Mom, I see You Angry at Me! Designing a Mobile Service for Parent-child Conflicts by In-situ Emotional Empathy

Chungkuk Yoo
IBM
Austin, TX, USA
ckyoo@ibm.com

Seungwoo Kang
KOREATECH
Cheonan, Republic of Korea
swkang@koreatech.ac.kr

Inseok Hwang
IBM
Austin, TX, USA
ihwang@us.ibm.com

Chulhong Min
Nokia Bell Labs
Cambridge, UK
chulhong.min@nokia-bell-labs.com

Seonghoon Kim
KAIST
Daejeon, Republic of Korea
shkim@nclab.kaist.ac.kr

Wonjung Kim
KAIST
Daejeon, Republic of Korea
wjkim@nclab.kaist.ac.kr

Junehwa Song
KAIST
Daejeon, Republic of Korea
junesong@nclab.kaist.ac.kr

ABSTRACT

While having a child is a real blessing, raising the child may require parents to continuously resolve day-to-day conflicts with their child. In this paper, we examine the possibility of a mobile service to help parents deal with the moment of conflict in a peaceful way. Through the consultation with five psychotherapists, we understand the presence and severity of parent-child conflicts in daily lives and the today's therapeutic practices. Based on the understanding, we propose the concept of *I See You* that enables the parents to instantly put themselves in the second-person's view, i.e., the child's view, at the moment of conflict. This aims to facilitate the parents to be aware of their own subtle and momentary nonverbal expressions, thereby to empathize with the emotion which the child may feel.

CCS CONCEPTS

• **Human-centered computing** → **Mobile computing**; **Mobile devices**; **Ubiquitous and mobile computing design and evaluation methods**; *Computer supported cooperative work*.

KEYWORDS

Parent-child conflict, children, parenting, design study, empathy with children, second-person view, nonverbal interaction, self-awareness

ACM Reference Format:
Chungkuk Yoo, Seungwoo Kang, Inseok Hwang, Chulhong Min, Seonghoon Kim, Wonjung Kim, and Junehwa Song. 2019. Mom, I see You Angry at Me! Designing a Mobile Service for Parent-child Conflicts by In-situ Emotional Empathy. In *The 5th ACM Workshop on Mobile Systems for Computational Social Science (MCSS'19), June 21, 2019, Seoul, Republic of Korea.* ACM, New York, NY, USA, 6 pages. https://doi.org/10.1145/3325426.3329947

MCSS'19, June 21, 2019, Seoul, Republic of Korea

ACM ISBN 978-1-4503-6777-6/19/06…$15.00
https://doi.org/10.1145/3325426.3329947

1 INTRODUCTION

For parents, having a child is a true blessing indeed. However, raising the child could be not entirely smooth but more likely a day-to-day continuation of conflicts and negotiations [5, 8, 9]. As the child begins interacting with their parents, miscellaneous conflicts are inevitable for various daily-life reasons such as eating habits, cleaning up the room, dressing up, shopping a toy, going to bed, and so on [8]. John Gottman, a renowned psychologist and therapist in family relationship, noted an exemplary episode [9]: *"Diane is already late for work as she tries to coax three-year-old Joshua into his jacket so she can take him to daycare. After a too-quick breakfast and a battle over which shoes to wear, Joshua is tense too. He doesn't really care that his mom has a meeting in less than an hour. He wants to stay home and play, he tells her. When Diane tells him that's not possible, Joshua falls to the floor. Feeling sad and angry, he starts to cry."*

An ideal course of action for Diane would be giving a kind explanation and negotiation to the child. In reality, however, she would not be always patient enough; she may frown upon her son, lose her temper, or even yell at him. A worse but more likely scenario is that Diane gets exhausted day by day and inadvertently develops such a response as a routine one, as raising a child is well-known to be like having a job for 365 days a year without a holiday [5].

A number of guiding books and television programs substantiate wide parental demands for advice on how to resolve such conflicts with their children in a constructive way of interaction [2, 4, 5, 8, 9]. Importantly, parenting experts highlight that parents should be particularly careful about their nonverbal responses to their children, such as facial expressions, voice tones, and so on. Nonverbal responses are highly important in face-to-face interactions. It is reported that the nonverbal responses constitute 93% of the total

emotion conveyed [31]. Their importance is even greater in parent-child interaction since young children are surprisingly sensitive to their parents' frown, lifted eyebrows, particular voice tones, tenseness of the facial muscles, and so on [8, 9]. The mother's subtle frown, stern voice tone, or turning away from the child may make the child feel scared, frustrated, or even abandoned [8]. Unfortunately, many parents are not fully aware of such a high sensitivity of young children on nonverbal expressions and the potential severity it may lead to [9]. Even if they know, it is a nontrivial challenge to promptly control their life-long established ways of interaction at every moment of conflicts, requiring significant devotion and patience from the parents [7, 8, 17].

In this paper, we explore the design issues of "*I See You*", a mobile service to help parents resolve the moment of conflict with their child in a peaceful way. The key strategy of *I See You* is to enable the parents to instantly put themselves in the second-person's view, i.e., the child's view, at the moment of conflict. This second-person's view is triggered upon the pair-wise interaction cues that indicate the elevating conflicts. Through this strategy, *I See You* aims to facilitate the parents to be aware of their own subtle and momentary nonverbal cues as close as what are reflected on the child's eyes, and thereby to empathize with the emotion which the child may feel.

The strategy above is instantiated with a child-worn tiny camera [3, 13], a parent-worn mobile display [1], and an instant conflict detection system based on techniques recently proposed in the field of mobile affective/social computing [27, 33, 34, 36]. At a moment of conflict, the second-person view is streamed from the child-worn camera and projected in-situ through the parent-worn display. A supplementary archive called conflict diary is also provided for the parents to review the captured views, helping them retrospect

I See You is motivated and designed through an expert study involving psychotherapists. We consulted five psychotherapists to understand today's therapeutic practices and advice to help such parents smoothly resolve the conflict situations. Grounded on the study, we set forth the core features of *I See You* and design the *I See You* service and build its usage scenarios.

We deliver three major takeaway messages. 1) We bring forward the issue of commonly prevalent parent-child conflicts and the opportunity therein for mobile computing and human-computer interaction. 2) We propose a new service model to facilitate momentary self-awareness driven by second-person's view during on-going interaction, particularly focused on the nonverbal interaction behaviors. 3) We outline the potential roles of our service as a promoter towards the parents' in-situ empathy with their children's emotion and as a braker against further catastrophic development of the conflict.

2 BACKGROUND AND RELATED WORK

2.1 Parent-child Conflict in Psychology

Parenting strategies in the moment of parent-child conflict largely affect the child how to develop her ability to regulate emotions. Children learn from getting their demands rejected in conflicts with parents. Moreover, they also learn how to negotiate through communicating with their parents. This ability is one of the most important factors in building their lifelong styles of interacting with others [10, 24].

In fundamental, Parent Effectiveness Training (PET) highlights the importance of parents' styles, strategies, and attitudes as cornerstones towards smooth resolution of parent-child conflict. Originally developed by Thomas Gordon, PET is one of the most well established and highly regarded parent education programs, having been taken by millions of parents [8]. For successful practice of this method, Gordon categorizes the common problems in parent-to-child communicating styles into verbal and nonverbal aspects [8].

Verbal: It is advised to forbear from using languages that might hurt the child's self-esteem, such as ordering, nagging, criticizing, blaming, and interrogating. For example, *"You make me crazy!"*, *"You are wrong."*, or *"Stop complaining!"*.

Nonverbal: Aside from verbal messages, we deliver our emotions via nonverbal cues which constitute 93% of the total emotion conveyed in face-to-face interaction [31]. It is noted that children have higher sensitivity to nonverbal messages than adults.

2.2 Approach of Seeing Yourself through the Eyes of a Child

We discuss previous researches that inspired our key design approach: 1) seeing yourself, 2) through the eyes of a child. *Seeing yourself.* It has been studied since 1970s that self-observation would help people understand themselves, often being a good starting point for behavioral changes [6] and can be applied for behavior-change programs [11, 18, 28]. *Through the eyes of a child.* Exploratory works have been presented to understand the viewpoint of children [29, 35, 39]. Smith et al. demonstrated the differences of visual experience between parents and children by attaching cameras to their foreheads [35]. Marcu et al. [29] adopted a wearable camera for a child with autism, in order to help the parents better understand their autistic child's needs by seeing the world from the child's view.

2.3 Computer Supported Parenting

A number of experimental systems for computer-supported parenting have been proposed. Kientz et al proposed capture and archival systems for recording a child's developmental milestones to detect developmental delays of a child in advance [20, 21]. Hwang et al proposed children's group-context sensing systems to analyze individual child's differences in terms of cognitive and behavioral responses to the same stimuli [15, 16]. In the context of conflict, Yarosh et al proposed remote interaction systems for parents and children in families under spousal conflict, to facilitate them to share emotion and metaphorical touch experiences [37].

Recently, ubiquitously available mobile smart devices and experimental sensing technologies have been actively integrated to build in-situ parenting support services. Hernandez et al analyzed the electrodermal activity (EDA) as an indicator to ease of engagement during adult-child social interactions [12]. ParentGuardian [32] explores the use of EDA sensing to recognize the stress status of a parent with a child with Attention Deficit Hyper-activity Disorder (ADHD), offering in-situ instructions to calm down in accordance to behavioral therapy strategies. TalkBetter [17] proposes a mobile

ID	Clinical career (year)	Doctor-in-training history (year)	Patients' age (min, max)
E1	4	12	(0, 22)
E2	12	8	(1.5, 15)
E3	5	5	(0, 13)
E4	14	6	(1, 22)
E5	10	5	(2, 13)

Table 1: List of experts

in-situ intervention service for parents who have children with language delay; it monitors the meta-linguistic features in parent-child conversation and provides in-situ reminders so that parents can re-adjust their conversation styles straying from clinical guidelines. Zaturi extended the utilization of in-situ intervention services to not only real-time but also asynchronous parenting [19].

We share the comprehensive and long-term goal with those works listed above, i.e., helping parents develop desirable interaction styles for smooth parent-child interaction. A major difference in its design is that, unlike those works listed above providing a predefined set of specific instructions to the parents, *I See You* takes an open-ended, implicitly appealing strategy to the parents.

3 SERVICE DESIGN STUDY

In addition to the domain knowledge from the background study, we wanted to understand the field experiences from clinical professionals (See Table 1). In this section, we report the results of the interview with five domain experts. Based on them, we draw a core feature of *I See You* towards helping parents deal with conflict with their child in a more desirable way.

Procedure: We had individual consultation sessions with one pediatric psychiatrist and four developmental psychotherapists, and learned their own counselling cases. Each session lasted 30-60 minutes. We collected extensive episodes of parent-child conflict, in which we identified the key aggravating factors in terms of immediacy of interaction, discrepancy between the parent's and child's emotional perception, and underestimated severity of subtle nonverbal behaviors. These findings led to the key design considerations of I See You, in which we expect the momentarily triggered child's view upon them would help the parents intuitively grasp a clue towards empathy with the children in front of them.

3.1 Experts Counselling

The experts agreed that many parents including ones from their clinical experiences had similar difficulties to handle various conflict situations. They commented that they usually advised parents to follow the three-step process to resolve conflict peacefully as a commonly applicable strategy: 1) understanding and empathizing the child's emotions, 2) limiting the child's unacceptable behaviors, and 3) finding alternative behaviors which the child's needs can be met with and parents can accept at the same time. This strategy helps parents resolve conflict in a way to achieve mutually beneficial results. Also, following such a process helps the emotional development of children, the improvement of their self-esteem, and healthy parent-child relationship building [9, 24].

The experts stressed that parents needed to be careful about their interaction style including verbal and nonverbal interactions when they practice this strategy. Regarding verbal interaction, parents should not give expressions that blame, judge, or criticize their child without understanding and empathizing feelings and emotions of the child. Moreover, they need to avoid nonverbal messages such as frowning, threatening look, or yelling at their child. Also, parents should not deliver inconsistent messages between verbal and nonverbal expressions. Among different factors of interaction styles, parents should be very thoughtful about their nonverbal style of communication since nonverbal messages substantially contribute to conveying their emotions [7–9, 31]. The experts said that children whose language development was yet completed, but in progress were highly sensitive to nonverbal messages sent by their parents. E2 stated *"It's OK. (With a sigh) It's OK. Children never miss the difference between these two. They are very, very sensitive. Children have really keen senses. Absolutely keener than adults. Ability for thinking and verbal communication of adults has been developed much. So, they are sometimes unaware of it or they are just fine even though they recognize it."* E3 also stated; *"One example for a child I have been in charge. The mother said, 'I'm not angry', but anyone could tell she got angry. The child said, 'Mom, you get angry. Why did you say you didn't?' Children know if their mom gets angry or not."*

All the experts, however, commented that parents did not often recognize their inappropriate and undesirable nonverbal/verbal behaviors well while interacting with their child. Moreover, they pointed out nonverbal messages were often delivered unconsciously. E1 stated, *"They manage to control their verbal messages, but they fail to do self-regulation in terms of nonverbal messages."* It is hard for parents to be aware of and change their interaction styles that have been established and habituated for a long period of time.

According to the experts, parents often did not recognize that inappropriate nonverbal/verbal messages sent to their child unconsciously or consciously could have huge impact on the child. For young children, parents are like a god who has enormous power and means for satisfying children's needs [8]. Even small or subtle behaviors that parents might shrug aside can affect the feeling of children significantly. More importantly, if similar behavioral patterns are repeated over time, it can seriously damage the parent-child relationship and the child's self-esteem [8, 9, 24]. E2 stated *"It's sort of double message. You say this way, but your face says differently. In case that children accustom themselves to it and are too tired with it, they think their mother always does that way, and they cannot believe their mother even though their mother says I'm OK."* Also, E4 mentioned *"Ignoring messages from children, making a child feel that my mom doesn't listen to me, huffing and puffing of angry mom. They are all sort of punishment actually. (. . .) It could have a very short-term effect. Children might become obedient to their parents. But it cannot solve a problem fundamentally."*

4 I SEE YOU SERVICE

We explore the possibility of mobile service to help parents deal with conflict situations in a more desirable and peaceful way. From the expert interview and literature study, we understand that the parents' interaction style is one of important factors for smooth

conflict resolution. Also, many parents often do not know what effect their nonverbal or verbal messages delivered to their child may result in. As an initial effort, we propose a mobile service, *I See You* that aims at enabling parents to have self-awareness of their nonverbal messages undesirably sent to their child.

4.1 Concept: Seeing Yourself Through The Eyes of Your Child

A key concept of *I See You* is to see yourself through the eyes of your child. It is intended to make parents look at themselves from the view of second person. Inspired by the previous research [29], our intuition is that this might help parents understand what their child sees on their face and body, and empathize what their child feels and perceives from the nonverbal messages sent by them. Accordingly, if noticed properly, parents can change their inappropriate nonverbal expressions. It is well known that self-awareness is the very first step towards one's behavior change [6, 18].

As an early design to realize *I See You* , *I See You* captures nonverbal expressions, especially visual ones, from the perspective of the child by a wearable camera on the child in a parent-child conflict situation. The captured scenes are delivered to parents via a smart glass worn by them or an ambient display deployed at home. Figure 1 shows a conceptual diagram to describe four major functional components necessary to realize the *I See You* service. The service begins with interaction segmentation. It triggers the conflict detection component when it recognizes conversational interaction between a parent and a child. The conflict detection component tries to detect a conflict situation during the interaction by monitoring a range of conflict cues, e.g., crying of child and yelling. Upon detecting the conflict, it is initiated to capture a conflict scene through a child-worn camera and a parent-worn device. Then, the captured videos from the child's view are delivered and displayed to the parent's wearable device for immediate intervention. From these, the parent can be aware of his/her own nonverbal interaction style at the viewpoint of the child in real-time. The captured videos are stored so that the parent can review their past behavior for retrospection after the conflict situation.

4.2 Potential Technologies

We introduce potential technologies to realize *I See You* . Specific implementation may require additional engineering, and also it may differ depending on detailed design requirements, e.g., the specification of wearable devices, conflict situations of interest, preferred user interface, and so on.

Interaction segmentation: A number of mobile systems have been proposed to detect face-to-face interaction in everyday lives by using smartphones [27] and wearable badge-type devices [36]. Given the fact that interaction often begins when people starts to talk with one another, they usually discover nearby people by performing Bluetooth scans and detect voice activity by processing sound data. It is also possible to determine whether people are facing each other if infrared sensors are used as in [36].

Conflict detection: A parent-child conflict can occur due to a variety of reasons, e.g., different opinions and demands and proceed in different aspects. It is challenging and almost impossible to computationally model and cover all possible conflict situations. We focus on two representative patterns that may occur in parent-child conflict situations and address how to detect them. First, in conflict situations, parents often get angry and speak in a different tone of voice, rhythm, and pace than usual, e.g., with higher pitch and greater energy. The anger can be detected by analyzing speech signals and their prosodic features [33]. Second, children often express their emotion such as anger and frustration by crying. The crying can be detected by a similar way but with different features [34]. With recent advances in online voice assistant services, *I See You* could adopt verbal features by subscribing to online natural language classification modules [23] and further accelerating the response times for timely delivery of conflict cues [25, 26].

5 DISCUSSIONS

In this section, we discuss extended design considerations and limitations needed prior to implementing *I See You* , as well as further implications of the strategy of *I See You* beyond the specific settings focused so far.

Realtime Feedback: The feature of in-situ feedback may involve potential distraction issues from ongoing interactions. McAtamney et al. reported their concern and anticipation based on their study with wearable glasses in face-to-face conversation, such as initial disruption but eventual adaptation along prolonged usage [30]. Crafting the interface design how to deliver the feedback may also mitigate the distraction. We can also employ an ambient display to avoid the disruption of conversation. Kim et al. showed that realtime feedback via ambient displays did not disrupt meeting situations [22].

Capturing the True and Clear View: Due to the limitation of chest-worn camera, there are chances that the child's sight and the child-worn camera's sight are not well aligned. Even if the camera is facing the parent, still the camera may not capture the whole picture of the parents due to its limited angle-of-view. SenseCam addresses this problem by attaching a fisheye lens to a camera [13]. Distortion caused by the fisheye lens can be restored using image processing techniques [14]. The child's movements and low ambient luminosity may degrade the quality of captured images. We can filter out these images as in FaceLog [38], but it risks loss of important moments. Eventually, designing a new capturing device with child-friendly wearability ensuring reliable angle and quality would be an important future work.

Cultural and Developmental Diversity: Since different cultures have different parenting styles, applying *I See You* to families with different cultural background would require new study on the service acceptance and additional design tuning specific to that culture. Even in the same cultural group, the major parenting disciplines may change over time; for example corporal punishment was considered necessary in the U.S. in 1970s but is no longer accepted [8]. Other than culture, extending *I See You* towards older children or adolescents requires multi-lateral consideration, mainly due to much more external factors influencing the conflict such as friendship, family financial issues, and so on. As the child develops higher language skills, the role of nonverbal emotion transfer may not be as influential as before. Still, we believe that emotional empathy with the child would be a primitive element that most parents seek in common.

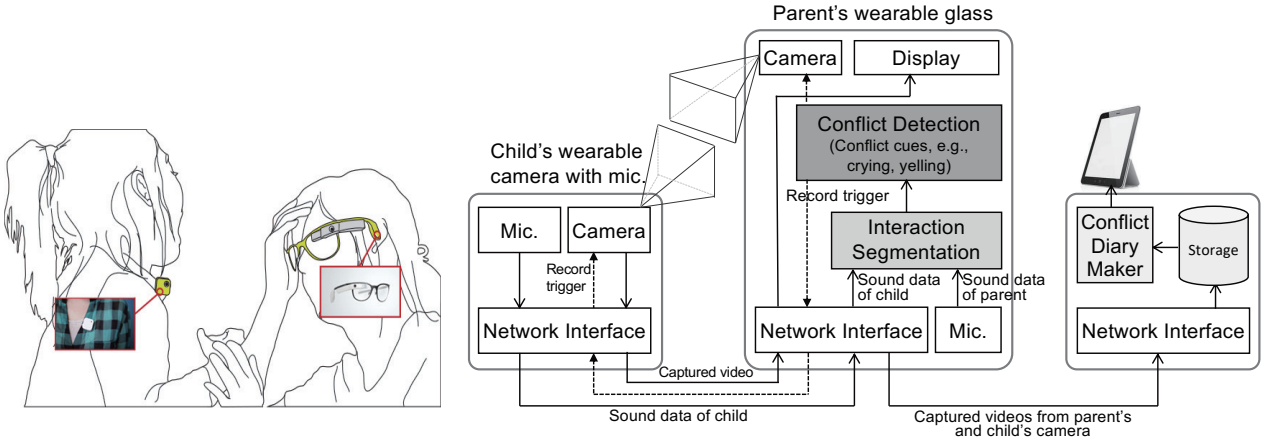

Figure 1: Flow of *I See You* . (Left) wearable devices for *I See You* . (Right) conceptual diagram of *I See You* system.

Privacy Concern: Recording the video inherently raises privacy concerns. Optimistically, such concerns may be mitigated if the service provides sufficient utility. Carrying wearable cameras in daily life could raise greater or different privacy concerns than expectation [13]. These observations necessitate protection mechanisms and selective recording features.

6 CONCLUSION

In this paper, we bring forward the prevalent issue of parent-child conflicts and the opportunity therein for mobile computing and human-computer interaction. We presented design study to comprehend the presence and severity of parent-child conflicts in daily life, and understand today's therapeutic practices. Based on the study, we proposed *I See You* , a mobile service to help parents for peaceful conflict resolution, and set forth its core features.

7 ACKNOWLEDGEMENTS

This research was supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT (2017R1A2B3010504, 2017M3C4A7065963)

REFERENCES

[1] Google glass. https://x.company/glass/.
[2] Nanny 911. http://www.tv.com/shows/nanny-911/.
[3] Narrative. http://getnarrative.com.
[4] Super nanny. http://www.supernanny.co.uk.
[5] F. Dodson. *How to Parent.* Signet Book, 1971.
[6] B. J. Fogg. Persuasive technology: Using computers to change what we think and do. *Ubiquity*, 2002(December), Dec. 2002.
[7] T. Gordon. *Teacher Effectiveness Training.* Crown Publishers, 1975.
[8] T. Gordon. *Parent effectiveness training: The proven program for raising responsible children.* Harmony, 2008.
[9] J. Gottman. *Raising an emotionally intelligent child.* Simon and Schuster, 2011.
[10] J. M. Gottman, L. F. Katz, and C. Hooven. Parental meta-emotion philosophy and the emotional life of families: Theoretical models and preliminary data. *Journal of Family Psychology*, 10(3):243–268, 1996.
[11] A. Hackmann, C. Surawy, and D. M. Clark. Seeing yourself through others' eyes: A study of spontaneously occurring images in social phobia. *Behavioural and Cognitive Psychotherapy*, 26(1):3–12, 1998.
[12] J. Hernandez, I. Riobo, A. Rozga, G. D. Abowd, and R. W. Picard. Using electrodermal activity to recognize ease of engagement in children during social interactions. In *Proceedings of the 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, UbiComp '14, pages 307–317, New York, NY, USA, 2014. ACM.
[13] S. Hodges, L. Williams, E. Berry, S. Izadi, J. Srinivasan, A. Butler, G. Smyth, N. Kapur, and K. Wood. Sensecam: A retrospective memory aid. In *Proceedings of the 8th International Conference on Ubiquitous Computing*, UbiComp'06, pages 177–193, Berlin, Heidelberg, 2006. Springer-Verlag.
[14] P. Hu, G. Shen, L. Li, and D. Lu. Viri: View it right. In *Proceeding of the 11th Annual International Conference on Mobile Systems, Applications, and Services*, MobiSys '13, pages 277–290, New York, NY, USA, 2013. ACM.
[15] I. Hwang, H. Jang, L. Nachman, and J. Song. Exploring inter-child behavioral relativity in a shared social environment: a field study in a kindergarten. In *Proceedings of the 12th ACM international conference on Ubiquitous computing*, pages 271–280. ACM, 2010.
[16] I. Hwang, H. Jang, T. Park, A. Choi, Y. Lee, C. Hwang, Y. Choi, L. Nachman, and J. Song. Leveraging children's behavioral distribution and singularities in new interactive environments: Study in kindergarten field trips. In *International Conference on Pervasive Computing*, pages 39–56. Springer, 2012.
[17] I. Hwang, C. Yoo, C. Hwang, D. Yim, Y. Lee, C. Min, J. Kim, and J. Song. Talkbetter: Family-driven mobile intervention care for children with language delay. In *Proceedings of the 17th ACM Conference on Computer Supported Cooperative Work & Social Computing*, CSCW '14, pages 1283–1296, New York, NY, USA, 2014. ACM.
[18] S. M. Johnson and G. White. Self-observation as an agent of behavioral change. *Behavior Therapy*, 2(4):488 – 497, 1971.
[19] B. Kang, C. Min, W. Kim, I. Hwang, C. Park, S. Lee, S.-J. Lee, and J. Song. Zaturi: We put together the 25th hour for you. create a book for your baby. In *Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing*, pages 1850–1863. ACM, 2017.
[20] J. A. Kientz, R. I. Arriaga, and G. D. Abowd. Baby steps: Evaluation of a system to support record-keeping for parents of young children. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '09, pages 1713–1722, New York, NY, USA, 2009. ACM.
[21] J. A. Kientz, R. I. Arriaga, M. Chetty, G. R. Hayes, J. Richardson, S. N. Patel, and G. D. Abowd. Grow and know: Understanding record-keeping needs for tracking the development of young children. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '07, pages 1351–1360, New York, NY, USA, 2007. ACM.
[22] T. Kim, A. Chang, L. Holland, and A. S. Pentland. Meeting mediator: Enhancing group collaborationusing sociometric feedback. In *Proceedings of the 2008 ACM Conference on Computer Supported Cooperative Work*, CSCW '08, pages 457–466, New York, NY, USA, 2008. ACM.
[23] Y. Kim. Convolutional neural networks for sentence classification. *arXiv preprint arXiv:1408.5882*, 2014.
[24] D. J. Laible and R. A. Thompson. Mother-child conflict in the toddler years: Lessons in emotion, morality, and relationships. *Child Development*, 73(4):1187–1203, 2002.
[25] J. Lee, I. Hwang, T. Hubregtsen, A. E. Gattiker, and C. M. Durham. Sci-fii: Speculative conversational interface framework for incremental inference on modularized services. In *2017 18th IEEE International Conference on Mobile Data Management (MDM)*, pages 278–285. IEEE, 2017.

[26] J. Lee, I. Hwang, T. S. Hubregtsen, A. E. Gattiker, and C. M. Durham. Accelerating conversational agents built with off-the-shelf modularized services. *IEEE Pervasive Computing*, 18(2), 2019.

[27] Y. Lee, C. Min, C. Hwang, J. Lee, I. Hwang, Y. Ju, C. Yoo, M. Moon, U. Lee, and J. Song. Sociophone: Everyday face-to-face interaction monitoring platform using multi-phone sensor fusion. In *Proceeding of the 11th Annual International Conference on Mobile Systems, Applications, and Services*, MobiSys '13, pages 375–388, New York, NY, USA, 2013. ACM.

[28] Y. H. Li and N. Tottenham. Seeing yourself helps you see others. *Emotion*, 11(5):1235–1241, 2011.

[29] G. Marcu, A. K. Dey, and S. Kiesler. Parent-driven use of wearable cameras for autism support: A field study with families. In *Proceedings of the 2012 ACM Conference on Ubiquitous Computing*, UbiComp '12, pages 401–410, New York, NY, USA, 2012. ACM.

[30] G. McAtamney and C. Parker. An examination of the effects of a wearable display on informal face-to-face communication. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '06, pages 45–54, New York, NY, USA, 2006. ACM.

[31] A. Mehrabian et al. *Silent messages*, volume 8. Wadsworth Belmont, CA, 1971.

[32] L. Pina, K. Rowan, A. Roseway, P. Johns, G. R. Hayes, and M. Czerwinski. In situ cues for adhd parenting strategies using mobile technology. In *Proceedings of the 8th International Conference on Pervasive Computing Technologies for Healthcare*, PervasiveHealth '14, pages 17–24, ICST, Brussels, Belgium, Belgium, 2014. ICST (Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering).

[33] K. K. Rachuri, M. Musolesi, C. Mascolo, P. J. Rentfrow, C. Longworth, and A. Aucinas. Emotionsense: A mobile phones based adaptive platform for experimental social psychology research. In *Proceedings of the 12th ACM International Conference on Ubiquitous Computing*, UbiComp '10, pages 281–290, New York, NY, USA, 2010. ACM.

[34] P. Ruvolo and J. Movellan. Automatic cry detection in early childhood education settings. In *2008 7th IEEE International Conference on Development and Learning*, pages 204–208, Aug 2008.

[35] L. B. Smith, C. Yu, and A. F. Pereira. Not your mother's view: the dynamics of toddler visual experience. *Developmental Science*, 14(1):9–17, 2011.

[36] L. Wu, B. N. Waber, S. Aral, E. Brynjolfsson, and A. Pentland. Mining face-to-face interaction networks using sociometric badges: Predicting productivity in an it configuration task. In *International Conference on Information Systems*, page 127, 01 2008.

[37] S. Yarosh, A. Tang, S. Mokashi, and G. D. Abowd. "almost touching": Parent-child remote communication using the sharetable system. In *Proceedings of the 2013 Conference on Computer Supported Cooperative Work*, CSCW '13, pages 181–192, New York, NY, USA, 2013. ACM.

[38] C. Yoo, J. Shin, I. Hwang, and J. Song. Facelog: Capturing user's everyday face using mobile devices. In *Proceedings of the 2013 ACM Conference on Pervasive and Ubiquitous Computing Adjunct Publication*, UbiComp '13 Adjunct, pages 163–166, New York, NY, USA, 2013. ACM.

[39] H. Yoshida and L. B. Smith. What's in view for toddlers? using a head camera to study visual experience. *Infancy*, 13(3):229–248, 2008. PMID: 20585411.