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Description	

How Does Telenoid Affect the Communication between Children in Classroom Setting?

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Abstract
It needs to be investigated how humanoid robots may affect people in the real world when they are employed to express the presence, a feel of being there, in tele-communication. We brought Telenoid, a tele-operated humanoid robot, into a classroom at an elementary school to see how schoolchildren respond to it. Our study is exploratory and we focused on the social aspects that might facilitate communication between schoolchildren. We found that Telenoid affected the way children work as group. They participated in the group work more positively, became more spontaneous, and differentiated their roles. We observed that Telenoid's limited capability led them to change their attitudes so that they could work together. The result suggests that the limited functionality may facilitate cooperation among participants in classroom setting.

Keywords
Tele-operation; android; minimal design; human interaction; role differentiation; cooperation

ACM Classification Keywords
H.5.m [Information interfaces and presentation]: Miscellaneous;

Introduction

How does the spread of robots in society effect changes in human relationships, especially in daily life? In this paper, we focused on a group work activity in an elementary classroom as a primary form of social interaction to explore the effects of a tele-operated android on human interaction. At the beginning of the 20th century, our bodily embodiment began to be thematized as a condition for the possibility of experience in the world [9,15]. It has also been focused on as a central condition of social life through which people take a stand toward each other. In the current development of robotics, humanlike androids have been produced as new media of human relationships. We expect that a tele-operated android, whose embodiments are varied, might change social interaction and even expand human capabilities. Whether an android would actually be accepted in the real world remains unclear, so we started to research the daily school life of children.

This exploratory research structures and identifies new problems. By introducing a new entity, the group form of the children might be changed and unusual reactions might be elicited. The intervention of the android among them created an unprecedented situation, but we could not predict how they would be affected. According to the theory of situated learning proposed by Lave and Wenger, it is insufficient to focus on a one-way transfer of knowledge or skill from one individual to another [12]. Learning is considered a social process through which knowledge is co-constructed. In this new type of social interaction with the android, children are expected to co-develop capabilities that they could not acquire in usual situations. We also considered another result: damaged or lost potential. For example, if the robot's operator or the other children in the class are treated as outcasts, their learning in the group will be lost. Both the possibility of promoting and obstructing learning existed in the socialization.

Vygotsky's social development theory argues that social interaction plays a fundamental role in the process of cognitive development. He writes: "Every function in the child's cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological)." [23] According to Vygotsky, the capability of children is first realized inter-personally and then intra-personally internalized to the individual. He also identified a zone of proximal development (ZPD), which is the difference between what a child can do without help (the actual level of development) and what he or she can do with help (potential development). A level of development exists at which a child can achieve with others even if he or she cannot do it individually in the same way that one learns to ride a bicycle with training wheels. The development of ZPD depends on social interaction, and the range of skills that a learner can develop expands but also depends on with whom he or she interacts and how. Instructors must coordinate interaction among learners. And there may be a level of development at which children can achieve with a new entity.

For a basic theory that describes how a group or an individual changes, we refer to Lewin's field theory [14], which proposes that human behavior is a function of both the person and the environment. This principle, which determines human behavior, is called life space or a psychological field and is composed not only of personal factors but also of the environment's representation. The process of changing a group or an individual is defined in a three-step model: unfreezing, moving, and freezing. Since Lewin's model is basic and representative of the structure that explains how people change their attitudes in a group or an organization, other models have extended it. According to Lewin's model of change, the first step involves preparing the group to accept that change is necessary, which involves razing the status quo, or the equilibrium state, which exists before members can erect a new way of operating. After the uncertainty created in the unfreeze step, in the change step, people begin to resolve their uncertainties and look for new ways to do things. They start to believe and act in ways that support the new direction. When the changes are forming and people have embraced the new ways of working, the group is ready to freeze. We expect that the attitudes of the children who communicated with each other through the android underwent a similar process of attitudinal changes. Due to the new behaviors achieved through the process, they have larger repertories of social and communication skills, although it remains unclear what capabilities they achieved through the android.

Related work

The android we immersed in a school activity was developed in a different direction from autonomous robots that depend on the advances of artificial intelligence. In our research, we focused on the development of human capability with Telenoid R1 (Telenoid) and explored the possibility of tele-operation. To define the significance of our research topic on tele-operated robot communication, we outlined the research trends in robotics and focused on the research development of social robots in child education.

Remote communication in robotics

Robots working in our daily lives require the intelligence to judge and act flexibly based on their circumstances. However, since implementing such intelligence remains too difficult, the Wizard of Oz method in which a person simulates the robot's movements is generally used for further development [6,24,25]. Most recent studies on types of robots have concentrated on autonomous schemes, and tele-operation systems have been used as supplements or substitutes.

The development of such remote communication systems as video conferencing has broken time and space constraints [21,1,2,17]. The common approach of these studies is to resolve the disadvantage or inconvenience in remote places because it sees the face-to-face as ideal. A recent study of tele-presence also showed that tele-operators could participate in face-to-face communication just as closely as local participants [13]. Many studies have resolved the remote disadvantage; on the other hand, our research question asks whether it is possible to determine the primacy of remote communication over face-to-face. It was a contention in [8] that new mechanisms of communication are required for new media. In the Beyond Being There project, Hollan, J. and Stornetta, S. argued that mechanisms that may be effective in face-to-face interactions might be awkward or ineffective if we try to replicate them in an electronic medium. It is required to develop tools that people prefer to use even when they have the option of interacting in physical proximity as they have heretofore.

Types of robots	The knowledge holder of education	Applications (Tele-operator)
Tele-operated	Tele-operator	Giraffe (Parent), PEBBLES (Child)
Autonomous	Robot	Papero, Robovie, RUBI, Qrio
Transforming	Tele-operator or robot	iRobiQ, Engkey (Native speaker)

Table 1: Types of educational service robots

Social robot study for educational services

For a social robot study, the application of robots to educational services has progressed, despite the limitations of artificial intelligence and more direct responses from children rather than adults [22,11,5]. As displayed in Table 1, an educational service robot is divided into three categories: the autonomous type, tele-operated type, and transforming or convertible type, according to the location of teacher's knowledge [7]. Current autonomous robots can work as instructors, instructor assistants and peer tutors even though they narrowly have teacher's subject knowledge but without pedagogical knowledge while tele-operated robots have substituted teachers in remote places. Transforming types can provide both tele-operation and autonomous control. Although most previous work concentrated on autonomous types, the operators of the tele-operated robots were not only adults like teachers or parents but also children.

Remotely sick students controlled PEBBLES, which are mobile video conferencing platforms, and their attitude gradually became more positive [3]. The robot was designed to enable a child to enjoy all the benefits of actual school life face-to-face and closely participate in the classroom. It is housed in a child-friendly, custom-designed shell and is egg-shaped with huggable contours. Theories on robot design are expected but they remain unestablished. One merit is that the humanlike design of robots enables people to act in the same way toward robots as they do toward humans. Recently robots have been produced whose appearances closely resemble humans and research on such minimal designs has started [10,4,16,18,19]. Designing tele-operated androids allows us to probe into the effects of modifying human body in its shape or function on human interactions, such as classroom discussions.

Objective and approach

Since we aimed to explore the various effects of the intervention of a tele-operated android on ordinary relationships among people, we placed it in a group work activity in an elementary school classroom as a real environment. The process of hypothesis creation is also required for extracting elements that can be checked in controlled experiments although we need longer-term follow-up data so that our field experiment has nearly the same high precision as a controlled experiment. The research for this paper serves as a starting point for such a series of field experiments. Our research explores the reactions of children to the android during the adaption process, and thus we find the key issues to be verified. Our strategy is action research and the following questions are posed.

Our major research question, which is how children accept Telenoid, is divided into three elements: 1) How do children conceive of the differences between face-to-face communication and Telenoid-mediated communication? 2) How do they get adapted to it?; how do their attitudes change during familiarization? 3) What factors promote and obstruct their communication by Telenoid? Since the goal of our project is to answer these questions, we conducted an experiment to see how children reacted to Telenoid.

To explore the reaction of the android users, we took the following approaches: 1) conducted a field experiment in a real environment, 2) explored the reactions of children because they might be more direct than adults, and 3) adopted the following two points of view for comparison: the differences between standard face-to-face and tele-communication and the changes of the children in the process of familiarization with the android. From the viewpoints, we conducted a two-day field observation in an elementary school and called this a field experiment. As an example of concrete situations, we imagined that the android was tele-operated when a child was hospitalized or went to the school clinic but could participate in classroom activities.

Telenoid R1

Telenoid is a new type of humanoid robot that is minimally designed to resemble a human and has the flexibility to look like anybody (other tele-operated androids Geminoids are made to appear and behave as exact copies of those masters). Its child-like body with short arms and no legs is covered with silicone skin. It can be picked up and held. Its mouth, head, legs, and lower body can be moved by an operator based on observations of the situation through cameras equipped in another room. The operator movements are automatically tracked and transmitted to Telenoid to

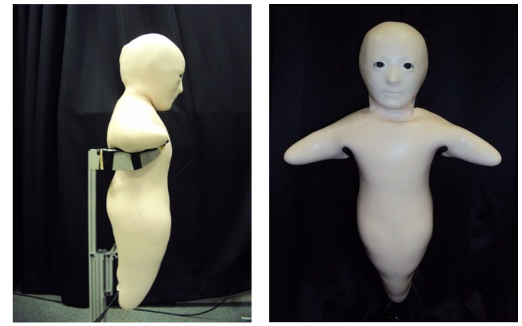

Figure 1: Telenoid R1

realize easy tele-operation. Telenoid is a new communication medium that can effectively represent and perceive human presence. In the next section, we describe its hardware and its tele-operating system to clarify the Telenoid concept.

Specification and tele-operation system

Telenoid has nine degrees of freedom (DOFs) (by contrast, Geminoid HI-1, a previous tele-operated android designed to look exactly as a specific human model, has 50 DOFs and can perform gestures using its entire body), which allow independent horizontal motion for the left and right eyes, synchronized vertical motion for both eyes, opening and closing of the mouth, yaw, pitch, and roll rotations for the neck, and left and right hand motions. Telenoid is 80 centimeters long and weighs about five kilograms. Its skin is made from silicon and feels pleasantly similar to human skin.

The operator's face direction, mouth movements, and facial expressions are captured by a face recognition system. These face tracking results are used to create commands sent to a server by TCP/IP. The face recognition video stream is obtained using a Web

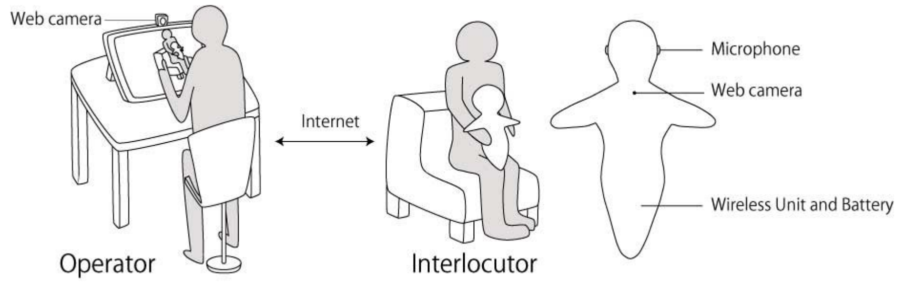

Figure 2: Conceptual diagram of Telenoid system

camera on a laptop. GUI display buttons control such specific behaviors as good-bye, happy, or hug. Such spontaneous behaviors as breathing and blinking are generated automatically to give a sense that the android is alive. Breathing is accompanied by slight, regular hand movements. Basically, the tele-operation system only requires a single laptop; an Internet connection enables Telenoid to be operated from anywhere in the world (Figure 2).

Design concept

Telenoid's objective is to create a minimal human, since such a design allows any kind of person to transfer her own presence to a distant location. This concept requires the following: 1) an omni-human likeness, 2) holdability, and 3) mobility. Omni-human likeness enables users to feel any kind of person's presence. Holdability facilitates physical interaction. Mobility encourages persons to use Telenoid in a variety of situations.

Among robots having commonality with Telenoid, the teddy-bear-like IP RobotPHONE targets tele-present communication [20]. Its appearance may, however, affect interactive use. For the design of a minimal human, the robot's appearance should avoid preconceived ideas about robots. Telenoid, as a minimalistic human, was created to remove as many unnecessary features as possible by: 1) choosing features for communication with humans and eliminating unrelated ones, 2) reconsidering the chosen features to fit design requirements by eliminating unnecessary features, and 3) obtaining essential features.

Telenoid R1's design is shown in Figure 1. At first glance, one can easily recognize that Telenoid resembles a human. It might be construed as either male or female, old or young. Due to this minimal design, Telenoid allows people to feel as if a far-away acquaintance is close. In this paper, we investigate children's natural reactions and impressions outside of the laboratory to verify our Telenoid concept and to find the key issues to be verified.

Laboratory interactions are rather artificial, because the situational context influences the participant expectations and attitudes. Since experimental laboratories are perfectly controlled environments, the obtained results can be very useful from a scientific perspective. But data regarding people's natural impressions or reactions to androids cannot be obtained easily in such an environment. We believe that field environments, although uncontrolled, are important for acquiring knowledge for further development of androids.

Field experiment

We introduced Telenoid to real classroom activity to explore how it actually affected the relationship among children and how it was accepted. To get natural responses from them, we utilized an ordinary classroom as the field of our two-day experiment and focused on their group work as an activity so that their interaction could easily occur. Also we utilized a small room next to the classroom to operate Telenoid so that an operator could remotely participate in the group work activity. This research conducted a qualitative method to interview the children and their teachers and to observe the records for problem finding and focused on the unpredictable phenomena in an uncontrolled field setting. We set up cameras in both rooms and analyzed the records to extract the characteristics of the responses from the children to Telenoid and their interactions with it. After the class, we conducted semi-structured interviews with the operators, all of the children, and their teachers to compare the differences between usual face-to-face and tele-communication and the differences between the first and second.

Method

As a school event, the children were preparing to perform a creative drama based on memories obtained from elderly citizens. Their group work task was making a scenario for the drama play in small groups, and the group work was conducted as a competition of each groups scenarios. During a field experiment on consecutive days, we placed a Telenoid in the group work and children had small-group discussions as usual, but a child from each group became an operator in another room. We describe the experiment method in detail below.

Participants: 28 children aged 9-10 years (19 boys and 9 girls) from the same class.

Experiment situation: The two-day field experiment was conducted in two rooms in an elementary school. Group work activities were conducted in a (9×12 m) classroom with audio-visual equipment where Telenoid was set up, and a small room (7×4 m) next to the classroom was utilized for tele-operation by the children who operated Telenoid. The children were divided into their usual six groups, each of which was composed of four to five members, for group discussions and were seated at six sets of desks in the audio-visual classroom. Only one Telenoid was placed in this classroom; therefore, the six groups shared Telenoid, which was stationed at one set of desks. One child in each group was assigned to operate it. The operators were all boys who applied for the role and in turns moved to the small operation room. All of the children in the class learned and practiced how to operate Telenoid the day before the experiment. During the two-day experiment, children talked with each other about their drama scenarios for about an hour on both days. The same member of each group served as operator on both days of the experiment, although time was limited to about 10 minutes each day since the operators of the six groups had to share one Telenoid (Figures 3 and 4). We also interviewed the operators

Figure 3: Children communicate with each other through Telenoid

one by one, all the members in each group as a whole, and their teacher after this series of experiments. Interviews with the operators were immediately conducted after their operation each day. We held interviews with all children including the operators after the group work each day and called them group interviews.

Procedure: The children in each group were asked to compose scenarios for a 4-frame cartoon. They received whiteboards (30×45 cm) to jot down their initial ideas and scenarios and then drew completed versions on regular stationery with pictures, explanations, and dialogue. The experiment was conducted in the steps described below. Prior to the introduction of Telenoid, the scenes of the group work activity by children were recorded. In the preparation for the experiment, we provided children with the experience of operating Telenoid and freely talking with each other through it. In such a class as group work activities, teachers work well together, and graduate students near the school sometimes volunteer to facilitate children's discussion. In this experiment, one of the teachers in the school, four graduate students, and one of the conductors of this experiment became facilitators in each group of children and also conducted group interviews with them. Other interviews were conducted by the conductors of this experiment.

1) *Recordings of regular group work prior to the introduction of Telenoid*: Two days before the first experiment, we recorded the dialogue scenes among the children without Telenoid. In the group work activity, they discussed the themes of their scenarios in each group.

2) *Initial training with Telenoid*: On the day before the first experiment, children saw Telenoid for the first time (45 min.) All of the children learned and practiced how to operate it. They were allowed to talk freely with each other through Telenoid to reduce the novelty.

3) *1st day*: Telenoid was placed in a group work activity for 90 min. Six groups shared Telenoid, which was stationed at one set of desks. One child

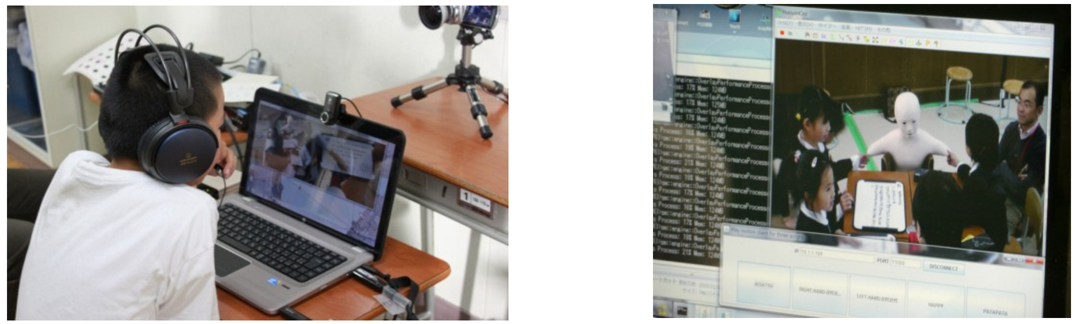

Figure 4: Operating scene and operator's screen

in each group moved to the next small room to operate it. The children scribbled out their initial ideas and scenarios on whiteboards and tried to make stories. The conductor of this experiment held interviews with all the operators immediately after their tele-operation. The facilitators in each group conducted 10 min. group interviews with all the children after the group work.

4) *2nd day*: Telenoid remained in the classroom and group work started again for 90 min. The children continued to make stories and drew completed versions of their scenarios on whiteboards and paper with pictures, explanations, and dialogue. Interviews with the operators and all the group members were conducted in the same way as on the previous day.

5) *Data collection after this series of experiments*: After the second day of the experiment, interviews were conducted with the supervising teacher and another teacher. Written descriptions of the children's impressions of the group work with Telenoid were collected after the experiment.

Analysis: For problem finding, we conducted a qualitative method with the data of the dialogue recordings of the children, the results of observing the children's behaviors based on video recordings, and the results of the interviews. We focused on the characteristics of the children's interaction by Telenoid and observed their behaviors from both viewpoints of the comparison: the differences between face-to-face and tele-communication and the changes of the children in the process of their familiarization with the android. Comparing the collected data, we explored the children's changes by extracting and categorizing the distinguishing phenomena in their interactions.

Structural changes of interaction

From a macroscopic viewpoint of the children's interaction, we observed the group's changing structure. A typical transition of the group form is represented in the model shown in Figure 5: 1) partial participation, 2) cohesion and negotiation, and 3) full participation.

Step 1: In the face-to-face communication before Telenoid was introduced, children proceeded to discussion, but the participants were limited to roles that centered around who was assigned as the leader. Since the other members had nothing to do or could not continue to focus on the discussion, they did something else that was irrelevant to the group task.

Step 2: After Telenoid was introduced, all of the children started to negotiate with the operator who became a newcomer to the group and the human members began to work together. Telenoid was accepted by the children as a special entity or a character that resembled a person but was a stranger or a non-human. A boundary was set between Telenoid and the other members, and the group form became a one-to-many relation.

Step 3: Telenoid was accepted as a member of the group with the help of the others, and the operator also contributed well to the group. As discussion proceeded, some of the children said that Telenoid seemed to be the operator himself. In other words, they felt the tele-presence of the operator. Telenoid let the operator's voices be heard and the other members accepted most of his opinions.

Since they were attracted to the novelty in the beginning, the children touched and stared at Telenoid. But once group work began, they turned their attention to its function as they confronted its constraints for cooperation with the operator. Although Telenoid nodded and made other gestures, they began to realize how communication with it was different from face-to-face communication. They became aware that Telenoid's voice was almost too soft to hear in the classroom where discussions were held and the operator could not write or draw, and they worried whether the operator could hear them and see the same things that they saw. With the awareness that the operator was weaker than usual, the spontaneity of the other children was elicited, and they began to support the needs of the operator, to whom they carefully listened and considered how to support. For example, one girl tried to support him: *"Should we talk louder so that you (operator) can hear us? We have to speak up and explain clearly. Let's see. Can you see the whiteboard?"* The spontaneour support of the children for the Telenoid operator was encouraged by its weakness or constraints and interactively developed with the operator's reactions.

Patterns of attitudinal change

Listened to carefully by the others, the operators slowly became able to talk. At first, most felt the difficulty of entering discussions being held by the others. For example, one operator gave the following answer in a group interview:

Operator: I felt something was wrong because I could not join the discussion.

Interviewer: Do you mean that it was difficult for you to jump in when you wanted to participate?

Operator: Yes, I do. It happened while everyone else was talking.

Another child: You did not feel like you were part of the group?

On the first day, an operator in the other group said, *"I could say what I wanted without Telenoid. But with Telenoid, it became hard to talk when I could not respond."* On the second day, however, the operator became more positive and made the follow comment:

Child: Yesterday you did not talk very much, did you? Was it hard to talk? But today you talked a lot.
Operator: Since everyone talked clearly today, it was easy for me to talk. Everyone asked me a lot of questions, which also made it easier.

It soon became easier for the operators to talk as the other children changed and adopted an unusual dialogue strategy for responding to the needs provided by Telenoid. With such assistance provided by the others as listening, asking, and showing educational materials, the operators could participate in discussions. Meanwhile, they took not only a passive role but also positively began to take a cooperative attitude toward the group. As a result, the unusual aspects of their personality were shown.

Telenoid introduced so much conditioning that the operators were pushed to express their hidden potential. They had constraints on their body movements including their extremities, their facial expressions, eye contact and what they did with others. These constraints became challenges for the operators to overcome for communicating as usual, and so they were stimulated to participate. They had to seek cooperation due to the constraints on what they could usually do by themselves, such as moving, writing, and drawing. They were forced to explore how they should collaborate with the help of others.

The operators, on the other hand, were visually and aurally augmented to concentrate objectively on the discussions with a microphone at the center of the group and a camera view from above. They were partially free from the constraints of their bodies to such an extent that they had a bird's-eye view of the group and kept their eyes open for the behaviors and the roles of others. The operators were in a passive position that elicited the spontaneous responses of others. But by paying attention to objective observations, they began to coordinate the roles of the members for mutual assistance.

As a striking example that indicated role differentiation, an operator began to take the role of coordinator, and all the members in the group answered in interviews that they finally felt a sense of unity. Although the operator preferred to do everything by himself and stripped others of their responsibilities before Telenoid was introduced, he said, "I was able to give others instructions while I was looking at the group as a whole." He actually changed his attitude toward the other members during a dialogue:

Operator: Please give her some advice about what she is writing. Tell her that she should change it like this. (Calling his friend's name, the operator said,) Come again?
Another child (The child called by the operator): Well, I'm giving her some advice.
Operator: OK. OK.

As a pattern of attitudinal change, we discovered coordinated behavior of the operators for overcoming their constraints and forging mutual assistance with other members. A decisive factor of the role differentiation and the collaborative work was the increase of what the operators could not do alone, and the reduction also affected the role making of others. The children who had nothing to do or had difficulty participating in the normal group work became

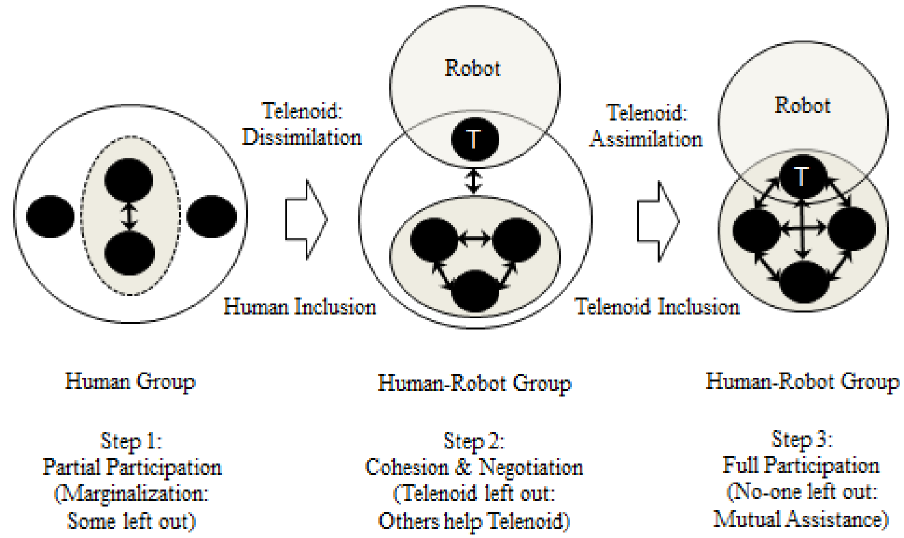

Figure 5: Model of change in group structure

mediators, which served to establish and reinforce the cooperative relationship between the operator and the others.

Typically, members worked by themselves. After Telenoid was introduced, those drawing changed their attitudes and participated in making up a story. A girl who had been scribbling joined the communication process between the operator and the other members. *"Can you see something?"* she asked the operator, *"Can you see this board? I can read this story for you. Listen carefully."* In another scene, she repeated the operator's talk and transmitted it to the others. She controlled the process so well that she turned the role on its head and intentionally repeated the words for fun. Thus, as another kind of attitudinal change pattern, such spontaneous role behavior of a mediator emerged.

By finding ways to respond to the operator's needs, the others developed spontaneous support for their own role making that might contribute to all of the members by promoting reflection and discussion participation. The operators became positive and overcame their own difficulties and developed a cooperative attitude. As in the model diagram depicted in Figure 6, the attitudinal changes of the children were caused by the introduction of Telenoid, which constrained and weakened their capability for autonomy but paradoxically released their potential to collaborate for mutual assistance. In addition to role differentiation, a role change in their supportive relationships was also seen from another perspective.

At first, the operators, who were supported by the others one-sidedly, assumed positions to coordinate the

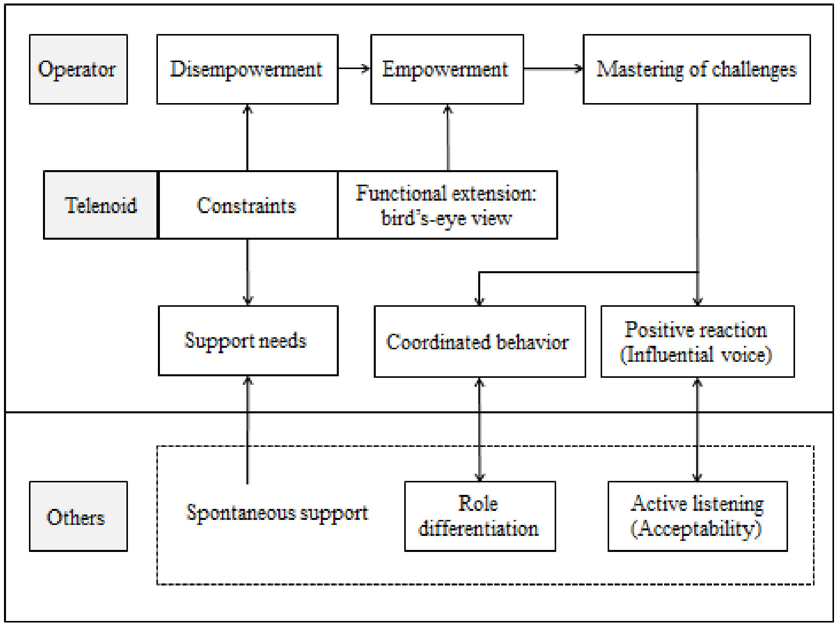

Figure 6: Attitudinal change mechanism

group. They also increased their influence over the members and were heeded carefully as they began to show positive reactions, ideas, and appropriate feedback. In an interview after the experiment, their teacher mentioned the operator's influential voice and described his impression: *"I'm not sure how, but the opinions provided by Telenoid were more strengthened and accepted by the other children than usual."* The children were also impressed by the operator's attitudinal change and said, "*He talked more than usual!*" Supporting the operator's needs, the others took a receptive attitude and actively listened to seek the operator's opinions in accordance with the development of positive reactions.

Discussion and conclusion

As a result of introducing Telenoid to the group work of the children, the structure of their interaction changed. Before Telenoid was introduced, the participation of the children in the activity was partially limited, but after its introduction all of the human members started to work together cohesively. Although at first the operator of Telenoid was treated as a stranger or an unusual new entity, he was eventually included and accepted as a member of the group with the help of the others. Thus, the group form in which all of the children could participate in the activity with their own roles was eventually created and they worked interactively and cooperatively.

In the structural changes of the group forms, attitudinal changes occurred in the children. The operator movements were limited when using Telenoid (e.g., they could not write or draw), and when the other children became aware of these limitations, spontaneity was observed in their attempts to help the operators; the children found themselves in the role of mediators assisting the operator, and participation in discussions was promoted. On the other hand, role differentiation also occurred with the operators. Due to their constraints, they assumed the roles of coordinators in the interactions, and by fulfilling a useful role despite their constraints, they exhibited more positive attitudes and displayed more cooperation and a spirit of mutual assistance in interacting with the other children. By showing positive reactions to questions asked by the other children and appropriately providing ideas, they increased their influence over the other members. In accordance with their reactions, the others assumed attitudes of active listening. A relation for mutual assistance was developed and strengthened. Thus, the unusual aspects of the operators were positively viewed and exploited and the spontaneity of others was elicited and developed.

Stimulating underlying needs of care-receivers

Such spontaneity of the other children to help the operator was probably due primarily to the constraints or weakness that Telenoid provided with the operator. This suggests that when a robot cannot perform certain tasks it gives an opportunity to the people interacting with it to fulfill their potential to carry out certain behaviors and participate more in interactions. The person interacting with the robot feels as if she should step in to provide the missing capability. This result also suggests that what parents and caretakers cannot do by themselves puts others like children or elderly who are always taken care of in positions to do what they can. Here is a reversal of roles, in which an operator who usually takes care of others becomes the one to be taken care of when using Telenoid, and in doing so, brings out the spontaneity of others. It seems noteworthy both in child and elderly care that Telenoid creates the spontaneous urge of interlocutors to take the role of helping the operator. The role change of caring relationships can be more easily carried out by the limitations of Telenoid than in normal face-to-face: the reversal of roles may stimulate the underlying need of the care-receiver as passive being to be positive and valuable to others. Hence, it also appears promising to probe into the mechanisms of communication among elderly care-receivers and others with Telenoid.

Minimizing communication for effective learning

We can also consider the result from another viewpoint. Face-to-face is supposed to always be the best way for communication. However, when the children became aware of their limitations to cooperate with each other, they changed their attitudes and cooperatively worked with each other. Face-to-face is not always best. The result suggests that remote communication that that limits our capability is useful knowledge and might be useful for training an effective way to work more cooperatively than face-to-face. After the group work session with Telenoid finished, some of children returned to work separately, and some were again left out of the group without any role. Even if the effect of Telenoid on their operation was temporary, it might be possible in future work to make them learn how to work cooperatively in a more conscious way than usual. We must develop a way of leading them to reflect on what they were able to do with Telenoid.

Originally, the objective of designing Telenoid was to create a minimal human appearance which could facilitate a feeling of close presence during remote interlocution; now we focus on a new concept, the establishment of “minimal communication”, in light of the benefits we have observed in the current work toward improving cooperation. In the future, the concept of minimal communication, i.e., the conditions required for promoting cooperation and what benefits can be realized by minimizing or restricting communication in various ways, should be investigated. We plan to observe users engaging in various forms of minimized communication using Telenoid or typical communications media such as telephones or Skype.

Limitations in the current work

One of the potential issues is whether or not the children were affected by the training they received for using Telenoid before the experiment. We think that even if they had not been trained, the children would still have tried to remedy the limitations of the robot (e.g., “Can you hear us?” “Can you see the whiteboard?”). This is because a restricted design, such as one with short arms and no legs, suggests through its appearance that help is required from others, and because the robot was tele-operated: operators tried to relay their requests to the other children and mutual needs were interactively explored. However, the result might have been changed if the operators had not been the acquaintances of the other children or the robot had been regarded as autonomous without any explanation.

Another issue is whether or not there was any influence of the actual physical distance between the tele-operator and the other children. During this initial study, we supposed that there was no difference in substance between the situations where the operator had been in a room nearby and somewhere further away (e.g., a long plane flight away). It could be the case that the children’s empathetic behavior of helping the operator child in remote to hear and see better might have been increased if the operator had been far away. The reason would be because the operator’s remote situation unknown for the other children in itself might have attracted their attention. Also, they might have been motivated to know what the operator could see and hear, and to interact with each other. Further investigation in each situation is required to address all the issues described above.

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