TalkingBoogie: Collaborative Mobile AAC System for Non-verbal Children with Developmental Disabilities and Their Caregivers

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AAC (Augmentative and Alternative Communication)

AAC display

Clicks “apple” symbol

TTS

(Text-to-speech technology)

APPLE!

AAC technologies/methods are widely used to help **non-verbal children** enable **communication**

Stakeholders of AAC

Child, for sure..

SLP (Speech-language pathologists)

Parents

Teachers

Collaboration between caregivers around the child is considered essential!

(Bailey et al., 2006)

Why caregiver collaboration is important?

Sharing observations on child with each other

→

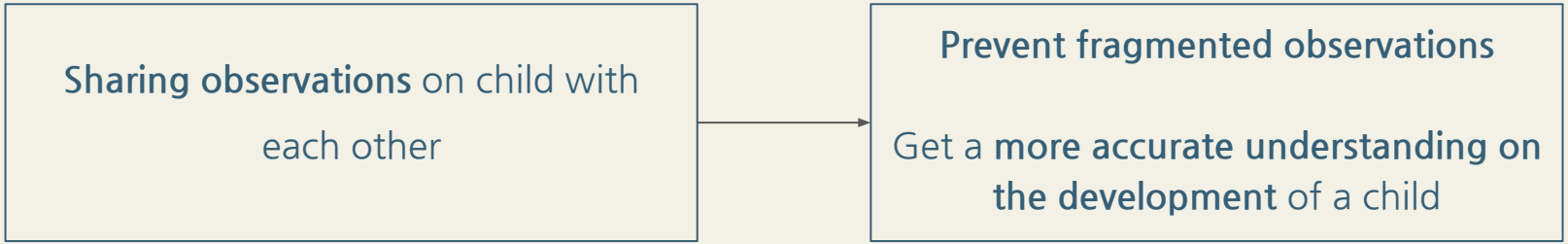
Prevent fragmented observations

Get a **more accurate understanding on the development** of a child

Donghoon now understands definition of “Play” in school!

Wow! Then I should do some activities with him to fully utilize it at home!

Why caregiver collaboration is important?



Nevertheless…

- Caregivers often find it **challenging** to **effectively share observations and achieve a consensus**
- To the best of our knowledge, there is **no AAC device** that **provides support for caregivers to effectively collaborate** with each other

(Alant, 2013; Parette et al., 2001; Stoner et al., 2010)

Our research direction

Focus on supporting **collaboration between closer and long-lasting caregivers**, such as **teachers or parents**

- Allow a **more sustainable approach** to address the limited transfer of skills from therapy to **daily life** (Espe-Sherwindt, 2018; Starble et al., 2005)

Preliminary study

Interview with parents & teachers

We conducted a series of **interviews** with parent and teacher groups of children with non-verbal developmental disabilities.

Interviews were on the following topic areas:

- **Reports over the current use of AAC** (or communicative aid) of a child
- **Self-reported role** in collaboration among **caregivers**
- **Factors that undermine successful collaboration** for the child's use of AAC
- Each caregiver's **methods of dealing with a child's communication issues**

Each had an experience of AAC methods. Results are open-coded with iterative clustering.

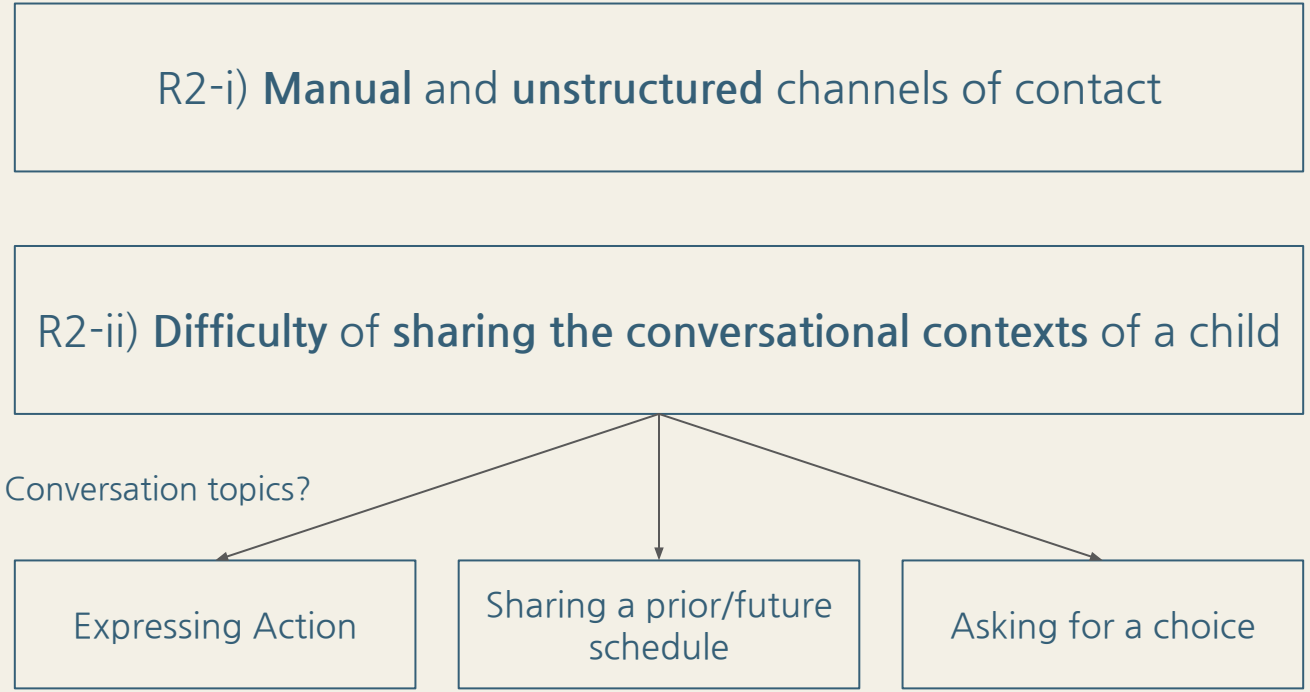
Result 1: Impediments to a balanced participation

R1-i) **Difficulty** of assisting a child to express idea with **AAC**

R1-ii) **Preference for nuanced information** on resolving child's communication issues

R1-iii) **Underestimating** the **significance of sharing observations** of a child and **discussing** them

Result 2: Inefficient process of collaboration

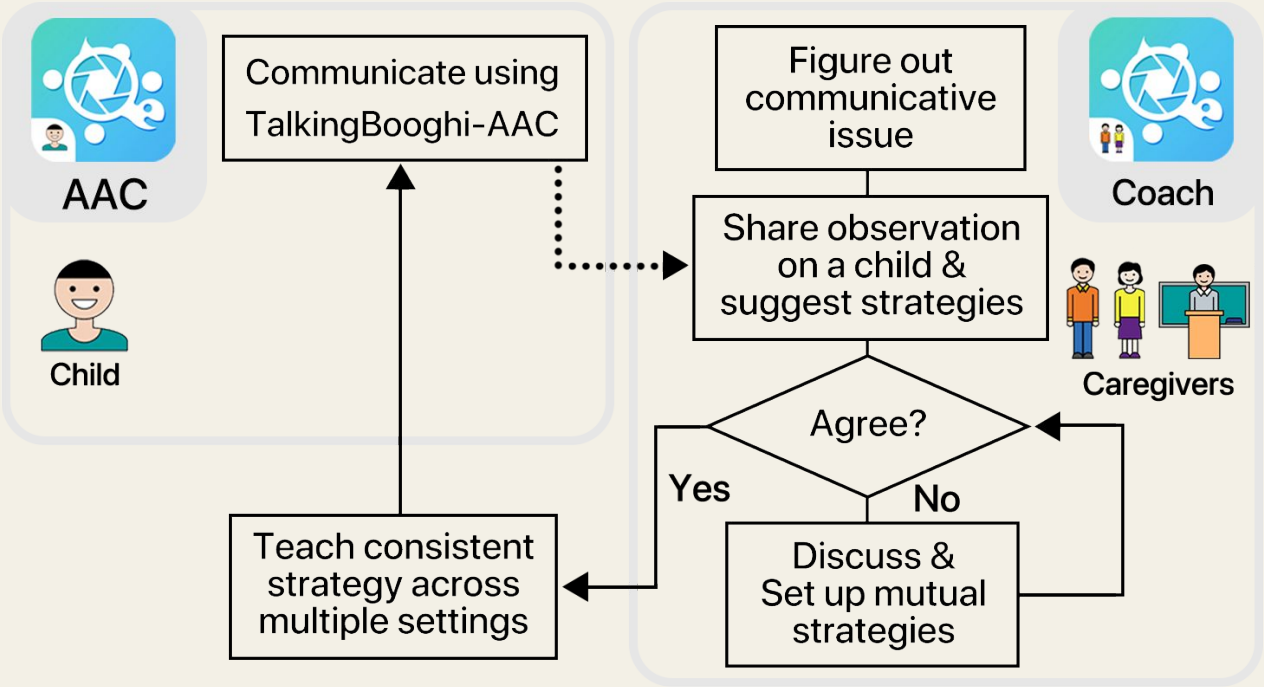


Design implications

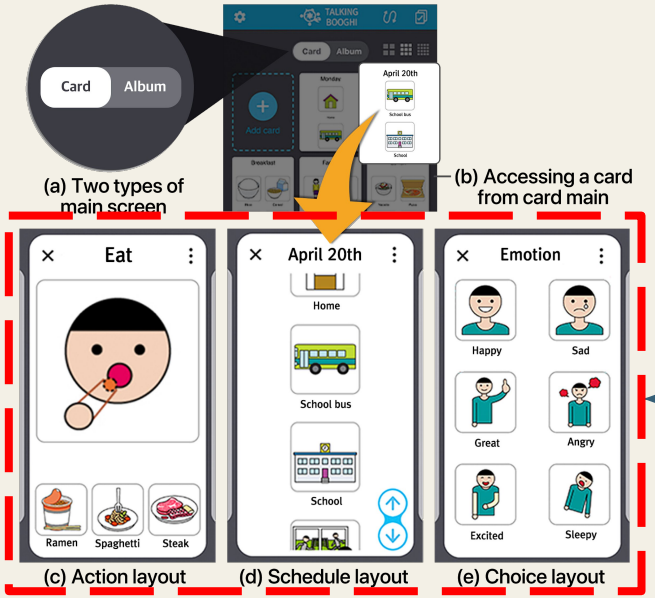
- A system should **scaffold** the process of **sharing observations** and **calibrating different opinions** for caregivers.
- A system should **induce the balanced participation** of caregivers.
- **Consistent and contextualized formats** for **symbol arrangement** might help collaboration among caregivers.

Design

Structure of system

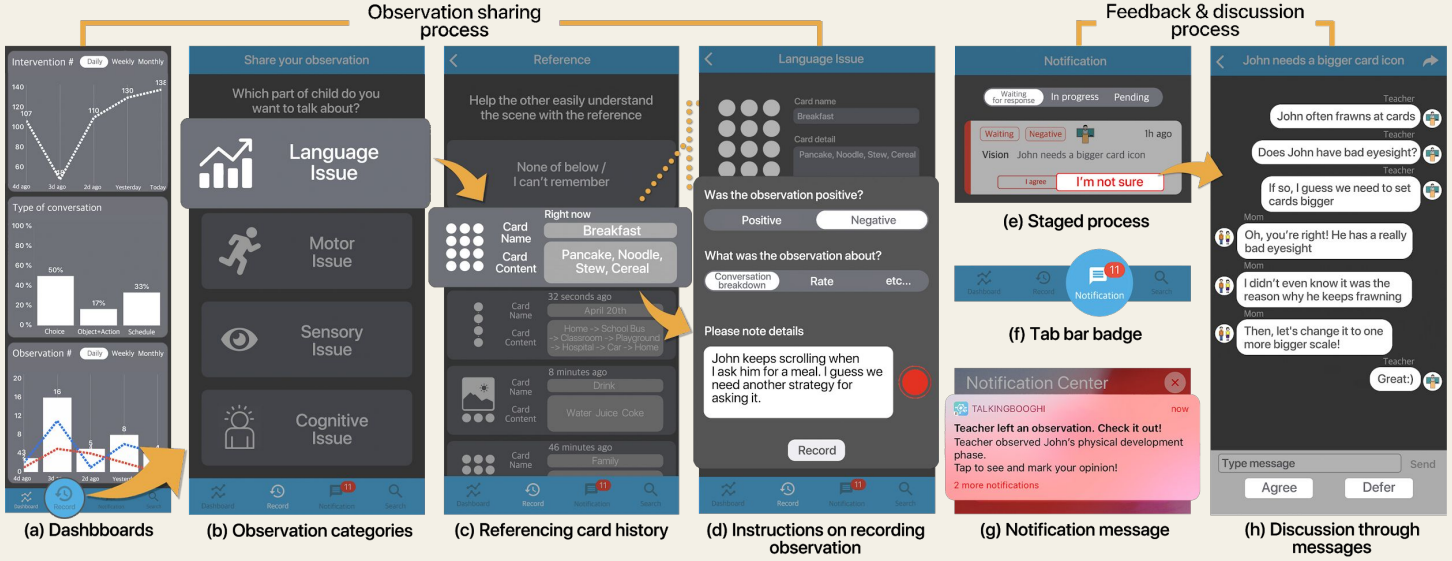


Design of TalkingBoogie-AAC



- **Existing AAC systems** require users to **construct sentences by arranging symbols by themselves**, reported to burden caregivers guiding children as well as the children.
- Furthermore, **caregivers lack** a consistent way to **reference a specific scene of conversation** with a child when discussing it with others.
- TalkingBoogie-AAC tackles these issues by extending the existing AAC with **predefined layouts** for arranging symbols

Design of TalkingBoogie-Coach

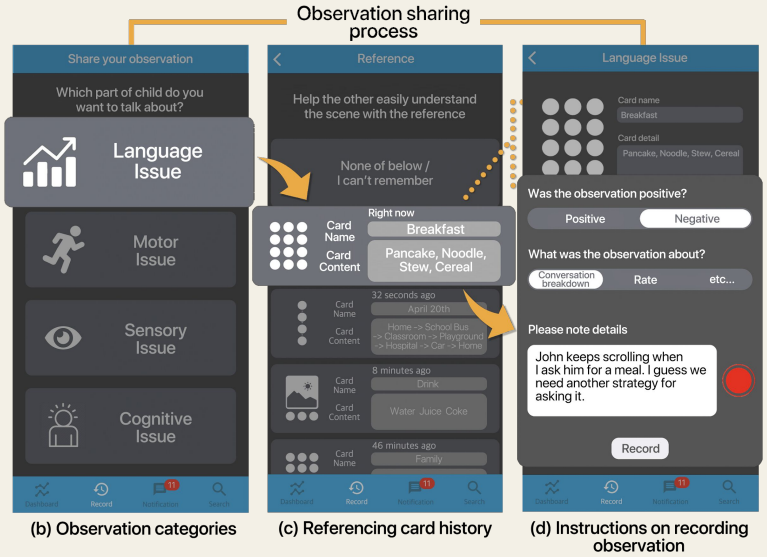


We designed a **collaborative system** that **scaffolds** the process of **sharing observations** and **calibrating opinions**, while at the same time **induces balanced participation**.

Design of TalkingBoogie-Coach

Recording observations

- The **template** informs a caregiver to first **clarify the type of observation** among four categories: **language, motor, sensory, and cognitive** observations (Figure 5b)
- Reference child's specific conversation scene (Figure 5c) *
- Filling out pre-defined templates is needed, which acts as **guidelines of recording notes**



Design of TalkingBoogie-Coach

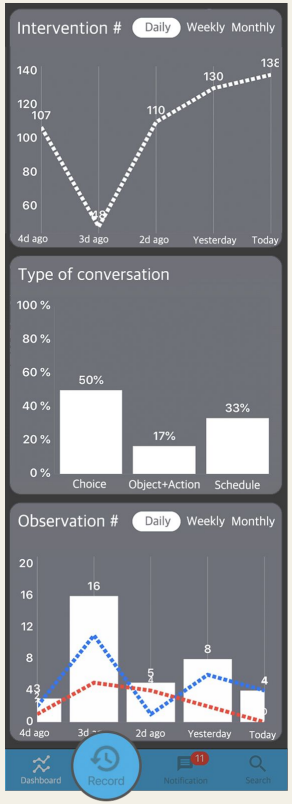
Resolving an issue

- The records are **classified** into four stages: **waiting for a response, in progress, pending, and verified** (Figure 5e)
- Being **notified** of updates, the other caregiver can give **feedback** on the record by selecting either **I'm not sure** or **I agree** (Figure 5e~g)
- Caregivers may **discuss observations** and employ strategies until they **reach a consensus** and convert its state to ***verified*** (Figure 5h)

Design of TalkingBoogie-Coach

Reviewing the overall activity

- For AAC intervention to be successful, caregivers should **continuously observe and support the child** (Gona et al., 2014)
- TalkingBoogie-Coach **tracks the data of cards** that were accessed in TalkingBoogie-AAC **and participation of caregivers**, of which later visualized in the dashboard (Figure 5a)



(a) Dashbboards

Design

Implementation of TalkingBoogie system

System Implementation

- Both TalkingBoogie-AAC and TalkingBoogie-Coach were implemented on the **iOS** deivces
- The usage log and caregiver strategies logs are uploaded to a Firebase server

Miscellaneous

- To ensure privacy when collecting user data, every data is uploaded on the server with an **anonymous identifier**
- We adopted an **Ewha AAC symbol system**, Korean-based symbol illustrations (Park et al., 2016), for our symbol display in order to support children in delivering region-specific ideas

Evaluation

2-week deployment study

To identify if our system successfully reflected the design implications, we ran a **two-week deployment study** with **four target groups** (each including one child with developmental disabilities, one parent, and one teacher)

- **Demographics (of child)**: 7~13y, diagnosed with ASD or (and) PDD-NOS

Group ID	Child age (Gender)	Child Diagnosis	Child's Communicative Mode (experience)	Role	Description / AAC experience
G1*	8 (M)	PDD-NOS	Low-tech AAC (Symbol boards) + Tablet AAC app	Child	Skilled at using smart devices
				Parent	1y
				Teacher	4y
G2*	9 (M)	Autism Spectrum Disorder	Low-tech AAC (Symbol boards) + Tablet AAC app	Child	Low hand motor ability
				Parent	6m
G3	13 (F)	Autism Spectrum Disorder	Non-aided AAC (Gesture)	Child	Low hand motor ability
				Parent	3y
				Teacher	6y
G4	7 (F)	PDD-NOS	Non-aided AAC (Gesture) + Mobile AAC app	Child	-
				Parent	1y
				Teacher	3y

Table 1. Participants of the evaluation *A single teacher (G1/2-T) participated in G1 and G2 at the same period

Evaluation

Recruitment

1. We **recruited teachers** of non-verbal children by delivering our experiment documents to the **local special-education schools**.
2. Then we **asked parents** of children, whose teachers showed intention to participate, to join the experiment.
3. Four groups (with two groups whose teacher were the same) were recruited

Of course, the whole procedure was THOROUGHLY reviewed and approved by IRB!!!

Evaluation procedure

Pre-evaluation

We offered an iPhone 7 device and manual for each participant
Each caregiver was asked to fill out NASA-TLX based survey on current workload

During evaluation

For each setting, participants were asked to freely use our system as manual
Each caregiver was asked to fill out a survey every 4 days

Post-evaluation

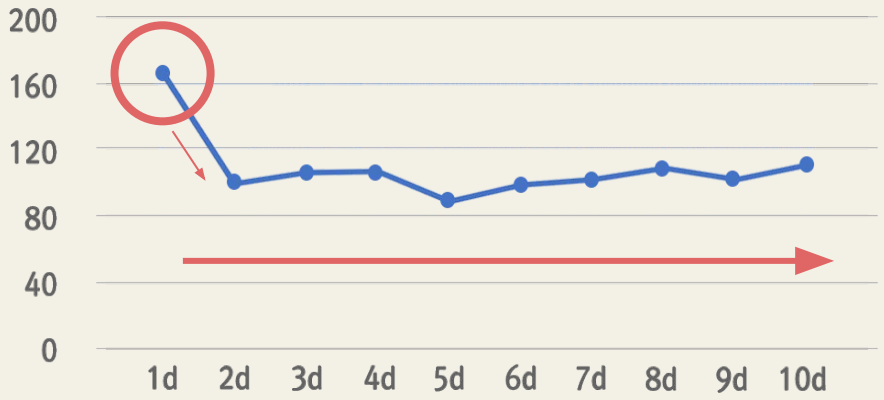
Each caregiver was asked to fill out a survey on the overall workload

Evaluation

Result: Overall usage pattern of TalkingBoogie-AAC

- **At first, the usage frequency was the highest,** then stabilized
  → Because caregivers had to **configure cards**

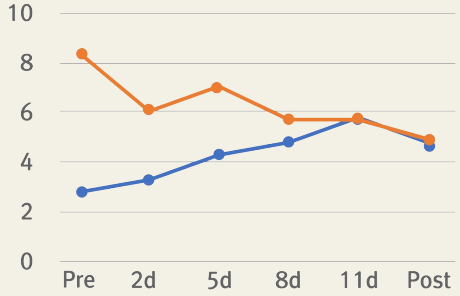
- Usage was **stable** after then, **without any significant drop**
  → **Continuous usage without abandonment**



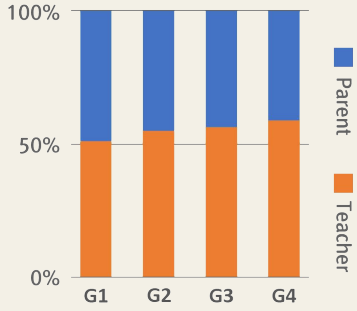
Result: Balancing the participation of caregivers

- The **participation ratio of parents** showed a **significant increase** ($t = -2.954$, $p < .05$) from 27.5% on average to 47.5%
- In contrast, the participation rate reported by **teachers significantly decreased** ($t = 3.889$, $p < .05$) from 83.3% on average to 48.9%

> *"I was a bit surprised that the parent was eager to participate in because I taught and prepared every strategy for G4-P before I started the experiment." (G4-T)*



(a) Workload perception change



(b) Ratio of sharing observation

Result: Balancing the participation of caregivers

What attributed to these results - 1: **Self-reflective participation**

- Two responded that **reviewing their previous contributions** with the **dashboard** in TalkingBoogie-Coach helped them **avoid falling into mannerisms**
- For instance, **visualizing** changes in the number of negative observations **prevented a parent from overlooking any difficulties**

> *"I realized myself having been habitually overlooking certain communication issues. It became clear to me that something should be done when I saw a clear increase in the number of negative observations." (G2-P)*

Result: Balancing the participation of caregivers

What attributed to these results - 2: **Increase in mutual awareness**

- Three out of four parents responded they were **motivated when identifying the active participation of the teacher**
- **Explicit visualization of the usage history in the dashboard** was a major source of seeing the participation of the counterpart, and **created mutual influence** between caregivers.

> *"Whenever I could see from the graph that the teacher had left new observations, I also began to think that I should also record some more." (G1-P)*

> *"The notifications and dashboard clearly imprinted on my mind that I was not doing this alone but together with the teacher, which made me more willing to participate." (G3-P)*

Result: Balancing the participation of caregivers

What attributed to these results - 2: **Clear identification of the effects of interventions**

- By **recording and discussing** the observations in a **partly uniform way**, caregivers could easily **review and search previous activities** with the help of TalkingBoogie-Coach
- Through **discussing each observation** in a separate thread, the **effects of strategies** in the communicative abilities of the child could be **clearly identified**, acting as a powerful stimulus

> *"Before, I had so little knowledge that I had no idea what to do . . . my child started to get used to the day concept with the 'day of the week' card . . . I could get clear insights on what I should do, which in turn let me more actively participate." (G2-P)*

Evaluation

Result: Effectiveness of TalkingBoogie symbol layouts

Report 1: **Ease of teaching sentence construction**

- The three layouts for **symbol arrangement** in TalkingBoogie-AAC not only act as a **guide for parents**, but also **prevent misunderstandings** among caregivers that arise from inconsistency when referring to a certain conversation
- Both parents (pre: 2.25, post: 5.75, $t = -2.898$, $p < .05$) and teachers (pre: 4.33, post: 8.00, $t = -11.000$, $p < .05$) reported a **significant increase in the ease of teaching sentence construction**

> *"It was hard to help my child express action concepts before, because a verb was a vague concept for her . . . In action layout, the verb is shown larger than others, so I could easily induce the child to focus more on and understand the concept." (G4-T)*

Result: Effectiveness of TalkingBoogie symbol layouts

Report 2: **Consistent and contextualized reference**

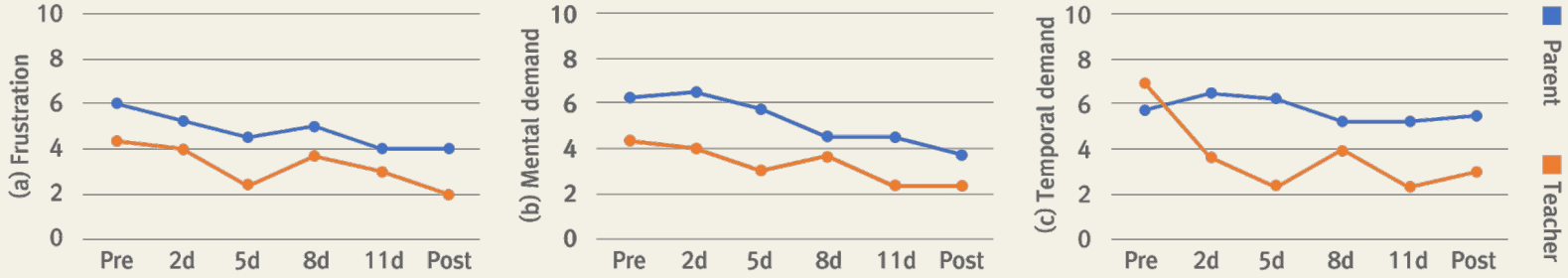
- Based on the **mutual awareness of the layouts**, caregivers could easily **refer to a specific situation** while discussing it with each other
- By including the actual trace of the behavior, the caregivers were able to **clearly convey the context**, which helped to r**educe misunderstandings** and ultimately their **burden of resolving those misunderstandings** one-by-one

> *"It was hard for me to remember every single detail to share. . . . TalkingBoogie-Coach showing the history of conversations with my child helped me easily recall the situation." (G1-P)*

Evaluation

Result: Scaffolding the process of sharing and discussing observations

Decrease in NASA-TLX indices



- **Mental demands**: 5.43 (SD = 1.81) → 3.14 (SD = 1.46), ($t = 2.596$, $p < .05$ *)
- **Temporal demands**: 6.29 (SD = 1.80) → 4.43 (SD = 2.23), ($t = 1.717$, $p > .05$)
- **Frustration level**: 5.29 (SD = 2.21) → 3.14 (SD = 2.34), ($t = 1.760$, $p > .05$)

Evaluation

Result: Scaffolding the process of sharing and discussing observations

What attributed to these results: **1. Increased understanding of what to observe and record**

- Recording observations using TalkingBoogie-Coach was helpful to **keep parents aware of the significance of observations**, providing guidance on what to observe and how to record it
- The template for observation in TalkingBoogie-Coach guided the caregivers to **enrich the content of the records**

> *"I used to check only the language abilities of the child, but now I also check many other aspects such as physical abilities. I realized her hand movements have improved a lot." (G3-P)*

> *"In order to write observations precisely based on the lists of the template I have to check when leaving an observation, I get closer and interact more with the child." (G3-T)*

Evaluation

Result: Scaffolding the process of sharing and discussing observations

What attributed to these results: **1. Increased understanding of what to observe and record**

- Meanwhile, G2-P wanted to **remove the sensory issue among the four categories** of observations, since her son did not have any sensory problems
- This suggests the need for **offering further personalizing features**

Result: Scaffolding the process of sharing and discussing observations

What attributed to these results: **2. Efficiency of the process of collaboration**

- By following the process in TalkingBoogie-Coach, caregivers were able to **reduce inefficiencies**
- TalkingBoogie-Coach syncs with TalkingBoogie-AAC, provides a **formulaic template for recording observations**, and supports a **staged discussion** where there is a separate communication channel for each issue

> *"The overall process became more efficient in that using AAC itself, observations, and discussion channels could be all seamlessly connected to one another." (G3-T)*

Evaluation

Result: Scaffolding the process of sharing and discussing observations

What attributed to these results: **2. Efficiency of the process of collaboration**

- At the same time, two parents (G1-P, G3-P) reported that some **education-specific wordings** (e.g. strategy, intervention) both in the system and during the conversation made the **collaboration less efficient**
- They cited that it would be much better if the words were **unwrapped enough to be understood**

Result: Scaffolding the process of sharing and discussing observations

What attributed to these results: **3. Increased level of consensus**

- Six caregivers showed a clear increase in their level of agreement over the intervention strategies
- **Consensus level**: 5.57 → 7 ($t = -1.987$, $p < .05$ *)

> *"The child (G2) sometimes keeps clicking a symbol of a cup. I asked his mom, and she shared that he clicks it when he doesn't want to drink milk with a straw . . . I created a 'drink → straw, cup' card in action layout for him." (G1,2-T)*

Evaluation

Result: Scaffolding the process of sharing and discussing observations

What attributed to these results: **3. Increased level of consensus**

- As **observations** of the teachers and parents are respectively **confined to certain settings**, they were knowledgeable about **only a fraction** of the communication of the child
- By **sharing** their knowledge thoroughly using TalkingBoogie-Coach, caregivers were able to learn about the behaviors of **the child in various settings** that they were previously unaware of

> *"The child (G2) sometimes keeps clicking a symbol of a cup. I asked his mom, and she shared that he clicks it when he doesn't want to drink milk with a straw . . . I created a 'drink → straw, cup' card in action layout for him." (G1,2-T)*

Discussion

1. Recognizing a child's communicative competence

What is communicative competence?

- Proposed by Janice Light (1989)
- Indicates "**dynamic interpersonal construct**" based on functionality of communication

Then, what is an issue?

- Ibrahim et al. reported that **caregivers' low expectation** on a child **limits the development of communicative competence** (2018)

Discussion

1. Recognizing a child's communicative competence

Enhancing the perception on children

- We received several reports of **caregivers** trying to **explore a communicative competence** and **help children develop it with the counterpart**
    - EX) G4-T reported that she used to **discipline the child for making noises**, which later found out to be talking about TV programs by **drawing attention** through TalkingBoogie-Coach
    - TalkingBoogie-Coach directly and indirectly helped caregivers **realize that the communicative abilities** of a child are not static but **developing**

Discussion

2. Extension to diverse caregivers

Our research limitation: Every participant was mother / female teachers

- Why?
  - Due to cultural influences, particularly in South Korea, holding mothers mostly responsible for childcare (OECD, 2015)
- Then?
  - Our system didn't consider any gender-specific traits
  - Thus, we believe that TalkingBoogie can be **extended to support caregivers other than mothers** and teachers (e.g., stay-at-home fathers)

Discussion

2. Extension to diverse caregivers

What if family members are still disregarded while using TalkingBoogie?

- Solution
  - One possible approach is to make the participation of **long-lasting caregivers** as a **requirement** for the system to **proceed to the next stage**
  - By assigning **different weights** for each caregiver when discussing the intervention strategies, it would be possible to **strengthen family members as equivalent decision-makers**

Discussion

3. Caregiver in charge of multiple children

- In classroom settings, it is **common for special education teachers** to **take care of multiple children** with special needs at the same time

  → Tackled this issue by asking **G1,2-T** to use TalkingBoogie with **two children** with **different levels of communication** in the **same environment**

Discussion

3. Caregiver in charge of multiple children

- Identified issue
  - G/2-T reported that she sometimes **confused one child from another** and even **left observations about the other child for once**
- Possible solution
  - May be possible **to extend the 'search' section** to **allow caregivers to integratively search among records about each child**
  - Future designs may focus on **increasing the visibility of the information of a child** to **prevent confusion**

Limitation of our research

- Small number of participants
  - **Extreme difficulty of recruitment** that is known as a prevalent issue in AAC research (Light & McNaughton, 2015)
- Short period of evaluation
  - Evaluating TalkingBoogie for a **longer period of time** may be needed in terms of **generalizability**

Future work

- **Data-driven evaluation**
  - **Distribute app** in the App Store
  - Ask for a consent & **collects each user's disability data**
  - Collects **clickstream / duration-of-screen** data
  - Using ANOVA / Tukey-HSD, compare each group

References

- Janice Light, David Beukelman, and Joe Reichle. 2003. Communicative Competence for Individuals who Use AAC: From Research to Effective Practice. Brookes Publishing Company.
- Rita L. Bailey, Julie B. Stoner, Howard P. Parette, and Maureen E. Angell. 2006. AAC Team Perceptions: Augmentative and Alternative Communication Device Use. Education and Training in Developmental Disabilities 41, 2 (2006), 139-154.
- Seokwoo Song, Juho Kim, Bumsoo Kang, Wonjeong Park, and John Kim. 2018. BebeCODE: Collaborative Child Development Tracking System. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). Association for Computing Machinery, New York, NY, USA, Article Paper 540, 12 pages.
- Erna Alant, Annette Champion, and Erin Colone Peabody. 2013. Exploring Interagency Collaboration in AAC Intervention. Communication Disorders Quarterly 34, 3 (2013), 172-183.
- Howard P. Parette, Mary Blake Huer, and Mary Jane Brotherson. 2001. Related Service Personnel Perceptions of Team AAC Decision-Making Across Cultures. Education and Training in Mental Retardation and Developmental Disabilities 36, 1 (2001), 69-82.
- Julia B. Stoner, Maureen E. Angell, and Rita L. Bailey. 2010. Implementing Augmentative and Alternative Communication in Inclusive Educational Settings: A Case Study. Augmentative and Alternative Communication 26, 2 (2010), 122-135.
- Marilyn Espe-Sherwindt. 2008. Family-centred practice: collaboration, competency and evidence. Support for Learning 23, 3 (2008), 136-143.

References

- Amy Starble, Tiffany Hutchins, Mary Alice Favro, Patricia Prelock, and Brooke Bitner. 2005. Family-Centered Intervention and Satisfaction With AAC Device Training. Communication Disorders Quarterly 27, 1 (2005), 47-54.
- Janice Light and Kathryn Drager. 2007. AAC technologies for young children with complex communication needs: State of the science and future research directions. Augmentative and Alternative Communication 23, 3 (2007), 204-216.
- Janice Light and David McNaughton. 2012a. The Changing Face of Augmentative and Alternative Communication: Past, Present, and Future Challenges. Augmentative and Alternative Communication 28, 4 (2012), 197-204.
- J. K. Gona, C. R. Newton, S. Hartley, and K. Bunning. 2014. A home-based intervention using augmentative and alternative communication (AAC) techniques in rural Kenya: what are the caregivers' experiences? Child: Care, Health and Development 40, 1 (2014), 29-41.
- OECD. 2015. How's Life? 2015 Measuring Well-being: Measuring Well-being. OECD Publishing.
- Janice Light and David Mcnaughton. 2015. Designing AAC Research and Intervention to Improve Outcomes for Individuals with Complex Communication Needs. Augmentative and Alternative Communication 31, 2 (2015), 85-96.

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