interaction for both parents and children.
>
> **Hand-holding:** a synchronous interaction allowing for intimate parent-child connection by simulating physical touch over a distance.
>
> **Emotion-sharing:** a visual and tangible interaction that enables children to easily express their emotions and provides parents with emotional awareness of their child.

In a user study with parent-child dyads ($n = 10$), we evaluate the design decisions of the prototypes and derive design implications for further work in this area.

2 RELATED WORK

Previous work has investigated the parent-child relationship [10] and presented suggestions on designing for parent-child communication [44, 59]. Multiple approaches for connecting parent and child remotely have been explored, including playful interfaces [38, 48], reading together [30, 37], remote touch [51], and shared virtual spaces [62]. Design implications from these works guided our investigation and design choices. We identified and focused on three aspects - physical interactions, asynchronous and synchronous interactions, and emotional awareness and support.

2.1 Interaction Aspects

Physical Interactions. Physical contact is crucial for parent-child connection [15]. Mediated social touch technologies facilitate this by replicating interpersonal human touch [19] [34, 39]. Existing prototypes show promise for supporting remote communication, for example, by simulating holding hands [17, 50], a squeeze of the wrist [45] or stroking the skin [33]. However, these technologies are typically designed for and evaluated with adults. Few works have investigated mediated social touch for children [26, 51]: Huggy Pajama [51] is a jacket containing inflatable pouches that simulate the sensation of a hug when a partner embraces the input device, a plush toy containing pressure sensors. The study showed that parent-child pairs overall enjoyed it, although some noted the lack of body heat. TouchMe [26] is a wristband for children that heats up when the remote parent squeezes a heart-shaped, tangible device. In a two-week field trial, the children gave positive feedback on the wristband, primarily associating the warmth with love, comfort and attention from the parent. For adults, multiple projects have demonstrated the efficacy of Shape Memory Alloy (SMA) actuation for mediated social touch, e.g. [20, 21, 33, 45, 61], and reported sensations similar to human touch. SqueezeBands [61] successfully generate hand-holding sensations by integrating SMA wire into a fabric band around the palm.

Synchronous and Asynchronous Interactions. Reviewing the literature indicates that both synchronous and asynchronous interactions hold value for parent-child communication. Synchronous interaction was suggested to be the preferred mode of communication in interviews with parents [31] and in a review of parent-child technologies [44]. However, in a field study with the ShareTable [62], a tangible communication interface connecting divorced households, issues arose with synchronous interactions when one party was occupied. Incorporating asynchronous interaction possibilities could resolve these issues and help address the needs of families with different schedules [31, 58, 62, 63]. Further, it is important to consider the different wants and needs of parent and child regarding frequency and mode of communication [31, 58]. While parents desire persistent contact and want to play an active part in their child's life [31, 58], children often focus on their ongoing activities

and the co-located people [58]. This gap can be bridged by allowing for (a)synchronous interactions, lowering the entrance barrier for using such communication devices [5, 31, 58], and engaging the child to interact with their parent [44].

Emotional Awareness and Support. Previous work concluded that for families experiencing separation, reproducing emotional awareness of each other is helpful [25, 48, 63]. Parents expressed a need for knowing the current status of their child, as they were worried about their well-being [25]. Also, they oftentimes experience a guilty conscience when separated from their child [31, 48, 63]. For children, it was found to be reassuring to know a remote parent was thinking about them [26, 48]. Shan et al. developed a glove that detects the emotional state of the wearer by measuring their galvanic skin response and displaying it on a light module [43]. Their findings suggested that the light module should be appropriately shaped and a suitable mapping used between the colors and the respective emotional state. However, they did not investigate the interaction with children.

2.2 Form Factors

Interactive Plush Toys. Previous work has explored the idea of tangible systems, specifically plush toys, as interactive communication devices [1, 9, 16, 22, 53, 57], with some focusing concretely on connecting parent and child when separated [9, 53, 57]. During evaluation, plush toys proved to be a good medium, as they are tangible, and typically familiar to children [9, 52, 53]. Introducing a physical proxy of the parent was found to help children cope during periods of separation [31, 44, 63]. Further implications include that the design should be approachable and not overwhelming with functionality [9, 53]. During user studies, however, only mock-ups are used [53] or no evaluation with parents and children is performed [56]. Additionally, few studies evaluate these principles with separated participants, except Chun et al. [9].

Interactive Gloves. Wearable interactive gloves have shown great potential in augmenting emotional communication by providing a tangible interface and physical interactions [17, 35, 46, 61]. However, little research has been done investigating their usage for parent-child communication [43]. An interactive glove can be worn and used anywhere throughout the day, thus addressing the needs of the parents, who oftentimes have busy schedules and responsibilities [44]. Additionally, the design needs to be wearer-friendly, non-obstructive and reduce the usage of visible cables [42, 43]. Interactive gloves serve as an intuitive and tangible alternative to traditional interfaces, capitalizing on the natural use of the human hand in communication [8, 29, 35]. Hand movements inherently reflect mental states [23], indicating that gestural interaction can offer compelling possibilities for remote emotional communication.

3 DESIGN AND IMPLEMENTATION

We developed two tangible prototypes designed to enable a child and parent to be connected and interact remotely. ChiParCo *(Child-Parent-Connection)* supports communication on the child's side (see Figure 2) and ParChiCo *(Parent-Child-Connection)* on the parent's side (see Figure 3). The design criteria for the prototypes draw from findings presented in Related Work and are tailored to meet the differing needs of children and parents.

3.1 Form Factors of the Prototypes

ChiParCo consists of a plush bunny acting as a proxy between a child and their remote parent. As suggested by prior work exploring plush toys as children's interfaces, we expect the appearance and feel of our prototype to be approachable for the child [9, 53, 57]. Previous work highlights the importance of the child being able to initiate communication without the help of a co-located adult, thus increasing the amount of contact with the remote parent [31] and allowing for more privacy when interacting [63]. Using our prototype enables the child to easily contact the remote parent. Moreover, children are found to turn to a proxy, when separated from their parent [31]. As it is an object they usually care for, the plush toy improves closeness to and a sense of presence of the remote parent [31, 48, 63].

ParChiCo is an interactive glove, interlaced with small electronic components. By designing a wearable textile, we aim to increase its usability within varied contexts (e.g. at the workplace). As research has shown, interactive gloves have great potential as intuitive, tangible interfaces [35]. With this interface, natural hand-based gestural interaction can easily be included to augment communication[29, 35]. Movements detected by the glove can also be translated to movements of the plush bunny, solidifying their connection and emphasising the bunny as a proxy of the parent.

3.2 Interactions

To support child-initiated contact, the design should not be overwhelming or technical, but kept simple and engaging [44, 53]. We place special importance on physical interactions, as they are important for parent-child communication and their relationship [10, 31, 48], but have rarely been tested with parents and children [26, 51]. Additionally, we allow for synchronous and asynchronous interaction possibilities since both were highlighted as important in previous work [31, 44, 58, 62]. We include an interaction that promotes emotional awareness, to meet the parental need for continuous updates on their child's well-being [48, 58]. For the child, our prototypes include interactions letting the child know their parents are thinking about them, to cater to their need for emotional support from their parent [44, 48, 63]. Building on these design criteria, we contribute to the field by combining physical, asynchronous and synchronous and emotive interactions within functional prototypes, which are tailored to the needs of both child and parent (see Figure 1).

Waving. We utilize the hand-based gesture of waving, universally understood as a form of greeting [7], to provide a physical and intuitive interaction. The parent can initiate contact by waving with the hand wearing ParChiCo. A notification light on the right paw of ChiParCo lets the child know they received a wave. The child can press a button below the light to make ChiParCo reenact the wave. After that, the heart-light on ParChiCo turns white for a few seconds, notifying the parent of the play-back. With this, we provide an asynchronous means of communication. Due to the bunny moving while reenacting the gesture of the parent, we hope to make the interaction engaging for the children and visualize the prototypes' connection. Moreover, the non-verbal message serves as a reminder that their parent is thinking about them, thereby providing further emotional support.

Hand-holding. Replicating hand-holding was found to help couples feel connected over distance [17], suggesting potential for connecting children and parents. Based on this, we devised a synchronous, bidirectional hand-holding interaction which both child and parent can initiate. On the child-side, the interaction is initiated by holding the gloved paw of the bunny. This triggers a vibration on the parent's glove. The parent can initiate by turning their palm upwards, symbolizing a gesture of offering their hand to the child. This causes the bunny's left paw to lift up, inviting the child to hold it. Only if both parent and child interact simultaneously will the SMA band of the parent warm up and contract while the left paw of the bunny also warms up and vibrates slightly. With this interaction we provide a means of mediated social touch, catering to the need for physical and synchronous interaction.
Emotion-sharing. We decided to implement emotion-sharing based on findings that colored LEDs correspond to emotional states [24] and that the three colours map to the respective emotions [11]. The child initiates this interaction by pressing a button mapped to a colored emoji on ChiParCo, which sets the color of a heart-shaped light on both prototypes. The colored emojis stitched on both prototypes help the parent and child to map the colors and emotions: green-happy, yellow-neutral and blue-sad. This interaction provides parents with awareness of their child's current emotional state and enables children to communicate emotions in a non-verbal way.

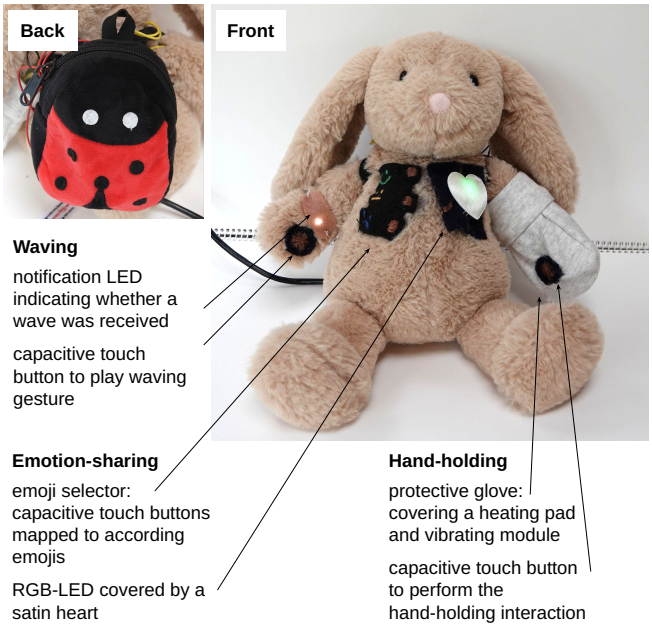


Figure 2: ChiParCo, the child-side prototype.

3.3 Implementation

ChiParCo. Figure 2 shows ChiParCo, consisting of an approximately 30 cm tall plush bunny. To realize the hand-holding interaction and the waving gesture, we used two servo motors (Miuzei DS3218 20kg, SG90 9g) and attached wooden sticks to each servo arm. The motors are placed inside the bunny's shoulders. The sticks, placed inside the paws, act as tendons. To mimic the feeling of touch, we placed a vibration motor (ADA1201) and a heating pad (ADA1481) on top of the left paw. Both are kept in place using a small glove, drawing a visual connection to the parent-side device. We use capacitive touch sensors consisting of hand-sewn conductive thread to detect when the child touches the respective buttons, e.g. the button on the left paw to signal that the child is performing the hand-holding interaction. An LED sewn onto the right paw indicates when a waving gesture has been sent and a button next to the LED enables playback. The emotion-sharing interaction consists of an RGB-LED (Lilypad). A satin heart is sewn on top to provide an appropriate shape for the light [43]. To select and send an emotion, emojis are stitched next to capacitive buttons in coloured threads corresponding to the LED colours. To hide most of the electronics (the circuit board and two battery packs), we placed them in a small backpack worn by the bunny, inspired by the approach of Agrawal et al. [1].
ParChiCo. Figure 3 shows ParChiCo, a glove with cut-off fingers to enhance wearability. For the implementation of all interactions, excluding hand-holding, we incorporated conductive yarn for circuitry to minimize obstruction and cable usage. To accommodate diverse hand-sizes of the users in our studies, we opted for the largest available glove size. For hand-holding, we crafted two textile bands incorporating Shape Memory Alloy (Flexinol LT) to encircle the palm, aiming to provide a comforting squeeze when the Shape Memory Alloy (SMA) activates, inspired by SqueezeBands [61]. Both bands have heat-isolated designs, comprising heat-resistant fabric (para-aramid felt) and muscle tape for skin protection. We use two bands to test two approaches for embedding the SMA wire. It is interwoven in the first band, and only connected at the endpoints for the second (while still protecting the skin). Velcro enables adjustment of the bands to accommodate different hand sizes. The bands, powered by a 9V battery, are activated via a MOSFET (FQP30N06L). To facilitate dynamic switching between the two bands during the study, thin wires were soldered to the I/O pins and connected via crocodile clips. Additionally, we glued a small vibration motor (ADA1201) onto the textile. To implement gesture recognition, we sewed an accelerometer (ADXL345) to the back of the glove, inspired by Tushar et al. [8]. Waving and hand-turnover are detected by computing tilt angles using the accelerometer data [36]. For emotion-sharing, we incorporated the same heart light and labelling emojis as for ChiParCo. The emojis are located directly beneath the light. The placement on the wrist ensures constant visibility, supporting emotional awareness.
Communication between Prototypes. The prototypes are powered by connecting them to a laptop, giving the researchers control when executing code. To enable communication between the prototypes we chose the Raspberry Pi Pico W micro-controller. It has a small form factor and contains a built-in WiFi module. Furthermore, we decided on the light-weight networking protocol MQTT and the mosquitto broker [28].

4 STUDY METHODOLOGY

To evaluate the prototype pair, we conducted a qualitative user study with children and parents. We explore how well the form

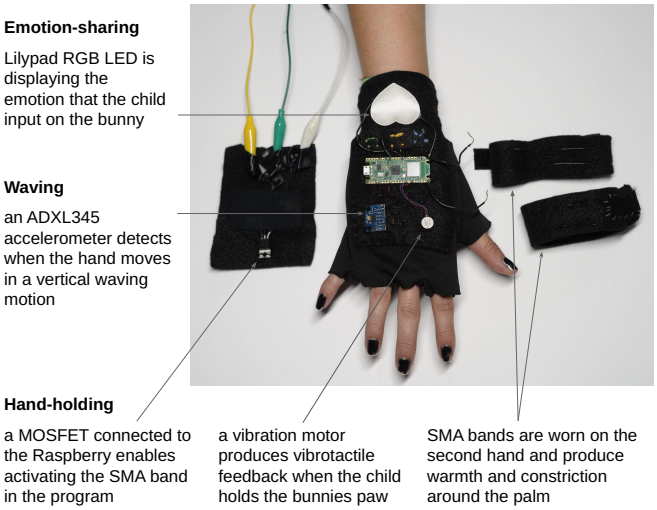


Figure 3: ParChiCo, the parent-side prototype.

factors and functions align with the preferences and usability expectations of children and parents. On the child-side, we evaluate to what extent ChiParCo affords interactions that are easy to use and allow the child to initiate contact, engage physically, express emotions and provide emotional support. On the parent-side, we evaluate to what extent ParChiCo supports interactions that allow them to stay in touch, feel connected with their child, and be aware of their child's emotional state. We draw from these findings to provide design implications to support the design of tailored tangible parent-child communication tools.

Participants. In total, we recruited 10 parent-child dyads through word of mouth; thus, most dyads were familiar to at least one of the researchers. Participants' demographic data is shown in Table 1.

Study Protocol. The structure of the study (see Figure 4) was as follows. The evaluation took place in the participants' homes. There were two experimenters, responsible for the child-side and parent-side respectively. Starting with the Warm-up Phase, we briefly outlined the context of the study and explained the procedure without providing details on the interactions afforded by the prototypes. The parent initially sat next to the child while wearing ParChiCo (see Figure 5). Next, during the Free Exploration Phase, the participants were told to explore the functionality of the prototypes, without prior explanation. This phase aimed to uncover participants' expectations, assessing the intuitiveness and visibility of the interactions. Next, the Joint Guided Interaction Phase started with an explanation of the concept of our prototypes and their interactions in context. We asked them to execute the three interactions via the prototype-pair:

> **Task A: Waving.** The parent is told to wave and the child receives it.
> **Task B: Hand-holding.** This was repeated twice to test both versions of the SMA band and to allow both child and parent to initiate.
> **Task C: Emotion-sharing.** The child is asked to send an emotion to their parent.

The order of tasks was randomized. Following this, participants X6-X10 engaged in the Separated Guided Interaction Phase, where they interacted via the prototypes from separate, yet close-by rooms. Because of the unavailability of an additional adult for supervision, whom the child is familiar with, we made the decision to not separate dyads X1-X5 based on ethical considerations. Consequently, the Separated Guided Interaction Phase was omitted from studies X1-X5. The co-located adult was acting only as an observer, ensuring that the child was comfortable in the study setting (see Selection and Participation of Children). In contrast, participants C6-C10 were accompanied by two familiar adults, such that one adult could remain with the child during the Separated Guided Interaction Phase. By separating the parent-child dyad, we aimed to place the usage of the prototypes into the context of separation and gather data on how the interactions are perceived when using them for remote communication. The tasks were identical to the Joint Guided Interaction Phase.

Data collection. Throughout the study, we made use of the think-aloud method, which is especially useful for evaluating the usability of prototypes involving children [4]. We prepared questions for the parent and the child (see the Appendix), which were asked organically during the interaction tasks to elicit more detailed information and additionally acted as a prompt for the children to voice their experiences. We further observed participants' facial expressions and body language. Throughout all phases, we took written notes or audio and video recordings, if the participants gave consent. All user studies were performed in German and quotes therefore translated to English by the authors. At the end of the study, participants were given questionnaires to collect additional quantitative data about their experiences with the prototypes. The parent-side questionnaire is based on the Affective Benefits and Costs of Communication Technologies (ABCCT) questionnaire [60]. The parents answered each question on a 5-point Likert scale 1 ("strongly disagree") to 5 ("strongly agree") [41]. We modified some questions of the ABCCT questionnaire to relate to ParChiCo specifically. For the child-side questionnaire, we employed simplified language and provided a 5-point Likert scale using emojis [49]. We read the questionnaire aloud for C2, C7 and C8. The remaining children did not need any assistance.

5 RESULTS AND DISCUSSION

We focus on extracting qualitative insights and thus use a qualitative description approach [40] to extract information regarding participants' preferences through observation of their interactions and analysis of the verbal and visual data. Additionally, see the Appendix for the questionnaire results.

In general, all participants responded positively to the concept of ChiParCo and ParChiCo. Everyone (except P6) would like to make use of the prototype-pair during times of separation (e.g. P3 to C3: "We would have needed that back then when I was gone for a long time [due to having to stay in hospital]."). Notably, all children agreed that they would like to use ChiParCo to help them not miss their parent as much. The parents thought that ParChiCo was fun to use (mean 4.6) and were excited about using it with their child (mean 4.1).

Family	Longest Separation (d)	Child	Age	Gender	Remote Comm Tech				Parent	Age	Gender
X1	0.5	C1	9	M	C	V	-	P*, S	P1	45	F
X2	16	C2	3	M	C	V	-	P*	P2	37	M
X3	28	C3	11	M	C	V	M	P	P3	45	F
X4	5	C4	8	M	C	V	-	P	P4	47	F
X5	21	C5	10	F	C	V	M	P, S	P5	37	M
X6	3	C6	10	F	C	V	M	P, S	P6	41	M
X7	4	C7	5	F	C	V	-	P*	P7	38	M
X8	0	C8	5	M	C	V	-	P*	P8	43	F
X9	10	C9	5	F	C	V	M	P*	P9	37	M
X10	2	C10	7	F	C	V	-	P*	P10	49	F

Table 1: The demographic information of all participants. Participants highlighted in grey took part in the Separated Guided Interaction Phase. The abbreviations for the used remote communication refer to the following: C - Calls, V - Video Calls, M - (Text) Messages. P and S distinguished between the device(s) used: P - Phone and S - Smart Watch. The asterisk (*) indicates help from a co-located parent.

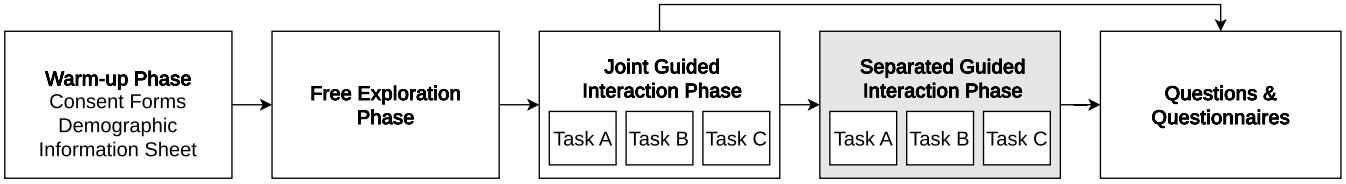


Figure 4: The study structure. The grey phase was omitted for participants X1-X5.

Figure 5: A snapshot from one user study. The parent-child dyad explores the interactions of the prototype-pair during the Joint Guided Interaction Phase.

5.1 Form Factors of the Prototypes

ChiParCo. Overall, the children enjoyed interacting with ChiParCo, expressing their fondness for the prototype both verbally and through facial expressions (mean 4.7). All children agreed that the plush toy was a good basis for a communication tool designed for them. Further, every child, except the youngest participant (C2) who was shy at the beginning, did not hesitate to interact with the prototype and was curious to explore its functionality.

ParChiCo. All parents (excluding P6) agreed on the glove's suitability for specific use cases, such as incorporating it into scheduled video chats. P8 showed interest in using ParChiCo when he is abroad to engage with C8, addressing the issue of distractions during phone conversations. Six parents expressed a desire to integrate an enhanced version of ParChiCo into their daily routines. For example, P2 envisioned using the glove after putting his 3-year-old to sleep during home office hours to stay aware of his son's sleep patterns. However, parents with full-time jobs found the glove's form factor too cumbersome for everyday use. P5, P8, and P9 specifically preferred an interactive wristband or smartwatch, still including haptic interactions and feedback. P6, who disliked haptic interaction, expressed a preference to use a mobile app instead.

Design Implications. Our findings complement previous work [9, 53] in suggesting that an interactive plush bunny is a promising concept as a communication tool for children. Despite positive feedback on the haptic nature of ParChiCo, the glove's form factor remains cumbersome in context of daily use. A more practical alternative could be an interactive wristband/smartwatch, still offering tangible interaction and haptic feedback while being less obstructive, thus better suiting the needs of working parents.

5.2 Interactions with ChiParCo and ParChiCo

Overall, seven of the children were fully engaged by the interactions for the duration of the study, while three (C2, C7 and C8) got slightly distracted and needed more prompts and guidance to interact. When sat next to their parent the children frequently asked their parents to interact with them via the prototypes, and during the separated phase they initiated contact themselves or instantly reacted to messages from their parents. Seven of the children demonstrated an understanding of the connection between the prototype-pair and thus to their parent. During the Separated Guided Interaction Phase,

four out of five children were able to explain what was happening and why (C10 struggled to explain hand-holding).

Waving

Children. This interaction was well liked by the children, as reflected in the questionnaire (mean 4.7) and seven children naming it their favourite. When the waving gesture was first replayed, all participants' reactions were to smile or laugh. Generally, it seemed that the movement of ChiParCo fascinated the children. Five children demanded more waves from their parent during the joint interaction and it seemed that all children understood the connection to ParChiCo. During the Separated Guided Interaction Phase all five children were able to explain the interaction. The gesture itself was intuitive for children to understand and three children waved back at the bunny as a response. The asynchronous nature of the interaction became clear to all children after a short amount of time. Every child was eager to press the button as soon as the notification LED lit up.

Parents. The waving was liked and appreciated by all parents, as reflected in the questionnaire (mean 4.7). While exploring the functionality, all parents (except P1, P6 and P8) executed a waving gesture intuitively. Notably, it was the first thing P2 did when putting on the glove. Two parents highlighted that the act of waving might feel awkward when separated from their child. However, when in close proximity, the tangible nature of the waving interaction, where the child can directly correlate the parent's wave with the bunny's response, was well-received. This observation supports the notion that the glove might be more fitting in a video call context, where the visual connection is retained. The asynchronous nature of the waving was appreciated. Nonetheless, some parents would like to switch between synchronous and asynchronous modes, based on being separated or not.

Design Implications. Waving appears to be a natural and intuitive gesture to understand for both parents and children, complementing previous findings on hand-based gestures [35]. The children were joyful when receiving a wave from their parents, showing the potential this interaction holds for emotional support. All parents saw the need for an asynchronous form of interaction.

Hand-holding

The hand-holding interaction was found to be hardest to grasp initially, with all of the dyads requiring some guidance to execute the interaction as a whole. This may be due to the interaction having multiple steps and the thermal feedback being delayed when heating up. Additionally, there was no feedback for the child while initiating hand-holding.

Children. Seven children understood the concept of the hand-holding interaction after an explanation. Even though some initially struggled, the children gave somewhat positive ratings in the questionnaire (mean 4.1), and two rated it their favourite. Five children, when queried, stated that performing the interaction reminded them of holding their parent's hand, supporting the concept of the bunny as a proxy. The haptic feedback implemented in the paw received mixed responses. No child disliked the thermal feedback, though four children did not notice it, and five children felt indifferent about the warmth. Potentially due to being instant, the vibration feedback was noticed and liked better by all. Initiating the interaction on the child-side required the parent to communicate that they had received the vibration. When the children discovered this, they were curious and enjoyed touching the button frequently. Interestingly, C9 used this to notify P9 that she was about to send a message using the emotion-sharing.

Parents. All parents (except P6) embraced the concept of distant hand-holding and physical connection with their child, with participants generally amazed by the idea of feeling touch sensations in remote communication. Generally, the warmth generated by the SMA bands elicited a comforting feeling, except for P1 (too warm), P5 and P10 (did not notice warmth). The warmth of the interwoven SMA band was preferred. However, the constriction produced by both bands was insufficient, as only half of the parents noticed it. There was no notable difference in the constriction produced by each band. Vibrotactile feedback received high praise, with P9 suggesting a greater emphasis on it in each interaction, especially for a device intended for everyday wear. This could serve as a simple and subtle notification method, aligning with the parents' need to physically feel connected to their child. The gesture symbolizing reaching out to the child did not resonate with many parents, except for P8, who appreciated the idea since she frequently holds hands with her child. Other parents mentioned a preference for hugging as a primary form of physical contact over the suggested gesture.

Design Implications. To make the interactions more understandable, instant and clear feedback seems to be beneficial. Generally, including a meaningful physical interaction was well-liked by participants. However, hand-holding was not intuitive for most participants as it was not common for them to do in their day-to-day lives. Hugging was suggested as an alternative gesture.

Emotion-sharing

Children. In the questionnaire, all children stated liking the emotion-sharing interaction (mean 4.6), and two participants rated it their favourite interaction. All children (except C2, the youngest participant) understood the color-emoji-emotion mapping. Some children initially struggled to figure out where to press, i.e. pressing the stitched emojis or the satin heart instead. However, once the light switched colours, the usage of the buttons and the connection to the heart light on the glove became apparent. It seems that the instant visual feedback on both prototypes helped the children to understand the underlying connection. When asked to send their current emotion during the Separate Guided Interaction Phase, all five participants immediately pressed the "happy" button.

Parents. All parents comprehended that the colored light on ParChiCo represented three emotions changeable by their child. Except P6, all parents acknowledged its potential to aid their understanding of their child's well-being and improving general communication. P6 mentioned that including emotion-sharing could introduce unnecessary worries. P8 voiced concerns about the negative connotation of messages, particularly when busy, and recommended re-framing the "sad" emotion to a more positively connoted "I miss you" message. Moreover, seven parents wished for the ability to transmit messages themselves. For example, they suggested sending an "I love you" message, symbolized by a red light on the ChiParCo.

Design Implications. While the emoji-color mapping was understood by most children, the mapping to the buttons should be clarified. Generally, the visual feedback on both prototypes helped children understand the interaction and the pair's connection. Replacing the "sad" emoji with positively connoted emotions and messages such as "I miss you", is recommended to reduce worry for the parents. Additionally, affording bidirectional emotion sharing would enable the parent to respond and send comforting messages to their child. Moreover, four children and six parents suggested sending pre-recorded audio messages using the prototypes.

6 LIMITATIONS AND FUTURE WORK

Our study yields crucial qualitative insights on our prototype-pair. While the small sample size of 10 limits the generalizability of quantitative data, it still allows for meaningful qualitative results [18]. However, participants only interacted with the prototypes in a single session. The novelty of the devices and the researchers' presence, coupled with their familiarity with participants, likely influenced responses. Moreover, the study simulated separation briefly or not at all, lacking the emotional realism of long-distance separation. Additionally, the presence of an adult during the Separated Guided Interaction Phase might have influenced the childs' interactions, yet at the same time reflects a real-life setting where another parent likely is also present. To assess the prototypes' performance and psychological factors during prolonged separation, future research should conduct long-term field studies.

There were limitations due to the prototypes being in an early stage of design, which may have impacted participants' perception of certain functions. Hence, more sophisticated prototypes are necessary for future work. ChiParCo's mobility was limited and the thermal feedback was delayed. Also, one could explore making the plush toy customizable to suit the individual likes and needs of each child. For ParChiCo, choosing a large-sized glove resulted in it being oversized for some participants. The adjustment of SMA bands for different palm sizes introduced variability in participants' experiences, which may account for some participants not feeling the constriction of the SMA. Given the positive findings in existing work on mediated social touch (e.g. [61]), and the parents' enthusiasm for the remote touch concept, future work will continue to explore the incorporation of remote touch. Additionally, one could compare the suggestions made by the parents; for example, haptic feedback on the wrist compared to the hand, or a hugging interaction compared to hand-holding.

Considering interactions, the results suggest that switching between synchronous and asynchronous modes within the same interaction could be interesting to explore in future implementations. To allow broader emotion-sharing and emotional support, additional emotions, predefined messages or bidirectional emotion-sharing could be explored. Another interesting approach for future work might be to explore using the prototypes together with video chat. Furthermore, one could explore the prototypes in other use contexts, such as remote sibling (e.g [3]) or grandparent-grandchild communication (e.g. [32]).

7 CONCLUSION

In this work, we designed and implemented two tangible prototypes - an interactive plush bunny and glove - supporting emotive parent-child communication over a distance. The prototypes were tailored to the differing needs of parents and children and evaluated via a qualitative user study with 10 child-parent dyads. Our findings verify and extend the design criteria suggested in prior work. The children's responses to ChiParCo confirmed that the plush bunny is an appropriate form factor for children. For ParChiCo, the tangible and gesture-based affordances of the glove received positive responses from the parents and we proposed an alternative form factor for daily usage. We extracted further design implications from participant responses to the three interactions. Waving was the most engaging and simple interaction, highlighting the benefits of intuitive physical interaction. Parents wished to switch between synchronous and asynchronous modes to fit with their activities. The physical interaction supported by hand-holding was also appreciated, but the concept was too abstract for some children. Our observations suggest that interactions with fewer steps and clear instantaneous feedback would be more appropriate. The emotional awareness provided by the emotion-sharing was liked by parents and children. Parents also wished to reciprocate and suggested more positively framed messages. Our findings show promising results for supporting remote parent-child communication with tangible interfaces.

8 SELECTION AND PARTICIPATION OF CHILDREN

As children play an essential part in our research and at the same time are a vulnerable group, we placed special importance to making sure that they stay safe and comfortable throughout our studies. We firstly requested and got approval for our study design by the ethical review board of Saarland University (reference number: 23-11-5). The experimenters were two female, undergraduate students. Additionally, the majority of the children were familiar with at least one researcher before taking part in the study.

We collected consent by having the respective parents read and sign a consent form, informing them about the study and allowing their child to participate. As the children are minors, they could not legally sign the consent forms themselves. Nevertheless, we made sure to inform them too and get their verbal consent prior to starting the user study. If both parent and children agreed, we took video as well as audio recordings of them. The data was pseudomized after it had been processed by the researchers of this paper. While the recordings themselves were deleted after a previously set date, we included a snapshot of one user study in this paper. For this image we gathered consent from both the parent and the child depicted.

The participants were made aware of why the researchers conducted the study, namely to investigate the interaction between parent and child using the two prototype-pair. While we initially did not explain the functionality of said prototypes, we gave them a rough overview of the study structure. This was part of the Warm-up phase which we included at the beginning of every study. This let researchers and participants get to know each other in order to make the children feel safe and comfortable. Furthermore, we

decided to perform the study in the respective families' homes. Additionally, at least one familiar adult always stayed with the child during every phase of the study to avoid separation anxiety for the children. During no part of the study did the children show signs of distress. Further addressing the needs of young children, we decided to keep the structure of the evaluation flexible, including breaks where necessary. We kept the language easy to understand as to not overwhelm nor intimidate the children.

ACKNOWLEDGMENTS

This work has been partly funded by the European Union (European Regional Development Fund, ERDF) and the state of Saarland, Germany (project "Multi-Immerse"). We extend our heartfelt gratitude to the families who took part in our user study.

REFERENCES

[1] Radhika Agrawal, Emily Kuo, Anokhi Kholwadwala, Marissa Renteria, and Alex Colello. 2021. Cara: A Smart Plush Toy for Support During COVID-19. In *Companion of the 2021 ACM/IEEE International Conference on Human-Robot Interaction* (Boulder, CO, USA) *(HRI '21 Companion)*. Association for Computing Machinery, New York, NY, USA, 636–638. https://doi.org/10.1145/3434074.3446951

[2] Richard Armitage. 2022-05-23. War in Ukraine: the impacts on child health. *British Journal of General Practice* 72, 719 (2022-05-23), 272–273.

[3] Stuti Arora, Qiao Jin, and Svetlana Yarosh. 2023. Exploring Embodied Approaches for Large Age Gap Sibling Communication through Technology Probes. In *Proceedings of the 22nd Annual ACM Interaction Design and Children Conference* (Chicago, IL, USA) *(IDC '23)*. Association for Computing Machinery, New York, NY, USA, 635–640. https://doi.org/10.1145/3585088.3593892

[4] Ester Baauw and Panos Markopoulous. 2004. A Comparison of Think-Aloud and Post-Task Interview for Usability Testing with Children. In *Proceedings of the 2004 Conference on Interaction Design and Children: Building a Community* (Maryland) *(IDC '04)*. Association for Computing Machinery, New York, NY, USA, 115–116. https://doi.org/10.1145/1017833.1017848

[5] Rafael Ballagas, Joseph 'Jofish' Kaye, Morgan Ames, Janet Go, and Hayes Raffle. 2009. Family Communication: Phone Conversations with Children. In *Proceedings of the 8th International Conference on Interaction Design and Children* (Como, Italy) *(IDC '09)*. Association for Computing Machinery, New York, NY, USA, 321–324. https://doi.org/10.1145/1551788.1551874

[6] Tomas Cano and Pablo Gracia. 2020. The Gendered Consequences of Parental Separation for Parents' and Children's Time Investments: A Longitudinal Study. (2020). https://doi.org/10.31235/osf.io/8j37s

[7] Giovanna Castellano, Antonio Cervelione, Marco Cianciotta, Berardina De Carolis, and Gennaro Vessio. 2020. Recognizing the waving gesture in the interaction with a social robot. In *2020 29th IEEE International Conference on Robot and Human Interactive Communication (RO-MAN)*. IEEE, 733–738.

[8] Tushar Chouhan, Ankit Panse, Anvesh Kumar Voona, and S. M. Sameer. 2014. Smart glove with gesture recognition ability for the hearing and speech impaired. In *2014 IEEE Global Humanitarian Technology Conference - South Asia Satellite (GHTC-SAS)*. 105–110. https://doi.org/10.1109/GHTC-SAS.2014.6967567

[9] Soo Wan Chun and Jinsil Hwaryoung Seo. 2023. Buddie: Design Exploration for Remote Interactions to Support Kids. In *Human-Computer Interaction: Thematic Area, HCI 2023, Held as Part of the 25th HCI International Conference, HCII 2023, Copenhagen, Denmark, July 23–28, 2023, Proceedings, Part II* (Copenhagen, Denmark). Springer-Verlag, Berlin, Heidelberg, 56–71. https://doi.org/10.1007/978-3-031-35599-8_4

[10] Thomas Dalsgaard, Mikael B. Skov, Malthe Stougaard, and Bo Thomassen. 2006. Mediated Intimacy in Families: Understanding the Relation between Children and Parents. In *Proceedings of the 2006 Conference on Interaction Design and Children* (Tampere, Finland) *(IDC '06)*. Association for Computing Machinery, New York, NY, USA, 145–152. https://doi.org/10.1145/1139073.1139110

[11] Ümit Demir. 2020. Investigation of color-emotion associations of the university students. *Color Research & Application* 45, 5 (2020), 871–884.

[12] Statistisches Bundesamt (Destatis). 2021. Parents working part-time. Retrieved 2023-03-11 from https://www.destatis.de/EN/Themes/Labour/Labour-Market/Quality-Employment/Dimension3/3_7_ParentsWorkingParttime.html

[13] Statistisches Bundesamt (Destatis). 2022. Divorces and affected minor children. Retrieved 2023-03-11 from https://www.destatis.de/EN/Themes/Society-Environment/Population/Marriages-Divorces-Life-Partnerships/Tables/divorces-children.html

[14] Patrick F Fagan and Aaron Churchill. 2012. The effects of divorce on children. *Marri Research* 1 (2012), 1–48.

[15] Tiffany Field. 2014. *Touch*. MIT press.

[16] Allan Fong, Zahra Ashktorab, and Jon Froehlich. 2013. Bear-with-Me: An Embodied Prototype to Explore Tangible Two-Way Exchanges of Emotional Language. In *CHI '13 Extended Abstracts on Human Factors in Computing Systems* (Paris, France) *(CHI EA '13)*. Association for Computing Machinery, New York, NY, USA, 1011–1016. https://doi.org/10.1145/2468356.2468537

[17] Daniel Gooch and Leon Watts. 2012. YourGloves, Hothands and Hotmits: Devices to Hold Hands at a Distance. (2012). https://doi.org/10.1145/2380116.2380138

[18] Greg Guest, Arwen Bunce, and Laura Johnson. 2006. How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability. *Field Methods* 18, 1 (2006), 59–82. https://doi.org/10.1177/1525822X05279903 arXiv:https://doi.org/10.1177/1525822X05279903

[19] Antal Haans and Wijnand IJsselsteijn. 2006. Mediated social touch: a review of current research and future directions. *Virtual Reality* 9 (2006), 149–159.

[20] Nur Al-huda Hamdan, Adrian Wagner, Simon Voelker, Jürgen Steimle, and Jan Borchers. 2019. Springlets: Expressive, Flexible and Silent On-Skin Tactile Interfaces. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (Glasgow, Scotland Uk) *(CHI '19)*. Association for Computing Machinery, New York, NY, USA, 1–14. https://doi.org/10.1145/3290605.3300718

[21] Alice Haynes, Melanie F Simons, Tim Helps, Yuichi Nakamura, and Jonathan Rossiter. 2019. A wearable skin-stretching tactile interface for Human–Robot and Human–Human communication. *IEEE Robotics and Automation Letters* 4, 2 (2019), 1641–1646.

[22] Hooman Hedayati, Srinjita Bhaduri, Tamara Sumner, Daniel Szafir, and Mark D. Gross. 2019. HugBot: A soft robot designed to give human-like hugs. In *Proceedings of the 18th ACM International Conference on Interaction Design and Children* (Boise, ID, USA) *(IDC '19)*. Association for Computing Machinery, New York, NY, USA, 556–561. https://doi.org/10.1145/3311927.3325332

[23] Masahiro Hirai and Yasuhiro Kanakogi. 2019. Communicative hand-waving gestures facilitate object learning in preverbal infants. *Developmental Science* 22, 4 (2019), e12787.

[24] Heejin Lee. 2019. *Effects of Light-Emitting Diode (LED) Lighting Color on Human Emotion, Behavior, and Spatial Impression*. Michigan State University.

[25] Jiyeon Lee, Yeong Rae Joi, JinHwang Kim, JongSung Lee, and Jun Dong Cho. 2017. Home Talky: SNS Service for Sustainable Communication for All the Family Members across Every Generation. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (, Denver, Colorado, USA,) *(CHI EA '17)*. Association for Computing Machinery, New York, NY, USA, 1809–1815. https://doi.org/10.1145/3027063.3053071

[26] Sunmin Lee and Thecla Schiphorst. 2016. Warmth and affection: exploring thermal sensation in the design of parent-child distant interaction. In *Human-Computer Interaction. Novel User Experiences: 18th International Conference, HCI International 2016, Toronto, ON, Canada, July 17-22, 2016. Proceedings, Part III 18*. Springer, 3–14.

[27] Charlie Lewis and Michael E. Lamb. 2011. The role of parent-child relationships in child development. In *M. H. Bornstein and M. E. Lamb (Eds.), Developmental science: An advanced textbook, 6th ed.* Psychology Press, New York, NY, US, 469–517.

[28] Roger A. Light. 2017. Mosquitto: server and client implementation of the MQTT protocol. *Journal of Open Source Software* 2, 13 (2017), 265. https://doi.org/10.21105/joss.00265

[29] Gan Lu, Lik-Kwan Shark, Geoff Hall, and Ulrike Zeshan. 2012. Immersive manipulation of virtual objects through glove-based hand gesture interaction. *Virtual Reality* 16 (2012), 243–252.

[30] Elaine Massung, Sarah Dickins, James Torbett, James Holmes, Kirsten Cater, and Victoria Bates. 2015. InTouch Tactile Tales: Haptic Feedback and Long-Distance Storytelling. In *Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems* (Seoul, Republic of Korea) *(CHI EA '15)*. Association for Computing Machinery, New York, NY, USA, 1289–1294. https://doi.org/10.1145/2702613.2732843

[31] Paulina L. Modlitba and Christopher Schmandt. 2008. Globetoddler: Designing for Remote Interaction between Preschoolers and Their Traveling Parents. In *CHI '08 Extended Abstracts on Human Factors in Computing Systems* (Florence, Italy) *(CHI EA '08)*. Association for Computing Machinery, New York, NY, USA, 3057–3062. https://doi.org/10.1145/1358628.1358807

[32] Flor B. Montañez, Victoria Meza-Kubo, Cristina Ramírez-Fernández, and Alberto L. Morán. 2019. Redesign and Evaluation of AffectiVest, a Wearable Tool to Convey Affection Gestures between Geographically-Separated Grandparents and Grandchildren †. *Proceedings* 31, 1 (2019). https://doi.org/10.3390/proceedings2019031066

[33] Sachith Muthukumarana, Don Samitha Elvitigala, Juan Pablo Forero Cortes, Denys JC Matthies, and Suranga Nanayakkara. 2019. PhantomTouch: Creating an extended reality by the illusion of touch using a shape-memory alloy matrix. *SIGGRAPH Asia 2019 XR* (2019), 29–30.

[34] Eleuda Nunez, Masakazu Hirokawa, Monica Perusquia-Hernandez, and Kenji Suzuki. 2019. Effect on Social Connectedness and Stress Levels by Using a Huggable Interface in Remote Communication. In *2019 8th International Conference on Affective Computing and Intelligent Interaction (ACII)*. 1–7. https:

//doi.org/10.1109/ACII.2019.8925457
[35] Oliver Ozioko and Ravinder Dahiya. 2022. Smart tactile gloves for haptic interaction, communication, and rehabilitation. *Advanced Intelligent Systems* 4, 2 (2022), 2100091.
[36] Mark Pedley. 2013. Tilt sensing using a three-axis accelerometer. *Freescale semiconductor application note* 1 (2013), 2012–2013.
[37] Hayes Raffle, Rafael Ballagas, Glenda Revelle, Hiroshi Horii, Sean Follmer, Janet Go, Emily Reardon, Koichi Mori, Joseph Kaye, and Mirjana Spasojevic. 2010. Family Story Play: Reading with Young Children (and Elmo) over a Distance. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) *(CHI '10)*. Association for Computing Machinery, New York, NY, USA, 1583–1592. https://doi.org/10.1145/1753326.1753563
[38] Hayes Raffle, Koichi Mori, Rafael Ballagas, and Mirjana Spasojevic. 2011. Pokaboo: A Networked Toy for Distance Communication and Play. In *Proceedings of the 10th International Conference on Interaction Design and Children* (Ann Arbor, Michigan) *(IDC '11)*. Association for Computing Machinery, New York, NY, USA, 201–204. https://doi.org/10.1145/1999030.1999061
[39] Roope Raisamo, Katri Salminen, Jussi Rantala, Ahmed Farooq, and Mounia Ziat. 2022. Interpersonal Haptic Communication: Review and Directions for the Future. *International Journal of Human-Computer Studies* 166 (2022), 102881. https://doi.org/10.1016/j.ijhcs.2022.102881
[40] Margarete Sandelowski. 2000. Whatever happened to qualitative description? *Research in nursing & health* 23, 4 (2000), 334–340.
[41] PhD Saul Mcleod. 2023. Likert Scale Questionnaire: Examples & Analysis. (2023). https://www.simplypsychology.org/likert-scale.html
[42] Jinsil Hwaryoung Seo, Annie Sungkajun, and Meghan Cook. 2017. InTouch Wearables: Exploring Ambient Remote Touch in Child-Parent Relationships. In *Proceedings of the Eleventh International Conference on Tangible, Embedded, and Embodied Interaction* (Yokohama, Japan) *(TEI '17)*. Association for Computing Machinery, New York, NY, USA, 671–676. https://doi.org/10.1145/3024969.3025057
[43] Ping Shan, Shijian Luo, Chengyi Shen, Zhitong Cui, Ze Bian, Huan Lin, Wenyin Zou, and Yufei Zhang. 2020. Wearable Smart Emotion-Aware Gloves: Develops a New Way People Interact with Others. (2020), 130–144.
[44] Ji Youn Shin, Minjin Rheu, Jina Huh-Yoo, and Wei Peng. 2021. Designing Technologies to Support Parent-Child Relationships: A Review of Current Findings and Suggestions for Future Directions. *Proc. ACM Hum.-Comput. Interact.* 5, CSCW2, Article 441 (oct 2021), 31 pages. https://doi.org/10.1145/3479585
[45] Melanie F. Simons, Alice C. Haynes, Yan Gao, Yihua Zhu, and Jonathan Rossiter. 2020. In Contact: Pinching, Squeezing and Twisting for Mediated Social Touch. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems* (<conf-loc>, <city>Honolulu</city>, <state>HI</state>, <country>USA</country>, </conf-loc>) *(CHI EA '20)*. Association for Computing Machinery, New York, NY, USA, 1–9. https://doi.org/10.1145/3334480.3382798
[46] Samarth Singhal, Carman Neustaedter, Alissa N. Antle, and Brendan Matkin. 2017. Flex-N-Feel: Emotive Gloves for Physical Touch Over Distance. In *Companion of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing* (Portland, Oregon, USA) *(CSCW '17 Companion)*. Association for Computing Machinery, New York, NY, USA, 37–40. https://doi.org/10.1145/3022198.3023273
[47] Unicef Statement. 2022-04-12. UNICEF concerned that COVID-19 prevention measures have resulted in family separation. Retrieved 2023-03-12 from https://www.unicef.org/eap/press-releases/unicef-concerned-covid-19-prevention-measures-have-resulted-family-separation
[48] Yingze Sun, Matthew P. Aylett, and Yolanda Vazquez-Alvarez. 2016. E-Seesaw: A Tangible, Ludic, Parent-Child, Awareness System. In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems* (San Jose, California, USA) *(CHI EA '16)*. Association for Computing Machinery, New York, NY, USA, 1821–1827. https://doi.org/10.1145/2851581.2892349
[49] Marianne Swaney-Stueve, Tegan Jepsen, and Grace Deubler. 2018. The emoji scale: A facial scale for the 21st century. *Food Quality and Preference* 68 (2018), 183–190. https://doi.org/10.1016/j.foodqual.2018.03.002
[50] Kazuaki Tanaka, Reo Mayuzumi, Tomomi Takahashi, Sho Takaki, and Natsuki Oka. 2021. Robot Mediated Handholding Combined with a Mobile Video Call Makes the Users Feel Nearer and Closer. In *Proceedings of the 9th International Conference on Human-Agent Interaction* (, Virtual Event, Japan,) *(HAI '21)*. Association for Computing Machinery, New York, NY, USA, 3–12. https://doi.org/10.1145/3472307.3484168
[51] James K.S. Teh, Zhenling Tsai, Jeffrey T.K.V. Koh, and Adrian D. Cheok. 2012. Mobile implementation and user evaluation of the Huggy Pajama system. In *2012 IEEE Haptics Symposium (HAPTICS)*. IEEE, Vancouver, BC, Canada, 471–478. https://doi.org/10.1109/HAPTIC.2012.6183833
[52] Nikki Theofanopoulou and Petr Slovak. 2022. Exploring Technology-Mediated Parental Socialisation of Emotion: Leveraging an Embodied, In-situ Intervention for Child Emotion Regulation. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (<conf-loc>, <city>New Orleans</city>, <state>LA</state>, <country>USA</country>, </conf-loc>) *(CHI '22)*. Association for Computing Machinery, New York, NY, USA, Article 217, 16 pages. https://doi.org/10.1145/3491102.3502130
[53] Kaisa Väänänen-Vainio-Mattila, Tomi Haustola, Jonna Häkkilä, Minna Karukka, and Katja Kytökorpi. 2012. Exploring non-verbal communication of presence between young children and their parents through the embodied teddy bear. In *Ambient Intelligence: Third International Joint Conference, AmI 2012, November 13-15, 2012. Proceedings 3*. Springer, Pisa, Italy, 81–96.
[54] Judith S Wallerstein. 1985. Children of divorce: Preliminary report of a ten-year follow-up of older children and adolescents. *Journal of the American Academy of Child Psychiatry* 24, 5 (1985), 545–553.
[55] Judith S Wallerstein. 1991. The long-term effects of divorce on children: A review. *Journal of the American Academy of Child & Adolescent Psychiatry* 30, 3 (1991), 349–360.
[56] Christian JAM Willemse, Dirk KJ Heylen, and Jan BF van Erp. 2018. Communication via warm haptic interfaces does not increase social warmth. *Journal on multimodal user interfaces* 12 (2018), 329–344.
[57] Christian J.A.M. Willemse, Gerald M. Munters, Jan B.F. van Erp, and Dirk Heylen. 2015. Nakama: A Companion for Non-Verbal Affective Communication. In *Proceedings of the 2015 ACM on International Conference on Multimodal Interaction* (Seattle, Washington, USA) *(ICMI '15)*. Association for Computing Machinery, New York, NY, USA, 377–378. https://doi.org/10.1145/2818346.2823299
[58] Svetlana Yarosh and Gregory D. Abowd. 2011. Mediated Parent-Child Contact in Work-Separated Families. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Vancouver, BC, Canada) *(CHI '11)*. Association for Computing Machinery, New York, NY, USA, 1185–1194. https://doi.org/10.1145/1978942.1979120
[59] Svetlana Yarosh, Hilary Davis, Paulina Modlitba, Mikael Skov, and Frank Vetere. 2009. Mobile technologies for parent/child relationships. , 285–306 pages.
[60] Svetlana Yarosh, Panos Markopoulos, and Gregory D. Abowd. 2014. Towards a Questionnaire for Measuring Affective Benefits and Costs of Communication Technologies. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing* (Baltimore, Maryland, USA) *(CSCW '14)*. Association for Computing Machinery, New York, NY, USA, 84–96. https://doi.org/10.1145/2531602.2531634
[61] Svetlana Yarosh, Kenya Mejia, Baris Unver, Xizi Wang, Yuan Yao, Akin Campbell, and Brad Holschuh. 2017. SqueezeBands: Mediated social touch using shape memory alloy actuation. *Proceedings of the ACM on Human-Computer Interaction* 1, CSCW (2017), 1–18.
[62] Svetlana Yarosh, Anthony Tang, Sanika Mokashi, and Gregory D. Abowd. 2013. "almost Touching": Parent-Child Remote Communication Using the Sharetable System. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work* (San Antonio, Texas, USA) *(CSCW '13)*. Association for Computing Machinery, New York, NY, USA, 181–192. https://doi.org/10.1145/2441776.2441798
[63] Svetlana Yarosh, Yee Chieh "Denise" Chew, and Gregory D. Abowd. 2009. Supporting parent–child communication in divorced families. *International Journal of Human-Computer Studies* 67, 2 (2009), 192–203. https://doi.org/10.1016/j.ijhcs.2008.09.005 The family and communication technologies.

APPENDIX

Children's Questionnaire	Mean	Median
Q1: I enjoyed playing with the bunny.	4.7	5
Q2: I felt closer to my mum/dad when using the bunny.	3.7	4
Q3: I enjoyed sending my emotions to my parents using the light.	4.6	5
Q4: I enjoyed holding the paw of the bunny.	4.1	4.5
Q5: I enjoyed it when the bunny was waving.	4.7	5

Table 2: The results of the children's questionnaire.

Parent's Questionnaire	Mean	Median
Q1: Communicating with my child using ParChico helps me tell how my child is feeling.	4.4	4
Q2: I feel that contact with me using ParChiCo is engaging for my child.	4.5	5
Q3: I am excited about using ParChiCo with my child.	4.1	4
Q4: I have fun with my child using ParChiCo.	4.6	5
Q5: Communicating with my child using ParChiCo makes me feel closer to my child.	4.1	4
Q6: Communicating with my child using ParChiCo helps me feel more connected to my child.	4.1	4
Q7: Communicating with my child using ParChiCo helps me provide my child with social support.	3.6	3.5
Q8: Communicating with my child using ParChiCo helps me feel less worried about something.	3.6	4
Q9: The interactions with the ParChiCo are straightforward and easily understandable.	3.8	4
Q10: During the holding hands interaction, it felt like I was holding my child's hand.	3.4	3
Q11: The ParChiCo made me feel physically connected to my child over distance.	3.6	4
Q12: I associate the color green with positive feelings.	4.5	5
Q13:: I associate the color blue with negative feelings.	2.6	2
Q14: The Emotion light makes me aware of my child's current emotional state.	4.3	4
Q15: The possibility to send a wave gesture to my child through the ParChiCo is useful (e.g., in a situation where I can't communicate with my child directly).	4.7	5

Table 3: The results of the parent's questionnaire.

Q1	Did you feel the warmth when the bunny lifted its paw? Did you like that, or not so much?
Q2	Would you like more than the paw to heat up?
Q3	Did you feel the bunny's hand shake? Did you like that, or not so much?
Q4	What did you like better, with the shaking or the heat? Or both?
Q5	Did it feel like your mum/dad held your hand?
Q6	What did you like doing with the bunny the most?
Q7	What did you not like so much about the bunny?
Q8	Do you understand the connection from the glove to your parent to the bunny?
Q9	Is there something you would like the bunny to do? Please demonstrate it to us with the bunny.

Table 4: The questions posed to each child mainly during the Joint Guided Interaction Phase. The order of questions was not strict.

Q1	Why is the light [notification LED] here turned on, what does it mean?
Q2	Why did the bunny just wave?
Q3	What happens if you press one of these buttons [from the emoji selector]?
Q4	Can you tell me why the bunny raised its paw?
Q5	What happens if you hold onto this paw [for hand-holding]?
Q6	Are you often away from your parents? Do you miss them then?
Q7	Would the bunny help you not miss your parents so much?

Table 5: The questions posed to C6-C10 during the Separated Guided Interaction Phase. For C1-C5 questions Q6 and Q7 were asked at the end of each study. The order of questions was not strict.

Q1	What did it feel like for you when the SMA bands contracted?
Q2	Did you feel warmth when the band contracted? If so, do you think it was too hot or could it be warmer?
Q3	The contraction is supposed to be imitating holding hands. Do you think that the contraction of the band was strong enough for that?
Q4	I showed two different versions of the band to you. Which one of them did you like better in the context of holding hands?
Q5	Was the waving gesture easy and intuitive to execute for you? Would you use that feature in an everyday context or would it feel strange to you?
Q6	Do you think it's useful to have an interaction that can be recorded without the child having to be present?
Q7	How did you like the Emotion Light? Do you think it's useful in order to be aware of your child's current emotions?
Q8	Do you think the colors used for mapping the emotions are appropriate?
Q9	In the context of communicating with your child over distance, would you wish for any other interactions? (e.g. something like video or voice interaction?)
Q10	Do you think the ParChiCo glove is useful for communicating with your child over distance? Was it intuitive to use? If not, what could be improved?

Table 6: Questions posed to the parent during each study in no particular order.