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An Accompaniment System for Healing Emotions of Patients with Dementia who Repeat Stereotypical Utterances

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Abstract. Our research aim is that even caregivers who are musical novices perform part of a music therapy activity. In this paper, we present an accompaniment system for calming the symptoms of patients with dementia with mental instability who repeat stereotypical behaviors and utterances. This system converts patients' utterances into pitches in response to an operator's key entry and automatically plays a cadence based on those pitches. The cadence begins on a chord that resonates with a patient's emotions and finishes on a chord that calms his symptoms. Because the use of this system is simple, even musical novices can use it to calm dementia patients' continuous stereotypical utterances.

Keywords: music, caregiver, convert into the musical notes from the sounds

1 Introduction

Music therapy is one of the methods known to alleviate symptoms of dementia. Dementia is a deterioration of intellectual function and other cognitive skills by an organic disorder (such as Alzheimer's disease, Dementia with Lewy bodies, Vascular dementia, and so on). The “Behavioral and Psychological Symptoms of Dementia (BPSD)” include wandering behavior, hallucinations, delusions, and others, but appropriate care is thought to alleviate and slow down the progression of these symptoms. A music therapist may therefore be requested to visit a nursing home on occasion to perform music therapy to alleviate BPSD.

Clark [1] found that playing recorded music could reduce the occurrences of aggressive behavior among the patients with dementia during bathing episodes. Ragneskog, et al. [2] showed that several caregivers had successfully used music to calm individual agitated patients. In the “Validation [3],” 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. Likewise, the “Iso-Principle [4],” 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 and that they then lead the patient to a different mood by gradually changing the mood of the music. This type of therapy is also effective for symptoms in which patients repeat stereotypical behaviors and utterances, such as occur with the mental instability of dementia. Our opinion is that if caregivers, even those who are musical novices, can address these dementia symptoms with music, their patients would become calmer and happier.

In this paper, we present an accompaniment support system that allows musical novice caregivers to calm the repetitive stereotypical behaviors and utterances of patients with dementia. This system converts the patients' utterances into pitches at a predetermined interval. In response to an operator's (e.g., a caregiver’s) simple key entry, the system automatically plays a cadence based on those pitches. The cadence begins on a chord that resonates with the patient's current emotions and finishes on a chord that calms his symptoms.

2 Patients who repeat stereotypical behaviors and utterances

In this section, we show some examples of patients who repeat stereotypical behavior and utterances. We recorded their utterances with mental instability for one month. Table 1 shows their symptomatic state, the cause of their dementia, their daily attitude, and the situation at the time of recording. The term “HDS-R (Revised Hasegawa's dementia scale) [5]” in the table refers to an intelligence test consisting of 9 simple questions, with a maximum score of 30. A score over 21 score identifies a person who is not a patient. The average score of a patient with mild dementia is 19.1, those with moderate dementia have mean scores of 15.4, and those with severe dementia have scores of 10.7.

The scores in the table show that most of these patients had severe dementia. Even patients who had mild dementia (i.e., Patients C and I) showed mental instability and repeated utterances. The examples show that the patients uttered a strange noise with emotion, calling for someone who was not there or for a caregiver. Even after the caregiver responded to their requests, several of them repeated the same requests, as seen with Patient A. In most cases, we could not understand what the patients were saying. Although doctors, nurses, and caregivers talked to the patients and led them to another action, it was not easy to calm them down. Therefore, music that could resonate with the patients’ emotions and calm their symptoms would be expected to help the caregivers in caring for these patients.

Table 1. Data of stereotypical utterances with mental instability.

Patients	cause of dementia	sex	age	HDS-R	daily attitude
	situation at the time of recording				
A	Alzheimer	female	89	7	She cries "I want to go to the restroom!"
	She repeated "Neeee" in a falsetto.				
B	Cerebrovascular	male	58	3	irritable, act menacingly, behave rudely
	He repeated "Try not to bother someone," "Please" in tears.				
C	Cerebrovascular	female	77	20	stereotypical utterances.
	She repeated "*taka? (Did you do it?)" in a falsetto.				
D	Alzheimer	female	69	inoperativeness	She utters meaningless sounds.
	She cried "Aaaa" in a loud whisper.				
E	Alzheimer	female	78	inoperativeness	severe symptoms.
	She repeated "Help me!" in a loud voice.				
F	Alzheimer	female	90	inoperativeness	She hang around in crying in a loud voice.
	She repeated meaningless sounds thickly.				
G	Alzheimer	male	78	inoperativeness	irritable, cry in a loud voice.
	He uttered meaningless sounds.				
H	Alzheimer	female	82	inoperativeness	She utteres in a loud voice, poor communication.
	She talked in anger. However, we cannot understand what she said.				
I	frontotemporal	female	70	17	good communication, stereotypical utterances.
	She locked herself in a bathroom, and repeated "*tadesuyo (I did it)"in a loud voice.				
J	Lewy bodies	female	83	13	irritable
	She repeated "Bakayaro (gumby)" with a furious voice.				

3 Set up System

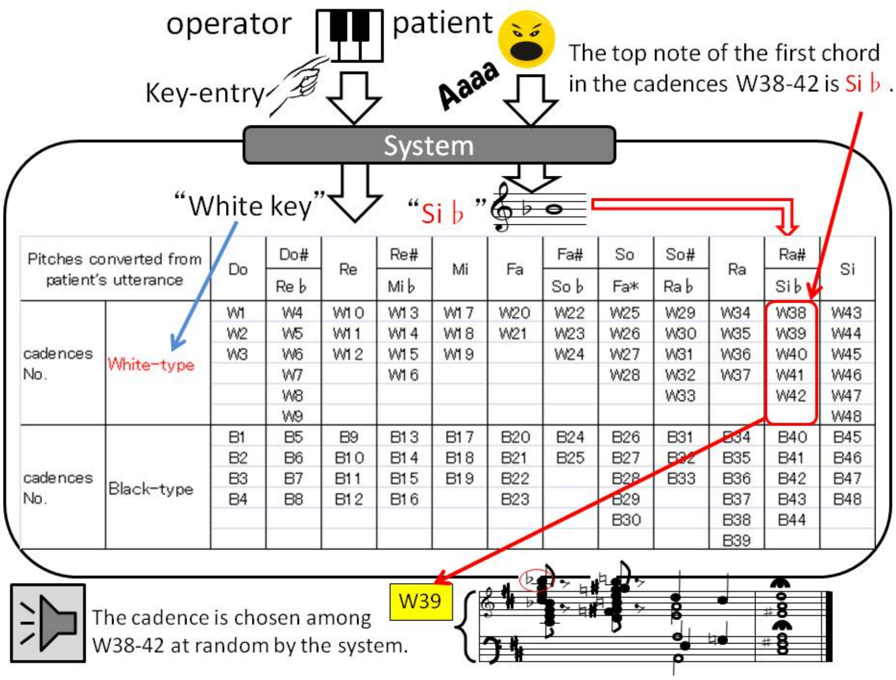
3.1 Outline of the system

We present an accompaniment support system that performs one of a variety of cadences when an operator (e.g., a caregiver) pushes any of the keys of the electronic keyboard, which can output MIDI (Musical Instrument Digital Interface) music. By cadence, we mean a harmonic sequence, such as is often found in the middle and at the end of pieces of music. It brings anticipation to continuous music or indicates completion of music. In this paper, we picked out 96 perfect cadences from established music scores to use as a database of cadences. The cadences were picked from the beginning of an unsteady or/and agitated chord (i.e., a dissonance chord) on the basis of our determination. The unsteady or/and agitated chord may resonate with a patient's mental instability. Then, the cadence aims towards a steady and mild chord, (i.e., a consonance), and finally a terminative chord that is expected to calm down the patient’s emotions.

The system also continuously converts the patient’s utterances into pitches. In response to the operator’s key entry, the system determines a pitch at a predetermined interval. The system selects a cadence in the database on the basis of that converted pitch. The top note of the first chord is same as the pitch converted from the patient's utterances.

Table 1 shows the database of the cadences and the process of the system after a key entry by the operator. The 96 cadences are considered to consist of two types of cadences. The first type of cadence begins with an extremely agitated chord (We call it a "Black-type cadence" in this paper). The other type of cadence begins with a milder, but unsteady chord (We call it a "White-type cadence" in this paper). The operator can easily choose from these types depending on the patient's condition. When he touches any black key (or any white key) on the keyboard, the Black-type (or the White-type) cadence is output through a speaker.

We will explain how to convert the patient's utterances into pitches in section 3.2, and provide details of the cadences in section 3.3.



Pitches converted from patient's utterance		Do	Do# / Re ♭	Re	Re# / Mi ♭	Mi	Fa	Fa# / So ♭	So / Fa*	So# / Ra ♭	Ra	Ra# / Si ♭	Si
cadences No.	White-type	W1	W4	W10	W13	W17	W20	W22	W25	W29	W34	W38	W43
		W2	W5	W11	W14	W18	W21	W23	W26	W30	W35	W39	W44
		W3	W6	W12	W15	W19		W24	W27	W31	W36	W40	W45
			W7		W16				W28	W32	W37	W41	W46
			W8							W33		W42	W47
			W9										W48
cadences No.	Black-type	B1	B5	B9	B13	B17	B20	B24	B26	B31	B34	B40	B45
		B2	B6	B10	B14	B18	B21	B25	B27	B32	B35	B41	B46
		B3	B7	B11	B15	B19	B22		B28	B33	B36	B42	B47
		B4	B8	B12	B16		B23		B29		B37	B43	B48
									B30		B38	B44	
											B39		

Fig. 1. Selection of a cadence.

3.2 Converting the patient's utterances into pitches

In our research, we employ a pitch extractor to convert the utterance of a patient into one pitch (i.e., Do, Re, Mi). It is based on the technique shown by [6] for conversion of sounds that have unstable pitches and unclear periods, like natural ambient sounds and the human voice, into musical notes. In the original system by [6], 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) and the system then calculates a histogram of pitches with the F0 time series between the start and end triggers. Finally, only the one most frequent pitch is selected and is output as the pitch of the period.

For our research, some processing designs were modified. Figure 2 shows the processing of the system. Considering the attitude of operator, we would assume that the triggers would be input "after" the operator catches the utterance of patient. Therefore, we omitted the start trigger. The system starts a short-term F0 estimation just after invocation of the system and continues it ever since then. 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 sequence of cadences (see section 3.1) that corresponds to the representative pitch. These modifications of our system are to improve usability by reducing the time lag between the input of the trigger and the output of cadence.

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 cadence where they are localized in the center position. The F0 estimation is then determined with these differential signals.

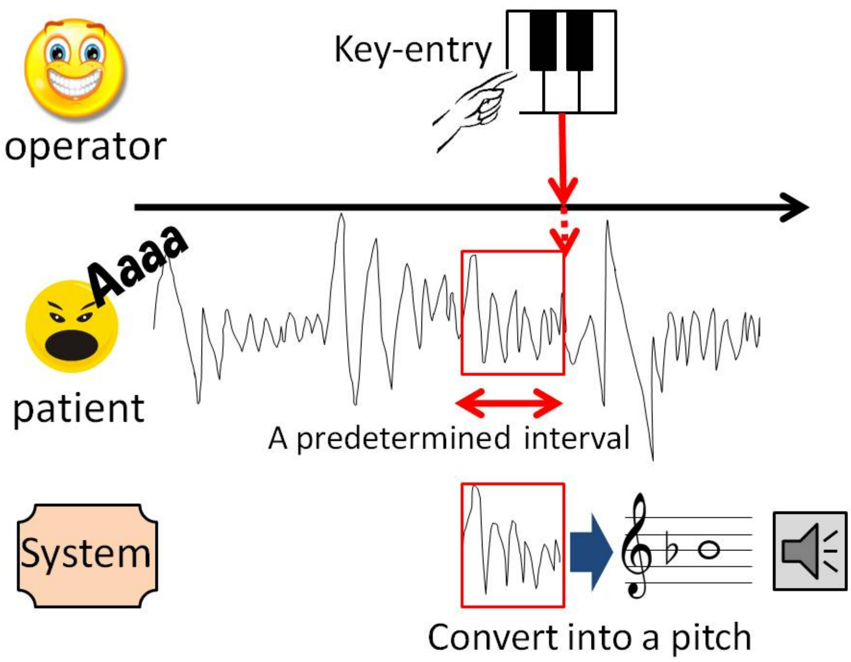


Fig. 2. Processing design for our research.

3.3 Cadence output from the system

The patients who repeat utterances have irritable moods and high anxiety in many cases. We would like to lead their emotions to calmness by performing music. What kind of music should the system output? 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. As a prototype system for the first step of our research, we prepared 96 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 pieces composed by Shostakovich conclude with a more agitated tone, with emotional and temperament cadences achieved through chromatic inflection, compared to those composed by Bach. Therefore, the cadences selected from the pieces composed by Shostakovich were tentatively designated “Black-type cadences (see section 3.1)” and the cadences chosen from the pieces composed by Bach were called “White-type cadences (see section 3.1)”. The operator can choose the type of cadences with a simple key entry.

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. In the same way, the converted pitch is applied as any of 12 tones. In both classifications, the system ignores determination of high or low octaves of tones, tentatively in this paper. In other words, the plural cadences correspond to each of 12 tones converted from the patient’s utterance.

4 Conclusion

We presented an accompaniment system that automatically plays a cadence based on pitches converted from a patient’s voice in response to an operator’s key entry. An important technique of the system is conversion of human voice that has unstable pitches and unclear periods into musical notes. Then, a theory of combination of tension and relaxation on the music also contributes to setting up the system. Clinically, these chords can elicit tension and relaxation within the human body.

We will conduct experiments using the system at nursing homes. Then, we want to improve the system for patients with dementia and their caregivers. Results of the experiments will show whether the system is useful in healing emotions of the patients and convenient for the caregivers. Moreover, the results will clear what kind of music resonates with the patients' emotions more than the music using now.

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References

1. Clark, M.E.: Use of Music to Decrease Aggressive Behaviors in People with Dementia. J. Gerontological Nursing. July, 10--17 (1998)
2. Ragneskog, H., Kighlgren, M.: Music and Other Strategies to Improve the Care of Agitated Patients with Dementia. Scand J. Caring Sci. 11, 176--182 (1997)
3. de Klerk-Rubin, V.: Validation Techniques for Dementia Care: The Family Caregiver's Guide to Improving Communication. Health Professions Press, Baltimore (2007)
4. Altshuler, I.M.: The Past, Present and Future of Musical Therapy. Podolsky, E. (Ed). Music Therapy, pp.24--35. Philosophical Library, New York (1954)
5. Imai, Y., Hasegawa, K.: The Revised Hasegawa's Dementia Scale (HDS-R) --Evaluation of its Usefulness as a Screening Test for Dementia. Hong Kong J Psychiatr. 4, 2, 20--24 (1994)
6. Itou, N., Nishimoto, K.: A Voice-to-MIDI System for Singing Melodies with Lyrics. In: Proc. of the int. conf. on ACE'07, pp.183--189, Salzburg (2007)