A Prototype System of Remote Music Therapy
Using the Latest Communication Technology in Japan

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ABSTRACT
This paper describes a prototype system of remote music therapy for elderly people with dementia using the latest communication technology in Japan. The system uses the latest high-speed optical network, called NGN (Next Generation Network) and the latest terminal especially for audio data communication called Hikari DUETTO NY1, which was released at the end of the last year. We did an experiment of the system using the real communication environment in this January between Tokyo and Osaka. The communication time of the system between Tokyo and Osaka was about 25.5 msec. Thus, we confirmed that the system was able to provide almost real-time audio data communication. Based on the result, the feasibility of music therapy activities, such as singing and exercises with music, using the system was examined. We confirmed that the singing activity which is the most important one in the music therapy was feasible.

Categories and Subject Descriptors
H.4.3 [Communications Applications]: Computer conferencing, teleconferencing, and videoconferencing.

General Terms
Design, Experimentation, Human Factors.

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1. INTRODUCTION
With advancement of medical technology, the number of patients who can live are increasing, even if they had serious disease and accident. This is really happy occasion, however, many of the patients are involving permanent damages, such as paralysis. They need nursing care and rehabilitation for their self-sustained life. In addition to this, the number of elderly people are increasing all over the world. Thus, the number of elderly people who has ailment are also increasing. Many of them also need nursing care and rehabilitation for their self-sustained life. These nursing care and rehabilitation should be provided in special institution such as one for day-service and rehabilitation center by special therapists such as physical therapists and speech therapists. However, it becomes difficult to provide enough nursing care and rehabilitation for the people because they are increasing year after year. Thus, telemedicine, telecare, and teletherapy which enable them to receive nursing care and rehabilitation in their own houses are expected.

We are researching and developing a remote music therapy system to provide music therapy for the elderly people with dementia living in isolated areas and islands where no music therapists exist. This paper reports the latest progress of the system development and the results of the first demonstration experiments.

2. Related Work
Telemedicine are actions to contribute health enhancement, medical care, and nursing care using ICT technology[1]. Recently, telecare becomes another type of telemedicine. Some telemedicine
and telecare are held on line, but some are held off-line. These are provided for people living in isolated islands and underpopulated areas, since there are not enough special medical staffs there. The kinds of actions in telemedicine are widely spread: from telephone consulting service and diagnostic imaging to operation using remote system.

As mentioned in the Introduction, the number of patients who won’t die when they had serious disease and accident are increasing according to the advancement of medical technology. Thus, problems of the patients become more various. As a result, not only in medical care but also in nursing care and rehabilitation, team medicine by various kinds of specialists such as doctors, nurses, physical therapists, councilors and so on is expected more and more. This means people living in isolated areas will be more difficult to receive enough team medicine since it needs various kinds of specialists. Thus, ICT technology to support telecare becomes more and more important in the future.

3. Music Therapy

Music therapy is defined as a curing technique that purposely and systematically uses physiological, psychological, and social nature of music to restore from psychosomatic disorder, to and systematically uses physiological, psychological, and social nature of music to restore from psychosomatic disorder, to

The quality of lives[2]. In Japan, a music therapy session is carried out for one-hour at once a week or a few times in a month. In the session, singing to improve cardiopulmonary function and breathing function, exercise with music to improve physical functions, ensembles to improve concentration, and conversation about old days hearing old music, which calls reminiscence are taking place.

In this super-aging society, the length of the nursing care and rehabilitation for the elderly people are extending. Maintaining elderly people healthy bodies and minds for a long time is one of the important family wishes. Moreover, it is one of the most important social problems, since it related to decreasing the cost of medical care. Rehabilitation should be designed to be done easily and with a lot of fun since its success highly depends on the patient’s motivation.

Music therapy is very popular in nursing care for the elderly people, however, sometimes problems shown in the followings will happen.

1. Music therapists have their own specialized domain. Some therapists specialize in the treatment of children, some therapists specialize in the treatment of the elderly people. Thus, even if there is a music therapist in the neighborhood, the therapist is not always the one whose specialized domain matches to the domain you need.

2. Institutions, such as a nursing house for the elderly people and a group home for people who has mental illness, in which people who need music therapy are sometimes are places where traffic is brutal. Thus, music therapists rarely visit there. Or, music session costs high, since travel cost may be added to the session fee.

3. Many music therapists need the piano or the keyboard which are too big and heavy to bring to the institutions by themselves. Thus, each institute should have the piano or the keyboard to have music therapy session, however, few institute has the instruments since they are expensive.

One of the ways to solve these problems, music therapy is provided via network. If a music therapist can do session for people living far from his/her house via the network from his/her house, the therapist is not necessary to go to the places bringing heavy musical instruments. Moreover, if there is no music therapist whose field of specialization matches to the clients in the neighborhood, the clients can find the matched therapist. The session fee for the music therapy may become cheaper, since therapists need no cost for the transportation.

In the remote music therapy, a therapist is not near to a client, but does the session via network. You can imagine a music therapy session with video telephone. By the growth of the Internet, we can communicate people in remote area seeing the faces via Skype, Google-hangout, and so on. So, you can easily imagine that people can participate music therapy using such a communication service. However, it is impossible to provide music therapy via network using the Internet. Because there must be delay in audio data communication and the delay cannot be predictable. This means we cannot control the delay of the audio data communication based on the prediction.

Singing is the most important activities in music therapy. A music therapist sings together with the clients and accompanies the client’s singing by quickly adjusting tempo and key to his/her singing. Not only in the singing, in other activities such as exercises with music and ensembles, the therapist provides music by quickly adjusting tempo and key according to the condition of the client. Thus, if there is long delay about audio data communication between the music therapist and the client, they cannot sing together nor the music therapist cannot accompany the client’s singing. If there is a private line between the music therapist and the clients, no-delay communication environment can be constructed, but it is not reasonable since it will be so expensive. Thus, there was no trial about remote music therapy.

But now, it became true by using the high-speed optical network and the latest voice communications terminal released last November in Japan, since it provides bidirectional real-time voice communication.

3.1 Dementia and Music Therapy

Dementia is a condition that recognition function which normally grew degrades widely and permanently beyond physical aging because of a posteriori damage[3]. Because damages appear in recognition function, not only the patient has difficulties in independent living according to ingravescence, but also for families and for care staffs, it is said that dementia is one of the most difficult diseases of caring. Unfortunately, we cannot expect a complete cure. There only is a medicine that can slow down the disease somehow. Thus, generally speaking, non-pharmacological therapies such as music therapy, aromatherapy, and horticultural therapy are recommended to be used with pharmacological care.

There are two kinds of symptoms in dementia: one is impairment of cognitive function called “core symptom” which relates on brain damage and the other is peripheral symptom called “BPSD” (Behavioral and Psychological Symptoms of Dementia) which comes from the core symptom. The peripheral symptom makes the nursing care difficult. There are many kinds of BPSD. For example, trick and delusion which do not make the nursing care so difficult, and wandering round and violence which make the nursing care so difficult. The peripheral symptom is not always developed. Though there are various reasons to develop BPSD, some develop BPSD since they feel anxiousness by reducing cognitive functions, and some develop BPSD since they cannot feel self-esteem enough since they frequently make mistakes.
Music therapy is expected to maintain cognitive functions by audio stimulus and to improve feeling of the self-esteem by singing songs in the clients' young days and enjoying conversation related to the songs.

4. System Structure
In this research, we use a network service which is called “Hikari DUETTO” for audio data communication.

4.1 Hikari DUETTO
Hikari DUETTO is a generic term used to refer to a service which enables music session (ensemble) among people in remote places using Hikari telephone service, Flets Hikari NEXT service, and Hikari DUETTO NY1. Hikari DUETTO NY1 is a special communication terminal. Hikari DUETTO service is supposed to be used for activities, such as ensemble session with people in remote places, and piano lesson by teachers in big cities for students living in remote places.

4.2 Hikari DUETTO NY1
“Hikari DUETTO NY1” utilizes NETDUETTO technology developed by YAMAHA. This terminal enables us to obtain almost no-delay audio data communication.

Hikari DUETTO NY1 can accept output of the musical instruments and output of the microphone as its inputs and can output audio both from monitor speaker and from a headphone. When it uses Hikari telephone network, it can connect two places. When it uses IPv6 network, it connect four places at the maximum simultaneously.

4.3 High-Speed Optical Network of Next Generation: NGN
NGN is the information communication network which utilizes internet protocol technology which aggregates fix-line, mobile line, telephone, and data communication in the next generation. It provides reliability and stability which are provided in the conventional telephone network and also provides flexibility and economic performance which are provided by IP network. In this research, Flet’s Hikari NEXT which is the NGN service of NTT group is used. It is an IP network which utilizes SIP to aggregate various kinds of network services such as telephone service and video data communication service. One of the important features of the service is that service provider can control QOS (Quality of service) and security via Service-Network Interface. Internet providers are connected by the conventional Network-Network Interface. Optical fibers are used for access lines.

The most important feature for this research is that the QOS control function. In NGN, there is the priority class which guarantees the quality as well as the conventional best effort class. The priority class is used for real-time communication such as video telephone and video broadcasting. The class can provide stable audio data communication and fine grain video communication by the QOS functionality.

4.4 Video data Communication: Hikari Danran TV Service
To do music therapy session via network, video data is also necessary both for the clients to see the face of the music therapist and for the therapist to check the clients’ faces and degree of the participation. Unfortunately, we cannot obtain video data communication without delay by the general network. Thus, about video data communication, we are not supposing specific video data communication services and terminals. Both SKYPE and Google hangout are also OK.

In this research, Hikari Danran TV service which is provided by NTT West Co. Ltd., is used. In the service, users can do video telephone using a TV monitor in their houses. In general, TV is placed in a living room in many houses, thus it is suitable to use it as a monitor for the remote music therapy. Moreover, clients may start receiving remote music therapy with ease, since they can use TV monitor which is familiar to them for a long time. A cable to connect TV monitor and a camera are included in the service, so
users can start video telephone by just connecting the terminal to the network.

5. Experimental results

5.1 Prototype System
Figure 3 shows the prototype system which was constructed for the remote music therapy in this research.

The network is the NGN. A home gateway is used to connect to the NGN. Hikari DUETTO NY1 for audio data communication and a Hikari Danran TV terminal for video data communication are connected to the gateway. A TV monitor in home and a camera are connected to the Hikari Danran TV terminal for sending and receiving video data. A keyboard and a microphone are connected to the Hikari DUETTO NY1 to play accompaniment and singing, and monitor speakers are connected to the Hikari DUETTO NY1 to listen to the singing and the talk of other person.

5.2 Experimental Environment
Figure 4 shows the experimental environment. This experiment was held between headquarters buildings of NTT East Co. Ltd., in Tokyo and of NTT West Co. Ltd., in Osaka. They are connected to NGN.

5.3 Experiments
In the experiment, two music therapists are set in both Tokyo and Osaka. They played two roles: a music therapist and an elderly person with dementia. In the experiment, activities shown in the Section 5.3.2 were held. Music therapists were asked to give their views about the feasibility and problems as specialists to provide music therapy, and also asked to give their views about the acceptability and problems for the clients with supposing the clients who receive the therapists’ music therapy.

5.3.1 Delay Measurement
Audio data communication time between Tokyo and Osaka of the system was measured. The result was 25.5 ms. Generally speaking, delay less than 30 ms is recognizable by trained people such as musicians, however, it is not recognizable for general people. Thus, the system was confirmed that it can provide almost no-delay audio data communication.

5.3.2 Feasibility Study of Remote Music Therapy
In this experiment, four music therapy activities of three kinds in the followings were used. Music therapists were asked to do activities as therapists and also receive activities as supposing the elderly people with dementia. Then they were interviewed about whether or not each music therapy activity could provide via network for the elderly people with dementia and about problems of the system which they felt.

Music Therapy Activities:
1. Singing
   1.1 singing of a simple song: a nursing song called “Furusato”, which means hometown in Japanese
   1.2 singing of a complicated song about rhythm and melody: a popular song called “Aoi Sanmyaku” which means Green Mountains in Japanese
2. Chase: a nursing song called “Morino Kumasan” which means Mountains in Japanese
3. Exercise with music: a Japanese ballad called “Zundoko Busi”.

The followings are the results.
1. Singing

There is almost no problem to provide singing activity in remote music therapy. Both simple songs containing only quarter notes in the constant tempo such as nursery songs, and complex songs containing various types of notes and changing tones frequently such as popular songs are OK.

In this experiment, a music therapist who played a role of the elderly person with dementia suddenly changed tempo and gradually changed key of the singing with thinking about the singing by the elderly people with dementia. Music therapists who provide music therapy tried real-time accompaniment to such singings.

As a result, music therapists who provide music therapy said that they could hardly accompany the client’s singings, when the therapists looked at the client’s singing face because there was a longer delay in video data communication than those of audio data. Music therapists who provide music therapy also said that they could accompany the client’s singing when they were concentrating only the singing voice of the client. They also said that they could provide music therapy about singing activity with the same feeling as when they provide music therapy in face-to-face style if they concentrate only the singing voice of the client in the remote music therapy. On the other hand, music therapists who played a role of the elderly person with dementia said that they could sing comfortably because they felt quite real that the music therapist adapted the musical accompaniment for their singing flexibly even though they frequently and intentionally changed tempo and key of the singing.

2. Chase

Chase is a kind of singing activity that two people sing one after the other. This activity was also no problem to provide one in the remote music therapy. Rather than that, we found that this activity has high potential becoming very important and very good activity in remote music therapy, since this activity requires paying attention to the other’s existence. For example one have to concentrate on the other’s singing and one have to wait for the other’s start singing. This is very good and important to provide activities to feel each other in remote music therapy, since both are not able to share the same air in remote music therapy.

3. Exercise with music

An exercise which requires moving both the upper body and the lower body was designed based on “Zundoko-bushi”. This song is
good for using exercise for the elderly people, since it is easy to listen because short phrases are repeated many times and it is very rhythmical.

The music therapists led the exercise both by showing how to move and indicating the movements by words, such as "next, please raise the right hand". Because video delays, the music therapists were asked to indicate the movement in time with music and to move a little bit earlier than the beats of the music.

As a result, the clients said that they could naturally do and enjoyed the exercise with the music therapists in the monitor, because the therapists indicated the movements by words and also showed the movement by moving a little bit earlier than the beats of the music. Before the experiment, we were afraid that the clients could hardly do physical exercise, since video delays. However, it was really OK for the clients. On the other hand, stress of the music therapists were so big because time lag between the time they started moving and the time they received the video of the moving clients was quite long. One of the solutions is that the therapists don’t see the video of the clients. However it is impossible for the music therapists, since they have responsibility of risk management, for example they have to apprise specific people when the clients get injury while the clients are doing physical exercise. According to the music therapist, the stress was not too serious that they could not bear. Moreover, they said that they got used to doing the physical exercise in this way while they were participating the experiment. Thus, music therapists will be required to have appropriate training to provide exercise activity in the remote music therapy.

5.4 Photos
Figure 5 and Figure 6 show the experiment of the day. Figure 5 is the photo in Osaka, and Figure 6 is the photo in Tokyo.

6. Conclusion
This paper described a prototype system of remote music therapy which used the latest communication technology in Japan.

By using the prototype system, we confirmed that we could obtain almost real-time audio data communication between Tokyo and Osaka, since the time for the communication was 25.5 msec.

Based on this result, three kinds of typical music therapy activities such as singing, chase, physical exercise with music were held to investigate the feasibility of the remote music therapy system.

Singing and chase had no problem to provide them in the remote music therapy. We found that the clients could participate physical exercise without stress, if music therapists gave the instruction of the movement by words and show the movement via video. Music therapists were needed to have training to move a little bit earlier than the beats of music.

Based on the results of this experiment, we are going to do experiments for the elderly people with dementia by constructing this prototype system between NTT lab and some nursing homes in remote places in the future.

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8. REFERENCES