

ORIGINAL RESEARCH ARTICLE

Online complementary interventions for the
development of social communication in
children during the early stage of the COVID-19
pandemic**Fusako Tomoto^{1,2}, Makoto Ota^{1,2}, Tomofusa Akita¹, Masanori Hariyama³ , and
Mamiko Koshiba^{1,2,3,4*} **¹Division of Systems and Design Engineering, Graduate School of Sciences and Technology for Innovation, Yamaguchi University, Ube, Yamaguchi, Japan²Department of Academic Research, Association of Children's Environment, Minato, Tokyo, Japan³Department of Computer and Mathematical Sciences, Graduate School of Information Sciences, Tohoku University, Sendai, Miyagi, Japan⁴Department of Pediatrics, Saitama Medical University, Irumagun, Saitama, Japan**Abstract**

For elementary school children, engaging in diverse communication experiences with peers of varying ages during free play is crucial for developing social adaptability. However, the COVID-19 pandemic caused an unprecedented interruption to this learning process, as the new school year in Japan, which typically starts in April, began with widespread school closures. A novel intervention was implemented to address the ongoing societal constraints of the “stay-at-home” mandate and the uncertainty surrounding its duration. This intervention aimed to facilitate and promote peer communication while minimizing the risk of COVID-19 infection. It utilized then-unfamiliar Internet-based conferencing systems on Children's Day, 1 month into the new school year. We explored two main analytical aspects to enhance the efficacy of this communication method: first, the types of play proposed by children that attracted the highest participation from unfamiliar peers; second, the duration of participation and communication, particularly regarding age and gender differences. Remarkably, despite only 2 days' notice, 15 children aged 4 – 14 from five different, previously unknown communities located 1,000 km apart participated enthusiastically. In the first investigation, 12 types of play were introduced by the children. The most engaging activities included collaborative drawing on a shared online whiteboard and a scavenger hunt for specified objects. Notably, older children participated significantly longer in the online presenter's activities, while younger children preferred to play within their own community. This study proposes that online conferencing can facilitate social interaction among children during pandemics. The intervention successfully fostered collaborative play among children of varying ages and from distant locations. In addition, the findings indicate the necessity to adjust the quality and focus of interventions based on age-specific psychological development. Further verification with more implementation examples and a larger participant pool is required.

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1. Introduction

A developing child learns to be motivated to spontaneously connect with the outside world by interacting with diverse social and physical environments.^{1,2} The variety of nature and people within the home, family, school, and society introduces complexities that often create interaction challenges.^{3,4} Children become interested in, recognize, understand, and relate to a world filled with diverse challenges. They learn to identify, create, and collaboratively solve problems with others.^{5,6} Through repeated experiences and reflection, children are expected to develop the ability to help each other and overcome challenges.^{2,7} However, this opportunity to interact with the learning environment is not always sufficiently guaranteed for all children.^{6,8} For example, as birthrates decline, children may spend more time in adult-dominated nurturing environments, which limits their spontaneous interactions with other children,^{9,10} thus eliminating the chance to encounter difficult social and natural environments essential for their development, potentially leading to learning disabilities.¹¹ The number of cases of developmental disorders with social maladjustment as a major symptom has recently increased. Attention deficit hyperactivity disorder (ADHD) and autism spectrum disorder (ASD),¹² for example, are known to include cases of coexistence of some genetic background,¹³ and may at the same time raise the possibility of dysfunctional social development,^{14,15} which we previously suggested in our model animal studies.¹⁶⁻²³ This may be caused by a lack of experience interacting with such learning environments.²⁴⁻²⁶ The importance of encouraging children to learn more in school is greater than in other age groups because the mechanism of learning during the developmental period is well-known in the formation of communication.^{18,20,27,28} including the acquisition of a native language. In addition, the “stay-at-home” orders implemented to protect children from COVID-19 began on April 16, 2020, when a state of emergency was declared nationwide in Japan. Most kindergartens and schools remained closed until May 25, as the infection continued to spread.²⁹ These measures led to children staying at home, which discouraged their willingness to connect with the outside world. Consequently, barriers to communicative experiential learning may have developed.³⁰⁻³² Several reports have revealed the psychosocial and mental health impact on children, including mood swings, loss of motivation, depression, and anxiety symptoms to post-traumatic stress disorder due to school closures, confinement, and a lack of peer interaction during COVID-19 lockdown and containment measures.^{33,34} Children with ADHD/ASD were particularly vulnerable, exhibiting negative emotional and behavioral effects during the lockdown.³⁵

In cases where children lack the social experience to interact and learn from each other, a “playpark” or “playground” has been proposed as a psychological education system to supplement this experience. Playpark encourages children to learn through play, which is based on spontaneity, motivation, creativity, collaboration, and perseverance in overcoming difficulties.^{2,8,36}

Information and communication technologies (ICTs), such as smartphones and Internet PC terminals, have the potential to expand and connect children in the home with the outside world, nature, people, and living things.³⁷ In addition, ICT is known to have a high affinity for children with developmental disabilities.^{38,39} On the other hand, it has the potential to be a new educational tool that requires monitoring and reflection on its use, including the risk of captivating children and keeping them away from the outside world and nature.⁴⁰⁻⁴²

To apply “a digital and analog network playpark,” we explored the form of a new system in which children spontaneously connect with the outside world using video and voice ICT. The event was held for the purpose of forming communication online, where participants play together while exchanging play information. At the time, they remained closed from April, the beginning of the school year, and about a month later, Children’s Day, a national holiday, was celebrated in a state of closed communication only within their homes. To do something for the psychological development of the children, we proposed and called upon five communities that were unknown to each other, different organizers in Yamaguchi and Chiba/Saitama Prefectures in the southwestern tip of Honshu, a long distance away, where communication is extended and made possible by online ICT, rather than remaining within the same local community. The “1000 km Online Play Park Project” was a challenge in which children proposed their own games, and all participants played together online over long distances. The performance of 15 children proposing their own play to other children and participating in the play of other proposers during the 2-h event was recorded and analyzed. Each individual’s behavior species in the video data were observationally identified and defined every 5 s. The purpose summary of this study is to examine the trial of the intervention aimed at communication formation, developed to counteract the panic-stricken pandemic society that had suppressed children’s communication learning. To design a communication intervention method with higher efficacy for any child generation and to find any requirements for the future, we explored two main analytical aspects. One was the type of play proposed by the children, which attracted a

greater number of first-time participants, and the other was the duration of participation and communication, with a focus on investigating age and gender differences. To investigate the impact of the ICT-based playpark trial on children's psychology, we evaluated their stay total time in each play, regarded as a quantitative index of willingness to participate, considering gender and age dependence.

2. Materials and methods

2.1. Ethics deliberations, event details, and participants

This study protocol was approved by the Yamaguchi University Review Committee for Non-Medical Research Involving Human Participants (approval ID: 2020-047). Consent for video recording was obtained from all parents, the children themselves, and the organizers. The data were recorded in such a way that individuals could not be identified. The children who were forced to stay at home in abnormal conditions were approached at random, and those who agreed to participate were analyzed. It was not required to ask whether the participants included children diagnosed with developmental disorders, for which quantitative diagnostic methods have not yet been established.

On May 3, 2020, assuming a communication scale of about 15 children, we randomly selected addresses that had participated in previous children's events in each city and sent an email invitation to participate in an event with the theme "Children propose play ideas to each other in an online conference, and the children who received the ideas participate in the play and co-create the play" without prior notice. We invited a total of five children's communities: three in Yamaguchi Prefecture and one each in Saitama and Chiba Prefectures, which are about 1,000 km apart. The number of children and parent participants who presented their own play were eight female and seven male children and two parents. All were included in the analysis. The event began on May 5, 2020, at 1:00 p.m. with an online conference system and at 3:00 p.m. on the Internet using the Zoom online conference application to share information about each other's favorite games and play together. The online conferencing system has three advantages: (i) to maintain a relatively stable connection between terminals for both video and audio; (ii) to separate into multiple groups and maintain communication with each group; and (iii) to securely record video. "Children's Day Project" and "1000 km Online Play Park" were named and announced. Parents were asked to be present on the day of the event. After receiving consent, the event was recorded. The order of the game suggestions was randomized.

2.2. Recording with an online conferencing application

Using the recording functionality standard with the Zoom online conferencing application, the event content was recorded on a local PC. During the event, we switched between a gallery view, in which the camera images of all participants' ICT terminals were displayed on the screen in a small size, and a speaker view, in which the screen of the person who was speaking was displayed in a large size by itself automatically, and selected a screen layout that facilitated observation of play and participants' actions and expressions toward each other.

2.3. Analysis of presented play

All types of play presented by children and parents were analyzed. Four introductory films were presented, which were considered one form of play. The number of children who participated in each type of play was visualized in bar graphs for females (red) and males (blue) and for lower and upper age groups. The age boundary between the lower and upper groups was defined as either 8 years old or younger or 9 years old or older, which is the average age of children in a 6-year elementary school in Japan.

2.4. Classification of each child's behavior

The video recording was viewed, and each child's behavior was classified every 5 s into one of the following eight types of emergent behaviors, which were used as the original data. These eight typical behaviors were preliminary classified and summarized in the same recorded video data by the children's educators, considering the contextual flows and vocal contents.

- (i) Engagement: All actions. All time spent at the event.
- (ii) Play suggestion: Actions to present and explain the play to the other participants as a time to take charge of the presentation, followed by actions to lead the play with the other children.
- (iii) Online participation: Behavior of the play suggested by the presenter together or outside of the time after the presenter's presentation. If the play presented was a self-introduction video, children were considered to be joining the play if they could confirm that other children were watching the video.
- (iv) Online conversation: A conversation was considered successful only if a two-way online exchange could be confirmed by reviewing the content of the conversation, e.g., a question followed by its answer or response.
- (v) Watch: Watch the screen.
- (vi) Satisfaction: Watching with a smile based on subjective judgment (for reference)

- (vii) Onsite conversation: Conversation among peers, including conversations with parents and siblings present.
- (viii) Onsite participation: Play various games among peers, including parents and siblings present.
- (ix) Solitary play: Examples of this behavior include playing unrelated digital games without looking at the terminal's video camera.

2.5. Statistical analysis of age dependency

The time-totals of eight different behaviors were analyzed by linear regression and Pearson product-moment correlation coefficients and intercepts. The probabilities <0.05 were considered significant.

3. Results

3.1. Play ideas presented by children

The event was conducted with five females and two males in the lower grades, three females and five males in the upper grades, and ten adult parents and staff. Regarding the age composition of the children, females were significantly younger than males in the upper grades (Table 1; $P = 0.0240^*$), but there was no significant age bias between the sexes in the overall composition of the lower and upper grades (Table 1; [All, $P = 0.1072$]).

For the age composition condition of the participant groups, P -values were calculated by a student t -test for each mean and standard deviation (Excel, Microsoft) for females and males in the lower and upper age groups.⁴³

Figure 1 visualizes a representative image of each play of all the twelve ideas suggested by children with the number of all children who participated and the number of participants who played the same one as the presenter introduced divided into female (red)/male (blue) and lower-/upper-grade groups in the bar graphs.

As an overall summary, the upper-grade group was characterized by frequent viewing of all the play by both females (Figure 1; red) and males (Figure 1; blue), whereas the lower-grade group showed only male participation in the earlier play activities presented. The involvement of multigenerational children in collaborative play was

Table 1. The age conditions of the child participants

Age (year)	Lower age		Upper age		All	
	Mean	SD	Mean	SD	Mean	SD
Female	6.2	1.3	9.0	0.0	7.3	1.8
Male	5.5	2.1	11.4	1.5	9.7	3.3
P by t -test	0.7241		0.0240*		0.1072	

Abbreviation: SD: Standard deviation. The significant p value is less than 0.05 (*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$).

somewhat limited, observed in four types (whiteboard drawing, cat's cradle, bring me something). Below are the play ideas presented in chronological order:

3.1.1. Plate spinner (10-year-old boy)

This play involved rotating a plate on a stick. Originally, a ceramic plate was used, but a child-friendly plastic plate was later utilized, which was shown spinning on the stick.

3.1.2. Rope-jumping (5-year-old girl)

A 5-year-old girl played a single jump with a jump rope in the room.

3.1.3. Lifting (7-year-old boy)

The boy demonstrated a soccer lifting technique indoors using a small soft ball.

3.1.4. My introduction video (three 1-year-old boys and one 9-year-old girl)

Children from various age groups watched the videos together.

3.1.5. Look this way! (9-year-old girl)

The player faces the viewer in front of the screen and points either up, down, left, or right with their arms and fingers while saying, "Look this way." If the viewer faces the same direction as the player, the player wins, and the viewer loses. The activity was canceled earlier because the player was inexperienced in operating the remote meeting camera to display her actions properly.

3.1.6. Whiteboard drawing (7-year-old girl)

Drawing pictures on a white piece of paper with the left hand was asked to guess what it was. The flowchart (Figure 2) summarizes the process of the online sharing feature of the teleconferencing system that was uniquely developed. Child 1 drew a picture on a white piece of paper and showed it over the screen, but it was unclear. So, Child 2 suggested drawing a picture on the whiteboard of the online meeting application. Both the child and parent of the playgivers did not know how to use the whiteboard. Several children and parents explored how to teach them, taking into account their understanding.

3.1.7. Origami: Folding paper to make things (6-year-old girl)

She seemed to be folding origami all the time, not facing the screen. She only showed it when she was finished, while the parent explained instead of her. A girl in the lower age group participated in the game by folding origami.

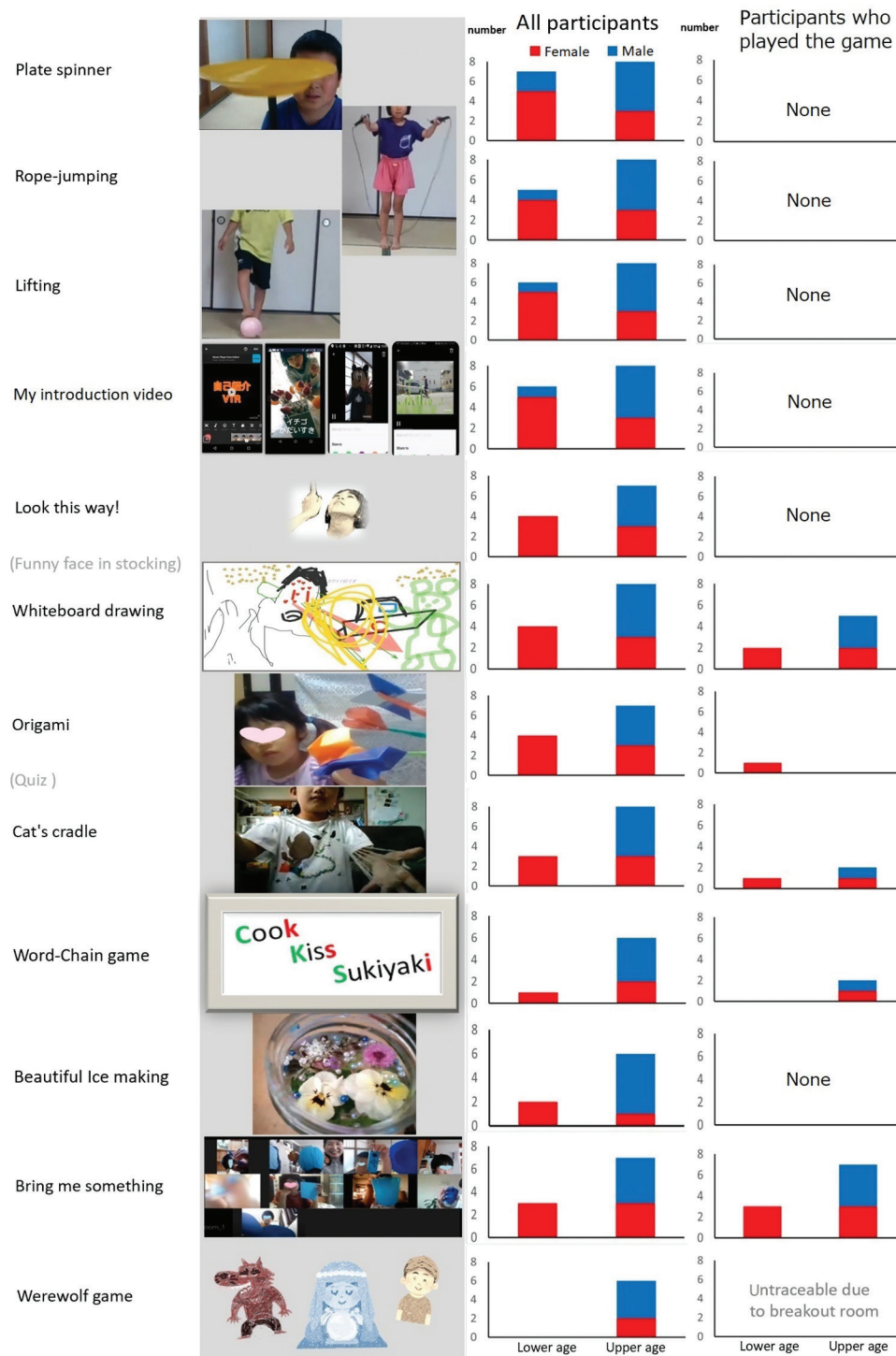


Figure 1. Twelve different play ideas presented by the children, with the number of children participating

3.1.8. Ayatori: Cat's cradle (8-year-old girl)

She demonstrated on camera the process of making a "broom" with Ayatori, from the beginning of creation to its completion. A total of three children played a similar game of Ayatori online.

3.1.9. Word-Chain game (11-year-old boy)

A play where the first person says a word, and the next person thinks of a word whose last letter is at the beginning of the word and says it. The first idea was to use the whiteboard sharing function on the screen and suggested

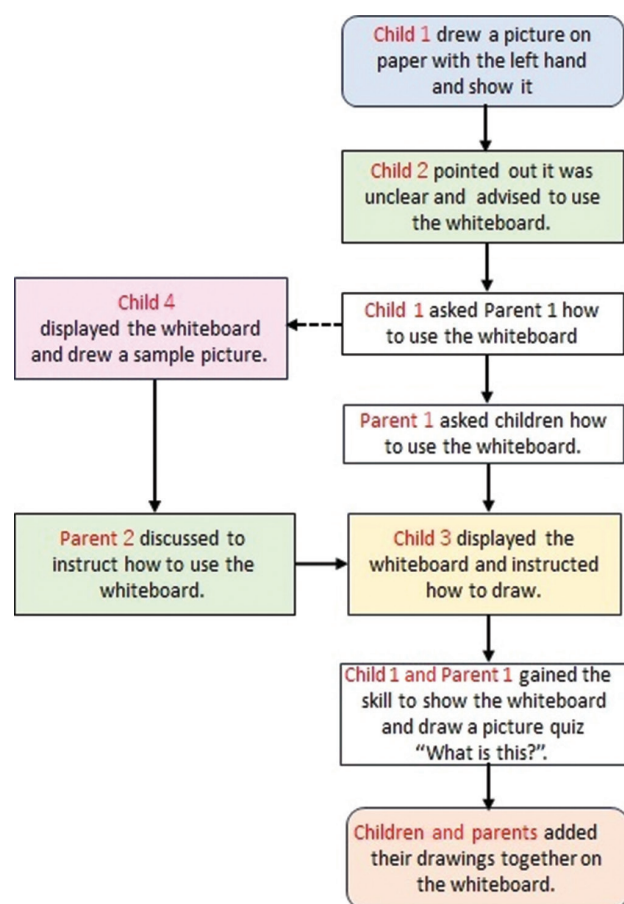


Figure 2. The flowchart of the multi-participant collaborative transformation process from a blank sheet of paper in real space to a shared whiteboard in virtual space

drawing a “Word-Chain game,” but screen sharing did not work for some communities, so it was changed to sharing in the chat. Since some people did not know how to play the game through chat, it was confirmed that only two participants understood each other.

3.1.10. Beautiful ice-making (9-year-old girl)

She showed how to collect colorful beads, buttons, flowers from the garden, and other pretty things found around the house, put them in a glass cup, pour water into it, and freeze them in the freezer to make beautiful ice.

3.1.11. Bring me something (14-year-old boy)

The display was set up in a gallery view where all participants could see each other’s actions on the screen through a teleconferencing system. A game was introduced: “Bring the blue object into the room,” and the first person to bring it back wins. Everyone went for the blue object at the same time, and when they brought it back, it was shown to the other participants on the camera. Other variations

of the task, such as “something golden or slippery,” were suggested. As a result, all the children who watched the play suggestions joined the game.

3.1.12. Werewolf game (11-year-old boy)

The rules and flow of the game were as follows: in a village, werewolves disguised as villagers are eating villagers one by one at night. There must be at least three villagers and one fortune teller. The victory condition for the village team is to kill all the werewolves. Another team has two werewolves, and the victory condition is that both teams have the same number of werewolves. The person with the most votes at noon is eliminated. At night, the werewolves discuss and decide who will be eaten. The soothsayer can ask the position of a living person. This process is repeated. The chat and breakout room of the teleconferencing system were used. Only the older children in the upper grades participated.

3.2. Play ideas presented by parents

Two games were introduced by two different parents. Figure 3 shows the games proposed and the number of children participating and actually joining.

3.2.1. Funny face in stocking

A parent put a stocking over her head and pulled the stocking with the child, showing “a funny face” and laughing at each other. A boy in the upper grade was amused and tried the same game.

3.2.2. Quiz

The quiz is given a portion of a dictionary semantic sentence and asks what the word is. Example: In the case of the question, “What is a sweet pastry baked with flour, eggs, and sugar?” The answer is “cake.” One boy in the upper grades answered the quiz.

3.3. Age dependency analysis of time by eight behavior types

Based on the observation of each 5-s unit of the recorded video during the event, Table 2 summarizes the total recorded time data for each type of behavior in 15 children.

These children’s duration data were analyzed for age dependence using a linear approximation equation based on Pearson’s product-moment correlation coefficient and its probability in a scatterplot with the horizontal axis, age (y), and the vertical axis, time (s) (Figure 4).

Linear regression and Pearson product-moment correlation coefficients, intercepts, and probabilities <0.05 were visualized as significant with red fonts and asterisks.

The results showed that the total participation time (Figure 4A), the willingness to join the proposed play

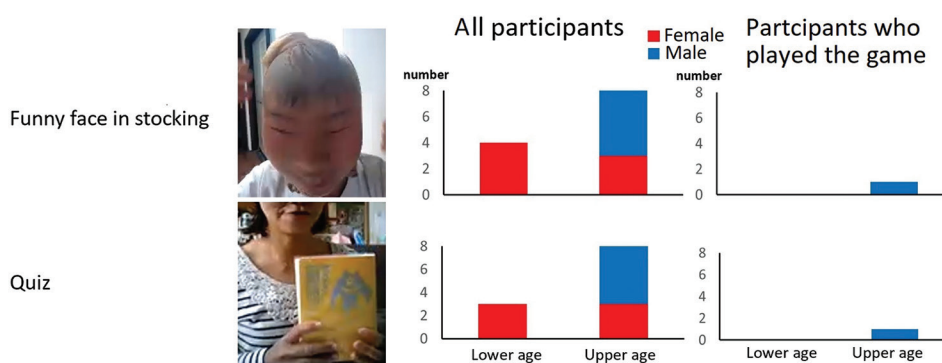


Figure 3. Two play ideas presented by parents and the number of children who watched and joined the play

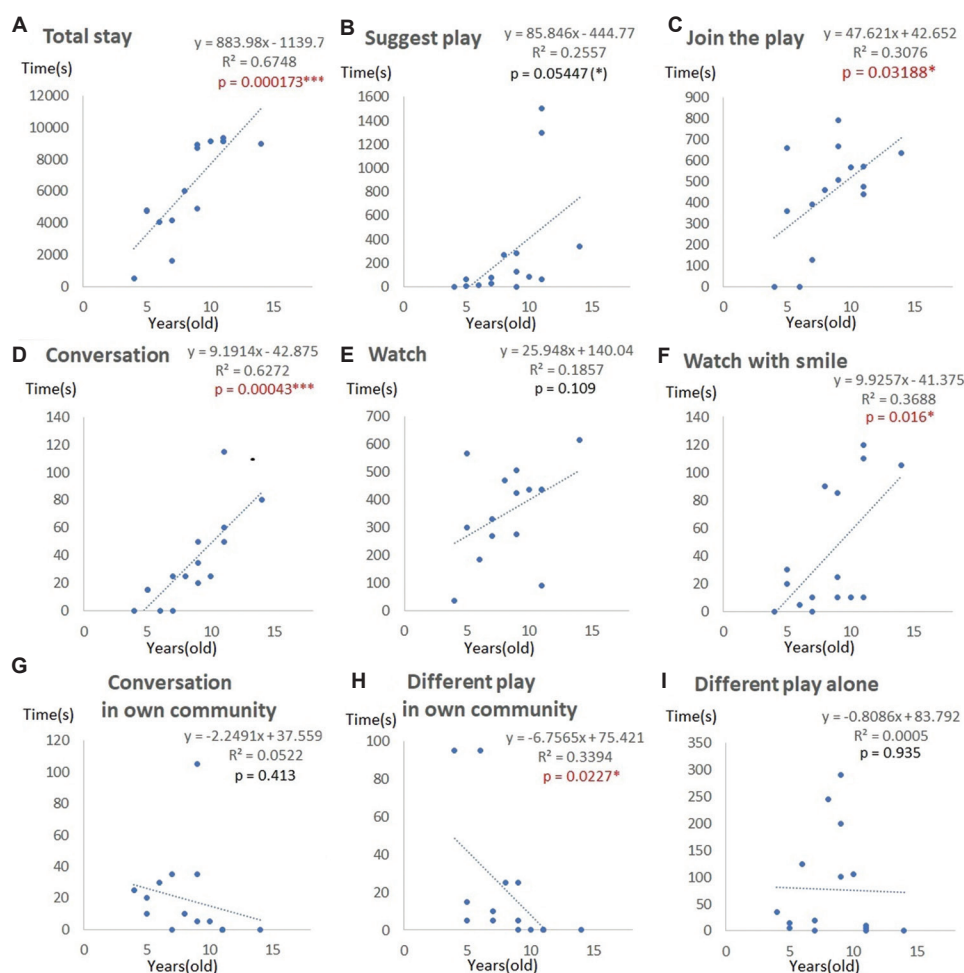


Figure 4. (A-I) Children's action and reaction time and age dependency

(Figure 4C), the online conversation with each other (Figure 4D), and the time spent watching the screen with a smiling expression (Figure 4F) increased significantly with higher age. In addition, although not significant, a similar trend could be seen for the duration of play suggestions (Figure 4B) and viewing (Figure 4E), as older children spent

longer. On the other hand, the tendency to engage in other play activities within one's own community, not with each other online, not alone but with several persons, seemed to be significantly higher at younger ages (Figure 4H). A weak tendency for younger children to have longer conversations with other members of their community

Table 2. Time-totals of eight different behaviors in eight females and seven males from five communities: Lower/Upper grades, gender, and mean ± SD

Community -child ID	Age	Grade lower (<9) or upper (≥9)	Gender	Seconds of a child's behavioral types								
				Engagement	Suggest play	Online participation	Online conversation	Watch	Satisfaction: watch with a smile	Onsite conversation	Onsite participation	Solitary play
1 – 1	5	Lower	Female	4730	5	360	15	300	20	10	5	5
1 – 2	7	Lower	Female	4180	75	390	25	330	10	35	5	20
1 – 3	9	Upper	Female	8705	125	790	50	275	25	105	5	100
2 – 4	5	Lower	Female	4820	60	660	15	565	30	20	15	15
2 – 5	7	Lower	Male	1615	30	125	0	270	0	0	10	0
2 – 6	10	Upper	Male	9150	85	565	25	435	10	5	0	105
3 – 7	4	Lower	Male	545	0	0	0	35	0	25	95	35
3 – 8	6	Lower	Female	4090	10	0	0	185	5	30	95	125
4 – 9	8	Lower	Female	6000	265	460	25	470	90	10	25	245
4 – 10	9	Upper	Female	4905	0	665	20	505	10	35	25	200
5 – 11	9	Upper	Female	8940	285	505	35	425	85	5	0	290
5 – 12	11	Upper	Male	9135	1295	570	115	435	110	0	0	5
5 – 13	11	Upper	Male	9365	1505	475	60	435	120	0	0	0
5 – 14	11	Upper	Male	9115	65	440	50	90	10	0	0	10
5 – 15	14	Upper	Male	8990	340	635	80	615	105	0	0	0

Abbreviation: SD: Standard deviation.

(Figure 4G). The time spent alone playing games unrelated to those proposed online was the least age-dependent, with the duration being longer for children between the ages of 8 and 10 (Figure 4I).

4. Discussion

School attendance, which was taken for granted under normal circumstances, was prohibited during the COVID-19 pandemic.^{44,45} In this situation, communication between children, which should be given the highest priority as a target factor for promoting development, was closed off, and children's social learning was abnormally interrupted.^{14,15} To restore communication opportunities for these elementary school children,⁴⁶ we attempted a play-interaction event using online conferencing.⁴⁷ The different communities met for the first time with each other, against the backdrop of the different local cultures in which they lived; for example, the community in the suburbs of the Tokyo metropolitan area with many older children had already mastered the skills of using the online teleconferencing system and were able to bridge the distance between members in the community divided by the COVID-19 pandemic.⁴⁸ Furthermore, the imagery and audio of the play introduction video were skillfully edited using Internet applications, as if the negative social repression of the COVID-19 pandemic might have been a springboard for the complementation of the communication network to promote skill development.⁴⁹ In contrast, there were at least some differences in the skills for using the teleconferencing system among the five communities in this study, and parents voiced some confusion in the community that consisted mostly of younger children who were not accustomed to using the system.⁵⁰ The fact that younger children are more likely to engage in play rather than online (Figure 4H) may be an expression that resolves the confusion for the children. Since the suppression of communication within one's own community was also considered due to the suppression of communication itself, the activation of communication within one's own community, even if not with a different community online, might be said to have a positive effect.⁵⁰ Furthermore, even in communities unfamiliar with the online teleconferencing system, the significant age-dependent⁵¹ increase in viewing time for older children (Figure 4C) and conversation time beyond online (Figure 4D), which statistically confirmed the high attention span of older children and the transfer of information from advanced skill users using the teleconferencing system (Figure 4),⁵² was an accomplished finding of this trial. Since the duration for looking at the camera accompanied by a smile was left to subjective identification by the observer, it will require a replication quantification technique using

an automatic smile recognition monitor by machine⁵³ in the future, but at the reference data level, it suggests the possibility that the upper-grade children might be satisfied more.⁵⁴

The play proposed by the younger children basically involves actions that involve physical control of real space, while the older children do not convey actions that involve physical control of real space as they are, but rather, as in the example of "Bring me something blue (3-1-11)," for example, they use online systems and video editing to create new virtual. The higher-order nature of extending functions on the space may be a feature.⁵⁵ In this participating child, there are differences between male and female participants at older school ages, and there is a bias toward older boys and younger girls, but the age-dependence analysis in Figure 4 has a certain degree of reliability because it confirms the age-dependence for all ages and genders,⁵⁶ where the bias is no longer statistically significant. When others suggested a play, they were observed to play video games alone, regardless of the play, and to repeat, perhaps practice, the behavior before presenting their own play suggestions, indicating that this more self-directed behavior was age-independent (Figure 4I). Its age independence may have suggested, for example, a more self-centered instinctive function that is different from the typically developing social function that is increasingly learned with age.⁵⁷⁻⁶⁰

The strengths of this study regarding the online mutual complementary intervention for children's formation of social communication at the early stage of the COVID-19 pandemic included five points: (i) the successful communication between children meeting for the first time over long distances; (ii) the absence of concerns regarding infection or weather, (iii) the mutual learning and thinking observed among the children; (iv) the ability for parents and children to participate together from their own homes; and (v) the fact that many participants genuinely enjoyed the experience and expressed a desire for it to be repeated. The strengths of this online intervention method include the ability to log and analyze participants' behavior and the possibility to statistically infer developmental status by entering participants' age information.

Immediately after the event, a survey was conducted asking participants about the challenges they faced, and the following issues were answered. From the staff, one was the need for initial icebreaker activities to help children get accustomed faster to each other, and another was considerations for providing support and shortening the duration for younger children. Older children have their own issue that they should be more considerate of younger children. The other comment of ours was the

design of a structure where age-specific scenes and mixed-age interactions could be alternated. In addition, a need to devise ways to deepen communication between children who have never met each other before; the need for training to improve skills in ICT operation, calling each other by nicknames, and holding information exchange meetings for all parents and children afterward were suggested. Improvement of these issues should be repeated multiple times, not just for a single event. Furthermore, because of the limitations of only obtaining information online, it is necessary to do about the onsite real space as well.

This study is limited by the small sample size and subjective description of the behavioral classification. A future study is needed to increase the sample size and to develop image deep learning technology to identify different behaviors for reproducible quantification.^{2,61}

Another limitation is that although the study intended for children to propose the play ideas on their own, in some cases, the parents proposed the play ideas. Future research should incorporate parents' play ideas as part of the study or ensure the children come to these online play groups without their parents.

5. Conclusion

This study examined the effectiveness of a new intervention method using an online conferencing system to enhance social communication among children who experienced social suppression due to infection avoidance during the early stages of the COVID-19 pandemic. The intervention involved 15 children, who had never met before and were separated by long distances, introducing and playing their games together online. The findings of this study showed that the intervention successfully promoted collaborative play among older children from distant locations, and the total participation time, the amount they proposed play, the online conversation with each other, and the time spent watching the screen with a smiling expression increased significantly with higher age. This study outcome in younger children was to promote different play in their community as an age-dependent social formation style.

Children with ADHD and ASD, who have social disabilities and were reportedly more susceptible to COVID-19 lockdown, may also benefit from this online intervention method, as they tend to have a high affinity for ICTs.

As directions for future research, we suggest improvements in design, primarily with age-dependent consideration with additional care of different ICT utilization skills. It is also necessary to investigate the effects of repeating the event as well as one-time events going forward.

Given the limited number of participants in this study, further exploration is needed, considering these limitations, for future instances of infection-related crises that suppress children's social development. Another limitation of this study is its focus on specific regions, and future research should explore intervention designs suitable for diverse geographical context.

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Conflict of interest

The authors declare that they have no conflicts of interest.

Author contributions

Conceptualization: Fusako Tomoto, Makoto Ota, Mamiko Koshiba

Formal analysis: All authors

Investigation: All authors

Methodology: All authors

Writing – original draft: Fusako Tomoto, Mamiko Koshiba

Writing – review & editing: All authors

Ethics approval and consent to participate

This study protocol was approved by the Yamaguchi University Review Committee for Non-Medical Research Involving Human Participants (2020-047).

Consent for publication

Informed consent for publication was obtained from the relevant participants.

Availability of data

The datasets for this study can be found in the main text.

Further disclosure

Part of the findings was reported in the blog of WEB magazine of the Association of Children's Environment published in May 2020 (https://www.children-env.org/magazine/blogs/blog_entries/index/23?page_id=4) for helping children and family against COVID-19 lockdown society.

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