A Case Study of a Practical Use of "MusiCuddle" that is a Music Therapy System for Patients with Dementia

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***Abstract*—In this paper, we conducted an experiment that an operator presented tunes using the "MusiCuddle" system to a patient with dementia who repeats utterances. MusiCuddle converted the patients' utterances into pitches (F0) at a predetermined interval. In response to an operator's simple key entry, the system automatically played tunes based on those pitches. This function may contribute to resonating with the patient's emotions on the basis of iso-principle that is one of principle of music therapy. In an experiment, we segmented a patient's utterances into sentences and compared her utterances when music was presented and was not presented. The results of the analysis showed that the sentences were uttered with music tended to include the word of the immediately previous sentence, as if she stutter out them. We thought that if a patient's attention could be captured by tunes, MusiCuddle could contribute to alleviating their symptoms.**

***Keywords*-** *Music*; *Convert utterances into pitch*.

I. Introduction

Dementia is the deterioration of cognitive ability and skills due to an organic disorder (such as Alzheimer's disease, dementia with Lewy bodies, cerebral vascular dementia, and frontotemporal dementia, and so on.).

As one of the symptoms of dementia, some patients repeat stereotypical behaviors and utterances. When we recorded the utterances of patients with mental instability for one month, regardless of whether a result of a test of cognitive function is good or bad, many patients repeated stereotypical utterances [1]. One of them repeated, "Did you do it?" in a falsetto, another cried, "I want to go to the restroom!" even after she had been to the restroom. Another locked herself in a restroom and repeated the same words in a loud voice all day. However, when a caregiver said something to her, she could greet clearly.

In most cases, we could not understand what the patients were saying. Although doctors, nurses, and caregivers talked to the patients and attempted to distract them into another action, it was not easy to calm the patients down. Therefore, music that resonates with the patients' emotions and calm their symptoms can be expected to help the caregivers in caring for these patients.

Music therapy is one of the methods known to alleviate symptoms of dementia. Park and Pringle Specht [2] conducted an experiment in which individuals with dementia listened to their preferred music. The result showed that mean agitation levels were significantly lower while listening to music than before listening to the music. Svansdottir and Snaedal [3] showed a significant reduction in activity disturbances, aggressiveness, and anxiety in the group assigned music therapy. The study of Nair, Heim, Krishnan, D'Este, Marley, and Attia [4] did not find that ambient Baroque music had any calming effect. However, they showed that in order to achieve the desired behavioral effect, music may need to be tailored rather than generalized.

The iso-principle [5], which is one of the principles of music therapy, suggests that a music therapist first perform music that matches the current mood of a patient. This type of therapy is also effective for symptoms of mental instability in which patients repeat stereotypical behaviors and utterances, such as in some dementia patients.

Therefore, we [1] present a music therapy system, "MusiCuddle," which accompanies patients' agitated repetitive

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stereotypical utterances with music that resonates with his/her mood. This system converts the patients' utterances into pitches (F0) at a predetermined interval. Then, the system presents a music phrase (tune). The first note of it is same as the pitch converted from the patient's utterances. Moreover, one type of tune is cadence that begin on a chord that resonates with the patient's current emotions and finish on a terminative chord that calms his symptoms.

In this paper, we prepare more tunes in the database of MusiCuddle. Then, we conduct an experiment that one of authors presents tunes using MusiCuddle to a patient with dementia who repeats utterances.

II. Resonate with the patients' emotions

The iso-principle is well known to music therapists trained in the United States [6]. "Iso" simply means "equal"; that is, that the mood or the tempo of the music in the beginning must be in "iso" relation with the mood or tempo of the mental patient. The principle extends to volume and rhythm [5]. The actual use of music in a particular therapeutic situation depends upon the particular needs of the individual, such as a need for therapy to change behaviors on an immediate basis to relieve troubling conditions [7]. For example, if the client is distressed or agitated, then the quality of the music initially should match his or her mood and energy. By adopting the iso-principle, the first choice of music may be familiar and energetic [8]. In improvised music with the client's music, "match" means that the therapist's music is not identical to the client's music, but is the same in style and quality [9]. Likewise, in "validation," one of the methods used for communication between clients and therapists, a therapist will observe the mood of a client and will emit the same tone with his voice to indicate that he sympathizes with the patient [10].

In our ongoing research, we are constructing a music therapy system that performs music semi-automatically. It is difficult for the system to play improvised music that resonates with the patient's emotion in the same way as a music therapist. However, we have tried to construct the system using an advantage point of a computer. In the first step of our research, we allowed the system to convert a patient's utterances into pitches (F0) continuously. In response to an operator's key entry, the system selects a short phrase in a database. The first note of the phrase is same as the pitch converted from the patient's utterances. We expect that this function may contribute to resonating with the patient's emotions on the iso-principle. Moreover, we prepared cadences that begin on a chord that resonates with the patint's agitated mood in the database of MusiCuddle.

III. Set up system

MusiCuddle is a music therapy system that performs music when an operator (e.g., a caregiver) pushes any of the keys of the electronic keyboard or a button on the display of the system [1]. The system also continuously converts the patient's utterances into pitches (F0). In response to the operator's key entry, the system determines a pitch at a predetermined interval. The system selects a tune, a short phrase, in the database on the basis of that converted pitch. The top note of the tune is the same as the pitch converted from the patient's utterances. To convert the patient's utterances into pitches, we employ a pitch extractor to convert the utterance into one pitch (i.e., Do, Re, Mi). This is based on the technique for conversion of sounds that have unstable pitches and unclear periods, such as natural ambient sounds and the human voice, into musical notes [11].

In the original system shown by [11], if the operator gave a start trigger, the system would initiate the processing to obtain the F0 (fundamental frequency) time series from the acoustical signals (i.e., a singing voice), which were being recorded via the microphone. The short-term F0 estimation by Fast Fourier Transform (FFT) and Inverse Fast Fourier Transform (IFFT) for the power spectral is repeated until the system catches an end trigger from the operator (i.e., the caregiver). The system then calculates a histogram of pitches with the F0 time series between the start and end triggers. Finally, only the most frequent pitch is selected and is output as the pitch of the period.

For our research, some processing designs were modified. Figure 1 shows the processing of the system. Considering the attitude of the operator, we would assume that the triggers would be input after the operator catches the utterance of the patient. Therefore, we omitted the start trigger. The system starts a short-term F0 estimation just after invocation of the system and continues it thereafter. When the operator inputs a trigger that is regarded as an end trigger, the system calculates a representative pitch for a predetermined period just before the trigger based on the above-mentioned method. Then the system plays a prepared MIDI (Musical Instrument Digital Interface) sequence that corresponds to the representative pitch. These modifications of our system improve usability by reducing the time lag between the input of the trigger and the output of phrase.

To extract the F0 against the mixed acoustical signal of the patient's utterance and the cadence output from the speaker, our system needed two of the same microphone (the better solution is one stereo microphone) and one speaker. The microphones are set in front of the speaker to record the speaker's sound at the same level from both microphones. On the other hand, both microphones are displaced against the patient to record the levels of the patient's utterance that are clearly different. The system calculates the differential signals from the signals of both microphones to cancel the sounds of the MIDI sequence where they are localized in the center position. The F0 estimation is then determined with these differential signals.

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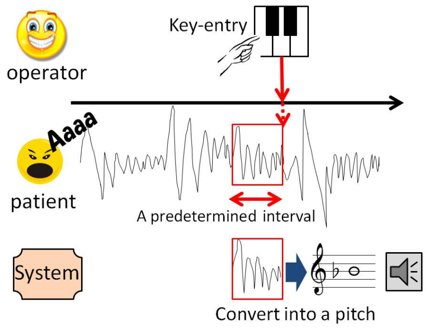

Figure 1. Convert into a pitch.

IV. Database of Tunes

Tentatively, we prepared four types of phrases in the database. Table I shows some details of the phrases. The patients who repeat utterances in many cases are experiencing irritable moods and high anxiety. Generally, dissonance chords indicate tension and consonance chords indicate relaxation. Clinically, a combination of these chords can elicit tension and relaxation within the human body. Therefore, we prepared dissonance chords and consonance chords. Moreover, we prepared cadences that begin with dissonance chords and finish with consonance, as well as terminative chord.

"Four chords" means that the same four chords are presented in one phrase (see Fig. 2). The chord is composed of two notes. Thirty-seven MIDI files, of which the top notes of the chords are C3∼C6, were prepared per one type chord (see Fig. 3). Accordingly, the system can select a MIDI file of which the top note of the chord is the same as the pitch converted from a patient's utterances. There are 888 MIDI files (phrase files) for a four-chord type phrase. In the "Rhythm" column of Table I, "Quarter note" means each of the four chords is presented in the rhythm at the rate of 60 times per minute. "Random" is unregulated rhythm [12]. The "Interval" column shows intervals between two notes composed of each chord. In the "Change of volume" column, "No change" means four chords are presented in the same volume. "Crescendo" means that the volume of notes gradually increases one by one, while "Decrescendo" means that the volume of notes gradually decreases.

In the type of "Cadence," we prepared 96 kinds of cadences that begin with dissonance chords and finish with consonance, as well as terminative chord. These cadences were picked out from two piano suites; "Das Wohltemperierte Klavier Band 1, BWV846-869," composed by J. S. Bach in 1722, and "24 Preludes and Fugues, Op.87," composed by D. D. Shostakovich in 1952. Both suites consist of 24 pieces (24 tonalities), and one piece consists of a prelude and fugue. We could prepare at least 96 cadences, if two cadences were chosen from one piece, the prelude, and the fugue. The top note of the first chord in each cadence is applied as any of 12 tones, Do, Do sharp, Re, Re sharp, and so on. Moreover, each piece is translated to go up/down one to three octaves to cover all possible tones converted from the patient's utterance. The plural cadences correspond to each of 12 tones converted from the patient's utterance.

In the other direction, we prepared phrases from Japanese school songs. Ashida reported that reminiscence-focused music therapy might reduce depressive symptoms in elderly people with dementia [13]. Therefore, we picked out short phrases from some familiar songs for elderly people. We created a simple accompaniment for each phrase. Each phrase was arranged into 37 MIDI files, the first notes of which were C3∼C6.

Fig. 4 shows two kinds of phrase. These are the same tune, "Akaikutsu." The top of them begins with C4 as well as the bottom of them begins with G#4. The difference in the pitch of the first notes affects and changes the entire mood of the music.

The last type phrases were created from the patient's utterance. All segments of her utterance could be converted into some notes. Fig. 5 shows an example. Previously, her utterance, "i-ma-se-n-de-su-yo [I am not here]," was converted into a phrase "re-re-re-si-ra-ra-si." This phrase was also arranged into 37 MIDI files, the first notes of which were C3∼C6.

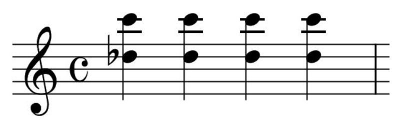

Figure 2. Same four chords are presented in one phrase.

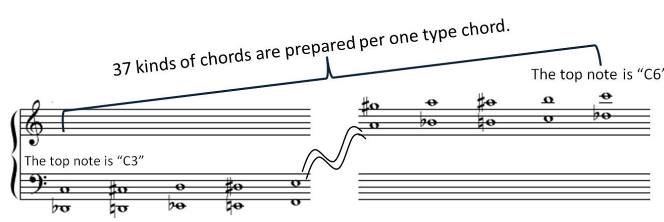

Figure 3. The top notes of the chords are C3-C6.

V. Experiment

A. Ethical Considerations

This experiment was approved by the Research Ethics Board of Saga University. The participant of the experiment,

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Table I
TUNES

Types	Details	
Four chords	Rhythm	Quarter note, Eighth note, Sixteenth note, Random
	Interval	Perfect prime, Perfect fifth, Major seventh
	Change of volume	No change, *Crescendo*, *Decrescendo*
Cadence	Bach	Das Wohltemperierte Klavier Band 1, BWV846-869
	Shostakovich	24 Preludes and Fugues, Op.87
Japanese school song	“Yuki,” “Akaikutsu,” “Hana,” “Tsukinosabaku,” etc	
Stereotypical utterance	*Ex.* Utterance, “i-ma-se-n-de-su-yo” is converted into a phrase “re-re-re-si-ra-ra-si.”	

Figure 4. The difference of the first note changes the entire mood of music.

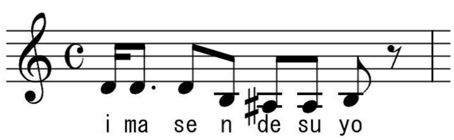

Figure 5. The segment of patient’s utterance is converted into some notes.

who is a patient with dementia, her husband, and the hospital director were informed about intention of the experiment and the treatment of personal information. Moreover, they were informed that they could withdraw from the experiment at any time. Then, we obtained written consents from them.

B. Participant

The participant is a patient with frontotemporal dementia (FTD) staying in a hospital. She is 72 years old. The score of Revised Hasegawa’s dementia scale (HDS-R[14]) was 17 two years ago. She repeats the same words for many hours a day. When she is agitated, she locks herself in a restroom. However, she is lucid enough to remember the nurse’s name and greet her clearly.

C. Preliminary experiment

When the participant was agitated and repeated the same sentences, one of the authors repeated sentences in accord with the participant’s repetition in the same melody and rhythm. Fig. 6 shows these sentences in music score. Sentence A means the participant’s sentence. First, the author tried to repeat the same sentence as the participant’s together. Namely, both of them repeated Sentence A, “i-ma-se-n-yo.” Second, the author tried to repeat a different sentence using the same melody and rhythm pattern as the participant’s together. Namely, the author repeated Sentence B, “go-han-de-su-yo” although the participant was repeating Sentence A.

In the first trial, the participant turned around to pay attention to the author. However, she kept repeating the same sentence harmonised with the author’s repeating. In the second trial, the participant changed the sentence A to the author’s sentence, “go-han-de-su-yo” in the same melody and rhythm.

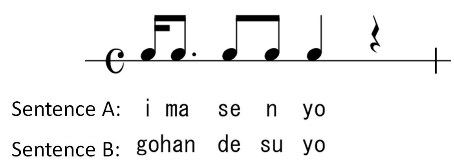

Figure 6. Author repeated sentences in accord with the participant’s repetition.

D. Method

When the participant is agitated and repeats the same words, an operator (one of authors) presents tunes using the system MusiCuddle. The tune is presented through a wireless cuboidal speaker, 123×36×35mm, and the patient’s utterances are recorded through a wireless columnar microphone, about 75mm in height and 24mm in diameter. These devices are set in the restroom.

E. Analysis method

In this paper, we analyze the participant’s utterances in three records: 16, 8, and 3 minutes. The participant’s utterances are segmented into small sentences based on the way of repeating. Then, we analyze ways to change the sentences.

First, we determine whether each sentence was uttered "with music" or "without music." If a tune was presented in the middle of a sentence, the sentence was considered to be uttered without music. In this case, the sentence was started to utter before presenting the tune. So, we consider that the sentence was untouched by music. In the following example, "hirugohandeha" is recognized as no music:

P: imasendesu **hirugohandeha** imasendesu
[
(Start a tune)

In the following example, "ima" as well as "gohanden" are recognized as they were uttered with music:

P: imasendesu ... imasen **ima gohanden**
[ ]
(Stop a tune)

The sentence, "ima" was started to utter with music. So, this sentence was affected by the tune. Moreover, we consider that "gohanden" was affected by the tune because this sentence was started to utter immediately after presenting the tune.

Second, we determine whether each sentence includes the words that are part of the immediately previous sentence. In the following example, "imasendesu" includes the immediately previous sentence "ima:"

P: ima imasendesu

F. Results

1) Presented tunes: In the first and second record, we presented the tunes arbitrarily by giving triggers to MusiCuddle. In the third record, we did not present the tune at all. Recording time is 27 minutes. The total time of presenting tunes was 6 minutes and 54 seconds, which is one-fourth of all recording time.

Table II shows kinds of tunes, times of the tune, and total time of the tunes at the first and second-record. First, we presented six four chords. In this record, we use one type of four chords: Major seventh, Quarter note, and No volume change. This chord can show unsteady images to the participant. Next, we presented a Japanese school song, "Yuki," four times. The patient sang only the last phrase, "zun zun tsumoru [accumulate rapidly]" along with the melody the first time. Continuously, "Akaikutsu" was presented five times. Next, five cadences were presented. The kind of cadences were decided by the pitch converted from her utterances. After that, we again presented "Yuki." She sang again. The last tune of the first record was a Japanese school song, "Hana." In the second record, first, we presented a Japanese school song, "Tsukinosabaku," four times. Continuously, "Yuki" was presented nine times. However, she did not song along with them. Next, we presented the phrase created from her utterance "i-ma-sen-de-su-yo" five times. At the end of the record, we presented "Hana" two times.

2) Classify utterances: The participant uttered all times of the experiment. Most of utterances were rhythmical and fit into same meter, although she uttered many kinds of sentences. Fig. 7 describes some examples of her sentences. One of the authors took rhythm dectation of these sentences. These example shows even if the sentences are different, they fit into four-four time.

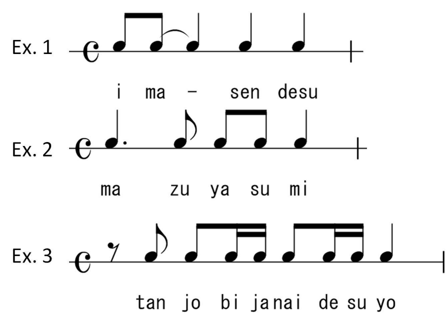

Figure 7. Sentences fit into four-four time.

Table III shows the kinds of sentences. The segmented sentences are 680 (84 kinds) in 27 minutes. There were many cases in which the contents of the sentences are almost the same even if the words among the sentences vary slightly.

Table IV shows the comparison between "with music" and "without music." The number of changing sentences is 114 with music and 179 without music. The tune-presented time is one-fourth of all recording time. Therefore, the change of sentences with music occurs with greater frequency than that without music. However, with music, the rate that the sentence includes the word of the immediately previous sentence is higher than that without music. The rate with music is 82.5%, whereas that without music is 41.3%.

Table IV
THE NUMBER OF CHANGING SENTENCES.

	with music	without music
changing sentence (ALL)	114	179
include the words of the immediately previous sentence.	94	74
rate (%)	82.5	41.3

VI. DISCUSSION

Patients with dementia who continually repeat utterances tend to repeat the same or similar content. Moreover, the

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Table II
PRESENTED TUNES IN THE EXPERIMENT.

Types	Tunes	Time(sec.)	Number of times	Beginning note	Total time(sec.)
Four chords	Major seventh & Quarter note & No volume change	3	6	D3(2),D#3,F3,A3,C4	18
Cadence	No.22 Fugue (B)	8	1	C4	8
	No.1 Fugue (B)	8	1	F3	8
	No.15 Fugue (B)	11	1	F#3	11
	No.22 Prelude (S)	15	1	D4	15
	No.3 Fugue (S)	25	1	F#3	25
Japanese school song	"Yuki"	9	21	D#3, E3(3),F3(7),G3(2),G#3,A3(3),A#3,B3,C4,D4	189
	"Akaikutsu"	10	5	D3,F3,F#3,G#3,A#3	50
	"Hana"	8	4	D3,G#3,A#3,G#4	32
	"Tsukinosabaku"	11	4	F#3,F3, C4,C3	44
Stereotypical utterance	i-ma-se-n-de-su-yo	3	5	G3,G#3,A3(2),A#3	15
Sum	–	–	50	–	414

In the "Tunes" column, "(B)" means the tune is a part of a piece composed by Bach, and "(S)" means the tune is a part of a piece composed by Shostakovich.
In the "Beginning note" column, C, D, E∼A, and B show Do, Re, Mi∼Ra, and Si. A4 is about 440Hz. Values in parentheses shows the time of each beginning note.

participant in our experiment uttered in the same meter, four-four time (see Fig. 7). Once patients fall into the pattern of repeating utterances, it is difficult for them end the cycle independently. Generally, their caregivers address the patients directly by calling out to them in attempt to shift their attention, but it is not easy.

MusiCuddle might resonate with his or her mood in accordance with the iso-principle. The first notes of the tunes that were presented in the experiment were also varied and wide-ranging because the pitches (F0) converted from the participant's utterances were varied and wide-ranging. The difference in the pitch of the first notes affects and changes the entire mood of the music (see Fig. 4). Tonality and pitch (high or low) are essential determinants of musical mood.

The results of our case study suggest that tunes presented by MusiCuddle may give patients an opportunity to stop repeating utterances. The participant in our case study stuttered when each tune was presented. Each tune presented by MusiCuddle began with a note in the same pitch as that of the participant's utterances. However, each melody presented by MusiCuddle was different from the pattern of the participant's utterances. On the other hand, in the preliminary experiment, when one of the authors repeated the same sentence as the participant's sentence using the same melody and rhythm pattern, the participant kept repeating the same sentence although she was paying attention to the author (see Sec. V-C).

These results suggest that the sounds that are presented to patients should neither be identical to nor entirely different from their utterances. The patients might attend to the tunes according to their similarity in pitch, and deflect attention away from repeating utterances if the melody is too strikingly different from their utterances.

VII. CONCLUSION

In this paper, we used a support system called "MusiCuddle" to present short music phrases to a patient with dementia. In our experiment, MusiCuddle presented a tune that began in the same note as a converted note from the participant's utterances. We then analyzed the changes in her utterances. When the tune was presented, she stuttered and tended to begin saying a new sentence that only contained a part of the immediately previous sentence. These results suggest that MusiCuddle may give the patients the opportunity to escape the pattern of repeating utterances.

We did a case study on only one participant to examine the effectiveness of MusiCuddle. Although we simply say "dementia" when referring to individuals who have deteriorating cognitive abilities, individual expression and progression of symptoms can very significantly from person to person. We have to consider the condition of participants and the advice of their primary doctors when we examine the participants. Thus, we will accumulate case studies of several participants step by step.

ACKNOWLEDGMENT

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REFERENCES

[1] C. Oshima, N. Itou, K. Nishimoto, N. Hosoi, K. Yasuda, and K. Nakayama, "An Accompaniment System for Healing Emotions of Patients with Dementia Who Repeat Stereotypical Utterances," Lecture Notes in Computer Science, B. Abdulrazak et al. (Eds.), Springer, Vol. 6719, pp. 65–71, 2011 [Proc. ICOST 2011].

Table III
SENTENCES SEGMENTED FROM THE PARTICIPANT'S UTTERANCES IN THE EXPERIMENT.

Estimated meaning	Sentences
I am (not) here.	imasu (1), imasendesu (201), imasen (48), imasende (43), ima (5), deimasendesu (1), sokoniimasen (1), imasenyo (1), uruchiimasendesu (1), ryugaimasende(1)
It is (not) luch time.	mazugohandesu (78), mazugohan (14), mazugohande (6), hirugohannarimasendesu (5) gohandesu (4), hirugohandashimasendesu (2), hirugohannarimasende (2), gohandashimasendesu (2) haisugugohandashimasendesu (2), mazugohandesuyo (2), gohan (2), gohanden (1), gohannarimasendesu (1) gohannaidesuyo (1), hirugohande (1), gohandashimasende (1), gohanninarimasu (1) gokaimenogohandashimasendesu (1), mawarinogohangoyamoyashisendesu (1)
First,	mazu (34), mazuyasumi (33), mazudesu (32), ma (6), mazuya (3), mazudesu (2), mazude (1), mazugo (1), mazuyasu (1)
Not do	masende (10), masendesu (6), masendesuyo (2)
Bath time, Break	ofurohaittadesuyo (2), ofuro (1), ofurojaimasende (1), hitoyasumi (1)
(Not) Birth day	tanjobijanaidesu (3), tanjokainaidesuyo (3), tanjobijanaidesu (1), tanjobijaimasendesuyo (1) tanjobijaarimasendesu (1), tanjobijaarimasendesuyo (1)
Time	1ji40fundesuyo (13), yoruninarimasendesu (9), 1jihandesuyo (8), 3jihanninarimasendesu (8), yoruninarimasendesuyo (5) handesuyo (4), 3jihandesuyo (4), 1jihande (3), 2jihandesuyo (2), 3jininarimasendesuyo (2), 1jihandesune (1) 1ji10fundesune (1), 1ji (1), 1jihandesuyo (1), 3jihanni (1), 3jihanninarimasendesuyo (1), mou3jininarimasendesu (1)
Snack time	oyatudesuyo (1), oyatujaimasendesu (1), keikihanaidesuyo (1), keikihanaidemasendesu (1), keikihanaitodesu (1)
Soon	suguha (1), suguhanaidesu (1)
"Yuki"	zunzuntumoru (2)
Question	imashitaka (1)
Greeting	konnichiha (1)
Others	dojoninarimasende (1), ugoninarimasende (1), sonouchimasende (1), mashi (1), bokujaarigatoarigato (1), basyohanaidesuyo (1)

Values in parentheses shows the time of each sentence.

[2] H. Park and J. K. Pringle Specht, "Effect of individualized music on agitation in individuals with dementia who live at home," J Gerontol Nurs. Vol. 35(8), 2009, pp. 47–55.

[3] H. B. Svansdottir and J. Snaedal, "Music therapy in moderate and severe dementia of Alzheimer's type: a case-control study, International Psychogeriatrics," Int Psychogeriatr. vol. 18(4), Dec. 2006, pp. 613-621.

[4] B. K. Nair, C. Heim, C. Krishnan, C. D'Este, J. Marley, and J. Attia, "The effect of Baroque music on behavioural disturbances in patients with dementia," Australasian Journal on Ageing, vol. 30(1), 2011, pp. 11–15.

[5] I. M. Altshuler, "The past, present and future of musical therapy," Music therapy, Podolsky, E. Eds. Philosophical Library, 1954, pp. 24–35.

[6] B. Koen, J. Lloyd, G. Barz, and K. B. Smith, The Oxford Handbook of Medical Ethnomusicology, Oxford University Press, 2008.

[7] D. E. Michel and J. Pinson, Music Therapy In Principle And Practice, Charles C Thomas Publisher, 2005.

[8] D. Grocke, and T. Wigram, Receptive Methods in Music Therapy: Techniques and Clinical Applications for Music Therapy Clinicians, Educators and Students, Jessica Kingsley Publishers, 2007.

[9] T. Wigram, Improvisation: Methods and Techniques for Music Therapy Clinicians, Educators and Students Jessica Kingsley Publishers, 2004.

[10] V. de Klerk-Rubin, Validation Techniques for Dementia Care: The Family Caregiver's Guide to Improving Communication, Health Professions Press, Baltimore, 2007.

[11] N. Itou and K. Nishimoto, "A Voice-to-MIDI System for Singing Melodies with Lyrics," Proc. of ACM International Conference on Advances in Computer Enter-tainment Technology (ACE 2007), ACM New York, NY, USA, 2007, pp.183–189, doi:10.1145/1255047.1255085.

[12] Y. Wakao and K. Okazaki, A handbook of impromptu for music therapy, Ongaku-no-tomosya, 1996.

[13] S. Ashida, "The effect of reminiscence music therapy sessions on changes in depressive symptoms in elderly persons with dementia," Journal of Music Therapy, American Music Therapy Association, vol. 37(3), 2000, pp. 170–182.

[14] Y. Imai and K. Hasegawa, "The Revised Hasegawa's Dementia Scale (HDS-R) -evaluation of its usefulness as a screening test for dementia," Journal Hong Kong Coll Psychiatr, vol. 4, 1994, pp. 20–24.