Journal of Mobile Multimedia, Vol. 5, No.1 (2009) 029-044

MOBILE MUSIC THERAPY WITH MULTIMEDIA QUALITY OF LIFE SUPPORTERS FOR ELDERLY AND DISABLED

NIKOLAY MIRENKOV

University of Aizu, Aizu-Wakamatsu City, 965-8580 Japan
nikmir@u-aizu.ac.jp

KAMEN KANEV

Research Institute of Electronics, Shizuoka University, Hamamatsu, 432-8011 Japan
kanev@rie.shizuoka.ac.jp

HIROSHI TAKEZAWA

University of Aizu, Aizu-Wakamatsu City, 965-8580 Japan
s1100135@u-aizu.ac.jp

Received June 2, 2008
Revised September 1, 2008

Music Therapy (MT) addresses physiological, cognitive, and social needs of individuals and employs music to enhance quality of human lives through creation of positive changes. In this paper, we consider applying mobile MT to human-computer interfaces, based on Quality of Life Supporters (QLS) of self-explanatory type, and oriented to elderly and disabled people. QLS are multi-modal communicators for person-environment (P-E) fit adjustments that take into account individual emotions and well-being. The "Circumplex model" published by Russell (1980) is employed for constructing optimal sequences of steps allowing smooth transition between any current and target emotional states in the course of computer assisted sessions. Findings regarding optimal step sizes and preferable types of music applicable for each step, as well as empirical methods of acquiring knowledge concerning relations between music and emotions are reported in result.

Key words: Quality of life (QOL), multiple view, cyberFilm, multimedia hieroglyph, assistive interface, human emotional state, mobile music therapy

1 Introduction

Over the last decades research and societal interest in Quality Of Life (QOL) has registered significant growth. Improving QOL of the aging population, and of those with disabilities, is of particular interest to Japan and other countries with fast-growing elderly population. The rapidly increasing ratio of older citizens incurs a variety of problems for individuals, for families, and for the society as a whole. Elderly people, for example, frequently suffer from mobility, memory, communication and general health problems. They often feel both physically and socially isolated, which leads to distress and to

poor mood states, all of what contribute to worsening of their QOL and health. Until not very long ago, most of the efforts in life sciences have been concentrated on health systems focusing on support and extension of physical life. Nowadays, the focus is shifting to reducing morbidity and to coping with disabilities, by targeting the development of treatments, technologies and systems that help increase the QOL and enhance the functional independence and mobility of disabled and older people.

According to Seeman [22], social relations are quite important for the emotional, physical, and psychological health of the elderly and serve as a protective factor against risk of cognitive decline and dementia. Consequently, strong inverse relationship between the strength of social networks and the incidence of dementia among the aged has been reported by Fratiglioni et al. [7]. Since new stimulating environments are expected to improve cognitive functioning [8], it becomes important to investigate how changes to the environment, especially those inflicted by recent advances in information and communication technology, could affect QOL. In fact, results reported by Kramer et al. [18], have shown that mental exercise improves the cognitive function in elderly people and Logan et al. [19] have revealed that even simple instructions can change old brain activation patterns into more youthful ones. Such research results make us believe that new frontiers in aging are opening, where computer supported social networks could play an important role. In this paper therefore, we will focus on computer-based methods and mobile supportive facilities for enhancing the social communication capacity of elderly and disabled people. Mobility could be ensured, for example, by small size computers attached to wheelchairs or by handheld devices such as PDAs, iPODs and MP3 players with properly tuned interfaces.

Portable devices are nowadays so widely available that listening to music becomes possible in virtually any environment. People, for example, often listen to music when they commute either by car or by public transport. While in the train or in the bus, one may listen to music that helps defocus and divert one's attention from the surrounding environment in order to feel more relaxed and to get some rest. While driving, however, such kind of defocusing and relaxation might be quite dangerous so different type of music should be chosen. One of our objectives with this research is to extend the concept of MT to more casual listening and to introduce some new features in assembling series of music pieces for different purposes. In this line, an impartial determination of the type, the length and the order of music pieces, composed into a targeted music stream appear to be quite important. This is particularly true for elderly and disabled people where MT might be applied for longer time intervals and with greater overall impact. In addition to MT, our approach should also enable such people to freely communicate with others through specialized assistive interfaces, which ensure adequate mental challenges and yet provide easy, nearly instant access whenever needed. QOL plays a central role in the design of our system, so we attempt to account for individual human emotions in the course of human-computer interactions and thus to help users have more independent and interesting life.

2 Related work

The aging society problem is of a serious concern in many developed countries. For example, the University of South Carolina (USC), USA, cooperates with the Fraunhofer Institute for Software Engineering of Kaiserslautern, Germany, and Columbia's Palmetto Health System to jointly develop technological responses to aging issues [1]. They promote the idea that aggressive employment of

innovative technologies enabling elderly people to continue living at home rather than moving to nursing establishments would actually incur lower expenditures to the society.

University of South Carolina has also made a major commitment for its SeniorSmart Center to develop mobility, activity, rehabilitation and transportation technologies for the elderly in collaboration with Clemson University, focusing on:

- Making the home safer for the elders, with technological systems that help monitor their needs and assist with daily activities that become more difficult with age;
- Examining and promoting mobility outside the home by improving transportation safety and driving responses for elders;
- Conducting brain health studies aimed at slowing or even preventing the onset of diseases such as Alzheimer's and Parkinson's.

At the Fraunhofer Institute for Software Engineering, improving the QOL is considered as a high priority matter, since Germany, has one of the fastest growing elderly populations. The number of Germans over age 65 is expected to double by year 2025.

Active research and development related to aging issues are performed in Sweden at Lund University in its CERTEC centre [5] and include the following projects:

- *Aging and design*, which deals with the expectations and needs of old people today and in the future;
- *Cognitive assistance*, where the interaction between people, environment and technology is considered;
- *Enactive*, where multidisciplinary approaches are used to develop a new generation of human-computer interfaces;
- *Peacemaking*, which focuses on stress: its causes, consequences and counter measures;
- *Isaac*, which is about using pictures as cognitive support and a means of communication.

Another place of the active work on aging issues in Sweden is the Umea University [20]. In the Department of Informatics there is a Q-Life (Quality of Life) group exploring new ways in which information technologies can be designed and applied to enhance life quality for a wide range of individuals: in everyday life, in clinical settings and under other specific circumstances. The group work is intrinsically multi-disciplinary, drawing on art, science, technology and social concerns. They believe that technology can potentially solve several seemingly intractable and growing problems in modern society, such as stress, depression, loneliness, some forms of age-related dementia, self-destructive lifestyles, and anxiety. They are interested in how technology can be used to create life-changing experiences: artistic, intellectual, emotional, practical, physical, social and spiritual.

In Australia, at the University of New South Wales, in the School of Safety Science anthropometrical data on 171 elderly people has been collected. The data set consists of 22 body dimensions relevant to design of living facilities, equipment, and workplaces for the elderly people [17]. The study was carried out in metropolitan Sydney and a comparative analysis with other populations demonstrated significant differences in the body dimensions.

Though studies show that the attitude of the elderly towards computers is no different than that of the younger adults [25, 6], elderly people do face age-related difficulties in accessing and using technology. To achieve universal usability for the elderly, it is necessary to understand the implications of age-related changes in functional abilities for the design and implementation of computer systems. A lot of work has been done regarding the physical and mental changes associated with aging, acceptance of technology by the elderly, training, and hardware and software design [6]. Some recommendations regarding hardware considerations, input device choices, training methods, and software issues for the elderly are available in [6] and [9].

Emotional aspects are quite important in the human society where elderly and disabled people tend to be most emotionally vulnerable. We focus therefore on exploring approaches for improving the emotional well-being of the elderly and disabled people through different therapies. Music, for example, being a powerful tool for influencing emotions, can have not only positive but also negative impact on humans, and therefore, the guidance of specially educated and properly trained professionals [4] should be sought when employing music for therapeutic purposes. Music Therapy (MT) interventions can be designed, for example, to promote wellness, to manage stress, to alleviate pain, to express feelings, to enhance memories, to improve communication, and to stimulate physical rehabilitation. MT is mostly employed in hospitals, nursing homes, psychiatric facilities, etc. in stationary conditions.

We would like to offer MT in a mobile format that would allow elderly and disabled people to take advantage of it in their everyday life without the need to visit special facilities. In fact healthy individuals often use music for stress reduction and relaxation by playing musical instruments, by passive listening or just as a background support for physical exercises, etc. The therapeutic effects of such music employment, however, have not been studied in detail and its direct application for elderly and disabled would be difficult to justify. To support this kind of MT activities, specialized research is in progress and technological infrastructure for producing audiovisual instruments is being developed [14]. This includes access to real-time sound control for those with limited movement, new sound worlds, and multimodal media interfaces involving visual arts. Further supportive background for our research and development is derived from the following projects:

- The *CareHere* project (http://www.bris.ac.uk/carehere/), which uses interactive multiple-media technology to improve people's motor and mental skills;
- The *Mediate* project (http://web.port.ac.uk/mediate/), which is related to the Multisensory Environment Design for an interface between Autistic and Typical Expressiveness and concerns the production of an audiovisual-tactile environment specifically for autistic children;
- The *Control of Gestural Audio Systems* project (http://www.cost287.org/), which focuses on how human gesture works in the context of controlling musical instruments and multiple-media technology.

However, it is very difficult to identify projects where systematic studies of music features and their influence on people's emotions are considered in depth.

3 Quality of Life Supporters (QLS)

QOL is a complex notion and its quantification appears to be a demanding and controversial task [23]. In this work we will regard QOL as an indicator of how well features of a physical environment surrounding individuals can satisfy their physical, psychological, and social needs in their everyday life. This, of course, includes mood states and positive and negative emotions that we will discuss in details in the following section, while in this section we will focus on QLS of self-explanatory type.

The main objectives of our approach will be 1) to model, design and develop interactive environments that could improve QOL by supporting cognitive, emotional and social well-being, and 2) to capture and analyse relevant data through adaptive multimedia interfaces with embedded functions for emotion and mood recognition, as well as to monitor activity levels and aspects of physical health.

3.1. Challenges and targets of QLS

We place in the centre of our research the design and development of QLS, which are multi-modal systems oriented to elderly and handicapped people with differing abilities and knowledge, and are based on adaptive features supporting P-E fit including the social context. Two core groups of QLS are considered.

The first group is for elderly people who live independently or in health-care centers and who need support for acuity, hearing, psychomotor and memory functions, and for other cognitive abilities. QLS could help such people preserve and extend their abilities to act and learn on their own, and thus allow them to continue planning their own life, to maintain communications with those who are nearest and dearest, and to find pleasure in good memories from the past.

The second QLS group is for children with communication disorders, mainly for mentally challenged, autistic and cerebral palsied children, and for children with learning disorders.

Our research is based on new approaches addressing the following three universal usability challenges, namely technological variety, user diversity, and gaps in user knowledge. The first challenge is related to the pace of technological changes and the variety of equipment that potential users could encounter. The second challenge is about accommodating users with different skills, knowledge, age, disabilities, etc. And the third challenge is about bridging the gap between what users already know and what they really need to know.

3.2. Structure and functionality of QLS

We address the challenges described in the previous section through an embodiment of a set of QLS based on self-explanatory components [12] and adaptive multi-modal interfaces allowing access to instances of knowledge and data through a multiplicity of channels. Within each group, we are developing a set of tightly coupled QLS with corresponding cyberFilm databases and communicators tuned for the defined target groups [11].

For the first group, we are developing several specialized QLS supporting old and very old people, and for the second group, QLS supporting mentally disabled, autistic and cerebral palsied children. The general architecture of the first group of QLS is depicted in Fig.1. Communicator (65-80,E) and Communicator (65-80,nE), shown in the figure are for elderly people of age between 65 and 80 with

experience in computer use, and with no experience in computer use, respectively. Communicator (81-1xx,A) on the other hand is for all elderly people over 80.

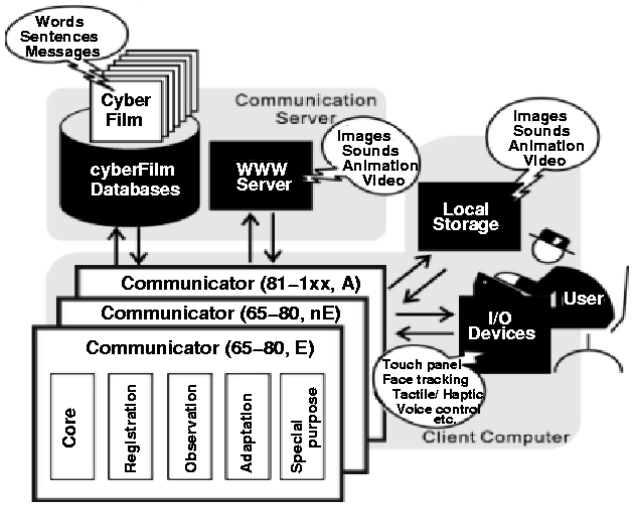

Figure 1. Architecture of QLS for elderly people

As a reference here we give a short outline of the employed Communicator components and their functionality:

- **Core**- to integrate other components and access to cyberFilm database for supporting the users in creating, sending, and receiving electronic messages in a language of multimedia words and sentences through a variety of interface devices;
- **Registration**- to get general data about sub-categories of users and some specific data about individuals, including those who tire easily, see poorly, hear poorly, and have problems with memory and motor ability;
- **Observation**- to collect statistics and other data about users in the process of their communications; such observation can include levels of users' confidence in manipulation of interface objects and devices, as well as history of user's actions and behaviour including social relationships among individuals and groups. Analysing the decline in colour discrimination ability and contrast sensitivity, fonts and frequency tones recognition, interface panel and panel's component size perception, which are of primary importance when making decision about collection and interpretation of input data;
- **Adaptation**- to use data of registration and observation components for simplifying human-computer dialogs and identifying senior citizens and disabled people needs via such dialogs. Special attention is paid to predictive features of communicators that help saving user's energy and balancing user’s emotions;
- **Special purpose**- to increase supportive functions of communicators, e.g. an observation subsystem to help forgetful people in keeping track of necessities, a subsystem to create family photo/video albums and archives, a story telling subsystems to develop disabled

children's vocabulary, to convey to them the meaning of time and to help them create diaries, etc.

The second QLS group of communicators is based on a similar architecture. Within the scope of such architectures we study and develop a range of specialized functionalities. Our prime focus is on methods for observation of user emotions, moods, patterns of communication, health conditions, etc. and related acquisition of corresponding data to adapt human-computer interactions. As appropriate, we use for this purpose implicit questionnaires embedded into user interfaces as well as interviews with users and caregivers for ensuring more intelligent adaptive computer assistance. In the following sections we will discuss in more details how we apply this approach to MT techniques for adaptively selecting types of music and their durations to positively influence user emotions and moods.

We also develop new formats of information resources understandable for users with different levels of physical and mental abilities, and with different degrees of knowledge, as well as human-computer interaction styles allowing such users to create complex information resources, to send and receive messages derived from them, and even to manipulate resources created by others. For example, we have designed camera-based and sensor-based interfaces simplifying interactions with QLS and enhancing the abilities of users to orient in time and space, including interfaces capturing body motions and employing them for Internet searching and e-mail writing. We also provide special-purpose supports through computer assisted diaries and time-management tools to help forgetful people keep track of their necessities as well as scrapbooks and memory support tools that could use albums of photos as interactive interface components, etc.

3.3. The cyberFilm format and QLS

To reach our goals, we use the idea of self-explanatory components and the technique of cyberFilms, multimedia words, and multimedia hieroglyphs or sentences [10, 13].

Figure 2. A hieroglyphic view of a sample sentence

A cyberFilm is a set of multimedia frames where each frame represents some key feature of an object or a process. One or more series of frames could be used for representing the multiplicity of

features of any given object or process. By providing sufficiently detailed multiple views of objects or processes, self-explanatory interface components could be created. The term "cyberFilm" means that associated frames are organized and presented in such a way that the semantic richness of knowledge and data is clearly pronounced.

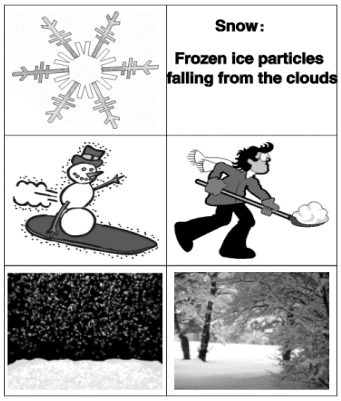

Figure 3. Multiple views for the word “snow”

A multimedia word is a set of multimedia frames or views where the meaning of a corresponding object or a process can be represented by animations, by images with captions, by short text, and by sound or voice. Usually, a basic view such as a picture with a caption is selected for use in multimedia sentences called multimedia hieroglyphs.

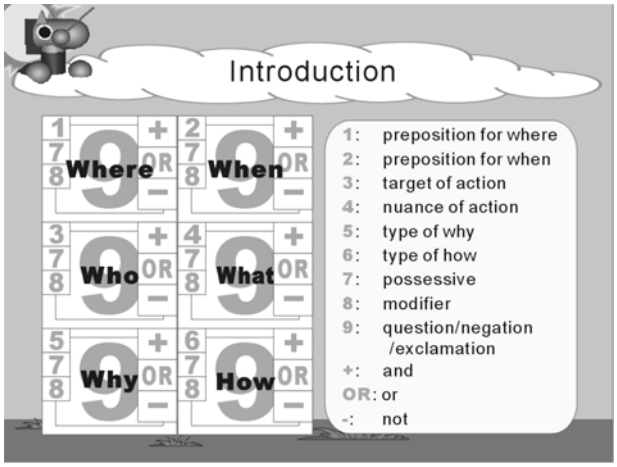

Figure 4. The hieroglyph template format

A multimedia hieroglyph is a set of multimedia words combined into a specialized 2D structure where some positions have predefined meaning and are reserved for answers to questions such as who, what, where, when, why and how. Fig.2 illustrates how the sentence "Prof. Mirenkov and I want to go to a hospital in Fukushima tomorrow by car because of catching a cold." can be represented in the hieroglyphic language. Fig.3 shows a multiple view representation of the word “snow”, and Fig.4 depicts the complex format of multimedia hieroglyphs and sentences. Users construct multimedia

sentences, by filling out the corresponding positions of the template with basic views of multimedia words. Drag and drop and other direct interaction methods [15] can be used in this process so there should be no necessity to access the keyboard.

In the context of QLS, in addition to self-explanatory interfaces, we are also designing and developing, interaction devices and methods of their adaptation, including mailers to send, receive, and understand electronic messages in the language of multimedia words and sentences through a variety of interface devices. Databases of multimedia words, sentences, and sound and music pieces, including databases of multimedia message samples specifically targeting disabled and elderly people, along with means for automatic translations of multimedia sentences, and Japanese and English localizations are also being developed.

Our research results have been employed in the design and development of the commercially available SORA Mail system (http://www.sora-art.jp/). This product incorporates multimodal interfaces specifically designed to accommodate the needs of disabled people and to allow them maintain flexible mobile communications with their relatives. Our novelty is in the employed approach and corresponding QLS models, facilitating studies of the QOL concept through direct measurement of data related to people's state of mental and social well-being, as well as in the efficient combination of the following:

- employment of multiple views to represent a variety of object and process features, rather than conventional single view representations, and ensuring that only highly appropriate media is used for disclosure,
- acquisition of data through multimedia facilities, such as direct interactions with pictures or multimedia words, rather than typing, and the possibility to use interface devices and technologies that better suit the needs of disabled and elderly people,
- application of intelligent techniques for multilevel customisation and user observation supporting P-E fit, rather than use of non-layered, static techniques.

4 MT and QLS

MT is often regarded as employment of music for enhancing quality of human life through creation of positive changes. In this section we discuss the potential of applying MT techniques to human-computer interfaces and QLS through employment of preferable emotions and sequences of human emotional states, based on the “Circumplex model” [21]. Our objectives are to identify required transition steps, to determine optimal step sizes, and to categorize types of music, applicable for each step. We implement this through experiments and dedicated user questionnaires.

4.1. The Iso-principle and the Circumplex model

We base our approach on the “Iso-principle” [3], which is considered to be an essential part of the alteration process. The Iso-principle states that, when music is employed for changing emotions, first music closely matching the initial emotional state, should be applied, and then that music should be gradually changed. If the music-incurred emotional state significantly differs from the initial emotional state, it appears to be more difficult and more time consuming to achieve required mood transitions.

According to the Circumplex model human emotions could be arranged in a circular way as shown in Fig.5, where similar emotions appear close to each other. For example, the highly similar emotions “nervous” and “tense” are next to each other on the circle, while the contrasting emotions “excited” and “calm” are on diametrically opposite sides of the circle. By adopting this model we are able to represent and refer to emotions by their spatial locations rather than by verbal reports. In this way we minimize the influence of cultural and other factors that are reported to be highly language specific [2]. In addition, the circular representation provides a convenient way to measure distances between emotional states by just calculating the lengths of the connecting arcs. Application of such measures to emotional state changes however is not straightforward and additional rules need to be applied.

First, since our objective is to induce just positive mood changes, only arcs in specific directions should be accepted. For better understanding, the circle in Fig.5 has been divided in four segments denoted as *Group 1* to *Group 4*, with arrows showing the direction of the positive mood changes in each group. Please note that the angular directions of the arrows for Group 1, 2 and 3 are positive, while that for Group 4 is negative.

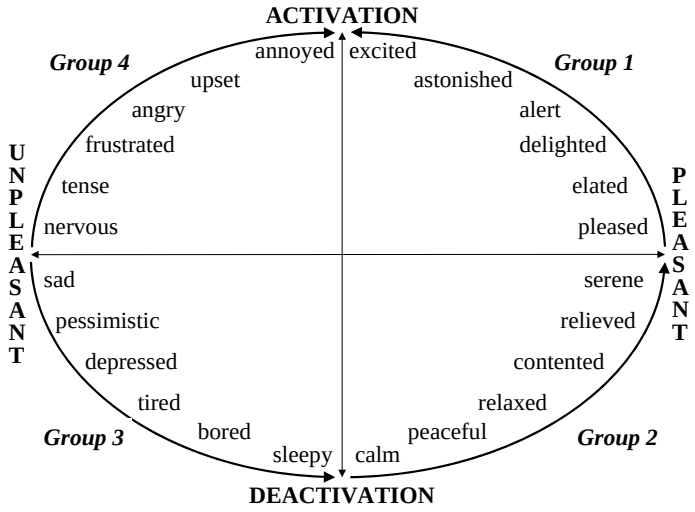

Figure 5. Schematic representation of the Circumplex model

Second, following the Iso-principle, an arc distance of three or close to three has been identified as a preferable step size. Using smaller step sizes significantly increases the required mood transition time, while larger steps violate the Iso-principle requirements.

4.2. Empirical studies and results

Two questionnaires have been prepared for investigating user perceptions of music and establishing mapping of characteristic music parameters to appropriate human emotional states and state changes. However, direct matching of human emotional states to music pieces with specific characteristics, although possible appears not to be sufficient for controlling transitions of human emotional states through music. With our first questionnaire therefore, we have attempted to identify the essential

music features that respondents associate with specific transitions between emotional states, rather than with target emotional states alone. Respondents have been asked questions such as “If you are sleepy, what kind of music would make you feel just relaxed?”. Here “sleepy” and “relaxed” are the initial and the target emotional states, respectively.

Table 1. Music descriptors

Fast	**Slow**	**Bright**	**Dark**	**Regular**	**Erratic**
Light	**Heavy**	**Loud**	**Quiet**	**Clear**	**Vague**
Pitch		*Voice*			
High	**Low**	**Adult**	**Male**	**Female**	**Child**

Answers to those questions have been acquired through selections of characteristic terms related to the melody, harmony, rhythm, and dynamics of music and voice. Possible answers have been organized in a table as shown in Table 1 and respondents have been allowed to make multiple selections from the table for each of the answered questions. We have used both, paper versions and online versions of this questionnaire, targeting people aged between 15 and 70. In total 147 persons have answered the questionnaire, 52 of which were over 25 years of age.

Our second questionnaire has been designed for investigating personal perceptions of music in more details by asking respondents to listen to pre-recorded units of music and to evaluate them. The music units have been created by recording pieces of classical concerts performed by the University of Aizu Orchestra “Dolce” (Fig.6).

Figure 6. The University of Aizu orchestra “Dolce”

Altogether three different concerts have been recorded, namely Overture ”Il Barbiere di Siviglia” (Rossini), Symphony No.6, Op.68 ”Pastoral” (Ludwig van Beethoven), and ”Unter dem Doppel-Adler” (J. F. Wagner). Evaluations of the music pieces have been conducted by selections of applicable music descriptors from Table 1, with voice-related ones being excluded.

Altogether 50 persons have listened to all pre-recorded music samples and have answered the questionnaire. Most of the respondents have chosen between two and four music characteristics, with a total average close to three. We use, therefore, triples of music descriptors to represent results, obtained from the questionnaires, as shown in Table 2. The first row in the table, for example, shows that a transition from “sleepy” to “relaxed” emotional state would require a music piece that is characterized as “bright”, “light” and “quiet”.

In Table 3 we provide a more detailed view on respondents' perception of music. As indicated in the table header, the three different music samples occupy separate columns, the middle column being divided into sub-columns to accommodate the five distinct movements in Symphony No.6, Op.68 "Pastoral" (Ludwig van Beethoven). The table thus, accommodates seven different music fragments that are rated individually.

Table 2. Emotional state transitions and essential music characteristics

Initial state	**Target state**	**Music characteristics**		
Sleepy	**Relaxed**	**Bright**	**Light**	**Quiet**
Sad	**Tired**	**Dark**	**Heavy**	**Slow**
Depressed	**Sleepy**	**Dark**	**Slow**	**Quiet**

The set of seven music classification criteria, each with two alternative choices, offered to our audience is shown in column 1 of the table. Each classification criterion occupies two consecutive rows in the table and the numbers in the rows reveal the corresponding selection ratios. The number "26.0" in the top-left cell, for example, indicates that 26% of the respondents have classified the Overture "Il Barbiere di Siviglia" as "high-pitched".

Table 3. Cumulative results from Questionnaire 2 reflecting respondents' perception of music

	Overture Il Barbiere di Siviglia (Rossini)	Symphony No.6, Op.68 "Pastoral" (Ludwig van Beethoven)					Unter dem Doppel-Adler (J.F.Wagner)
		The first movement	The second movement	The third movement	The fourth movement	The fifth movement	
High-pitched	26.0	18.0	8.0	22.0	12.0	22.0	34.0
Low-pitched	8.0	4.0	12.0	4.0	10.0	0.0	0.0
Regular	22.0	34.0	8.0	12.0	4.0	22.0	34.0
Erratic	18.0	0.0	2.0	18.0	12.0	2.0	0.0
Bright	72.0	68.0	36.0	38.0	20.0	36.0	74.0
Dark	0.0	0.0	0.0	12.0	32.0	0.0	0.0
Light	46.0	46.0	28.0	24.0	10.0	16.0	58.0
Heavy	8.0	0.0	0.0	12.0	32.0	0.0	0.0
Fast	54.0	22.0	8.0	26.0	20.0	10.0	34.0
Slow	0.0	4.0	26.0	0.0	4.0	4.0	0.0
Loud	32.0	14.0	0.0	34.0	34.0	16.0	54.0
Quiet	8.0	26.0	48.0	8.0	6.0	8.0	0.0
Clear	62.0	28.0	12.0	34.0	28.0	34.0	66.0
Vague	8.0	8.0	16.0	8.0	10.0	6.0	0.0

Human perception of music characteristics may vary considerably, and sometimes, good agreement may be difficult to obtain. For example, the fourth movement in Symphony No.6, Op.68 "Pastoral" (Ludwig van Beethoven) has been classified as "high-pitched" by 12% of the respondents and as "low-pitched" by 10% of the respondents. The registered difference of only 2% is rather insignificant and, therefore, the high/low-pitch characteristic of the fourth movement should be

dropped. Such a decision could be further justified based on the fact that only 22% of the respondents have actually made a high/low-pitch characteristic selection. This relatively low percentage of respondents could be considered as an indication that listeners had difficulties applying the high/low-pitch criterion to the specific music fragment.

To identify all valid data in Table 3 we have:

- compared the percentages of the alternative choices in each pair and then ignored all pairs with insignificant percentage differences, and
- calculated the cumulative percentages of the respondents for each pair and then ignored the pairs with relatively low sums.

For all remaining pairs the cells with higher percentage values have been assigned a distinctive gray background representative of the valid data that they contain.

4.3. Integrating music in QLS

Our preliminary empirical studies deal with a limited number of music features and produce in result a rather coarse music emotion classification. Since in QLS human emotional states are managed through a multiplicity of multimedia channels, the impact of employed music emotion classification appears to be quite limited, especially at the design and development stage. We are investigating however other, more refined music classification approaches [16] and we are planning to conduct experiments with some continuous methods [24] that might help us better evaluate the impact of music emotion classification on the overall QLS performance.

Combined results from the questionnaires allow us to construct emotional state transition plans for employment in QLS such as the one shown in Table 4. The sample plan begins with the initial emotional state “sad” and prescribes music treatment for a transition to the target emotional state “alert” in five steps. Step durations and features of the prescribed music are derived from the Circumplex model and from the questionnaire results.

Table 4. A sample emotional state transition plan for QLS

Stage	**Initial state**	**Target state**	**Time**	**Music characteristics**		
1	**Sad**	**Tired**	**3**	**Dark**	**Heavy**	**Slow**
2	**Tired**	**Sleepy**	**2**	**Regular**	**Quiet**	**Vague**
3	**Sleepy**	**Relaxed**	**3**	**Bright**	**Light**	**Quiet**
4	**Relaxed**	**Pleased**	**4**	**Bright**	**Light**	**Clear**
5	**Pleased**	**Alert**	**3**	**Bright**	**Loud**	**Clear**

Functionality of the currently developed QLS system with integrated MT could be summarized in the following way. User interactions with QLS are constantly reported to the dedicated Communicators, responsible for monitoring the emotional states of QLS users. Current emotional state

of the user is then evaluated, following the Circumplex model. When a need for emotional state improvement is detected, the system selects a new target emotional state and the pair of the current and the target emotional states is communicated to the state transition planner for processing. The planner then works in an independent, automatic way and produces an emotional state transition plan similar to the sample shown in Table 4. This plan is communicated to QLS and executed. According to the emotional state transition plan, QLS retrieves appropriate music pieces from a multimedia database and presents them to the user following the plan's time schedule.

5 Discussion

Music plays a great role in our life and it is created for people of all ages and abilities. Usually, music is employed for entertainment, and understanding of its influence on our emotions is rather vague. MT, on the other hand, is a practice where professionals study and try to employ the effects of music in a more precise way. Their efforts, however, are mostly oriented to people with mental or physical disorders and are based on collections of treatment cases, that are not so easy to categorize into forms with predictive features. There is, therefore, a necessity for a more systematic analysis of the types of music, their relations to different emotional states and the possible influence on people of different ages and abilities. Embedding music into computer-human interfaces oriented to healthy people may also benefit from such analysis. In addition, the interfaces should be adaptive and should take into account current user's activity, types of devices available in the environment, as well as the time of the day, the yearly seasons, etc. We believe that for progress in this area, active cooperation between musicians, therapists, and computer experts will be essential. How to organize the fundamental basis of such a multi-disciplinary activity, however, is a question that has still to be answered.

Relations between music and visual arts are well known and different methods for real-time generation of images from music patterns and vice versa are now available. Linking music and visuals, however, could go beyond the magic of art and could be entrusted with much richer semantics. In this line, more practical tasks useful for supporting QOL for various group of people and, first of all, for elderly and disabled could be considered. Current technologies, for example allow us to employ specially prepared music as a way to transfer information with precisely defined semantics. How to apply this to the musically enhanced human-computer interfaces of the future, however is still to be discovered.

We are finishing our discussion but we are not closing it, because we expect this paper to stimulate generation of new ideas and to invoke new constructive debates on the issues that we have raised and especially on QOL, QLS and MT.

6 Conclusions and future work

In this work we have introduced an innovative concept for computer assisted QOL support based on multi-modal communicators for P-E fit adjustments. QLS of self-explanatory type have been discussed and their integration with media-rich, assistive human-computer interfaces for elderly and disabled people have been revealed. MT has been considered as one possible way to manage human emotional states within QLS and experiments and user surveys have been conducted accordingly.

To properly position and understand reported results they need to be evaluated in the wider context of exiting research developments in this area. This could be greatly facilitated if well defined

rules and criteria for more reliable comparisons of different systems and corresponding results are established by the research community in this field.

We will be continuing our work on this project by elucidating the QLS architecture, investigating and applying new, more subtle music classifications and finally implementing a fully functional computer assisted QOL support system for elderly and disabled.

References

1. ACM TechNews, April 25, 2008 (on-line), http://technews.acm.org/archives.cfm
2. Altarriba, J., Basnight, D. M., Canary, T. M., Emotion Representation and Perception Across Cultures, In Lonner, W. J., Dinnel, D. L., Hayes, S. A., Sattler, D. N. (Eds.), Online Readings in Psychology and Culture (Unit 4, Chapter 5), 2003, http://www.ac.wwu.edu/~culture.
3. Altschuler, I., A Psychiatrist's Experience with Music as a Therapeutic Agent. (The series of classical articles). Nordic J. of Music Therapy, 10 (1), 69-76.
4. American Music Therapy Association (on-line), http://www.musictherapy.org/
5. CERTEC (on-line), http://www.english.certec.lth.se/doc/certec/
6. Czaja, S. J., Handbook of Human-Computer Interaction, second edition, Elsevier 1997
7. Fratiglioni, L., Wang, H-X., Ericsson, K., Maytan, M., Winblad, B., Influence of Social Network on Occurrence of Dementia: A Community Based Longitudinal Study, The Lancet 355, 9212, pp.1315-1319.
8. Gutchess, A. H., Welsh, R. C., Hedden, T., Bangert, A., Minear, M., Liu, L. L., Park, D. C., Aging and the Neural Correlates of Successful Picture Encoding: Frontal Activations Compensate for Decreased Medial-Temporal Activity, J. of Cognitive Neuroscience, 2005, 17: 84-96.
9. Hawthorn, D., Possible Implications of Aging for Interface Designers, Interacting Computers, Vol. 12, No. 5, April 2000, pp. 507-528.
10. Hirotomi, T., Mirenkov, N., Augmentative and Alternative Communication Based on Multimedia Hieroglyphs, J. of the Japanese Society for Wellbeing Science and Assistive Technology, Vol. 3, No. 2, 2004, pp. 40-49.
11. Hirotomi, T., Mirenkov, N., Multimedia Communication Environment for Children, Handicapped, and Elderly People, In Proc. of the 22nd Int. Conf. on Distributed Computing Systems Workshops (ICDCSW'02), Vienna, Austria, 2002, pp. 122-127.
12. Hirotomi, T., Mirenkov, N., Self-explanatory Components: A Basis for New Communicators, J. of Visual Languages and Computing, Vol. 14, No. 3, Elsevier Science, 2003, 215-232.
13. Hirotomi, T., Mirenkov, N., Fujita, K., Filmification of Words and Sentences Towards Teaching and Learning, In Proc. of the Int. Conf. on Advances in Infrastructure for e-Business, e-Education, e-Science, e-Medicine on Internet (SSGRR 2003w), L'Aquila, Italy, January 6-12, 2003.
14. Hunt, A., Kirk, R., Neighbour, M., Multiple Media Interfaces for Music Therapy, IEEE Multimedia, July-September, 2004, pp. 50-58.
15. Kanev, K., Kimura, S., Direct Point-and-Click Functionality for Printed Materials, The J. of Three Dimensional Images, Vol. 20, No. 2, 2006, pp. 51-59.
16. Korhonen, M. D., Clausi, D. A., Jernigan, M. E., Modelling Emotional Content of Music Using System Identification, IEEE Trans Sys. Man. And Cyber., Vol. 36, No. 3, pp. 588-599, 2006.
17. Kothiyal, K., Tettey, S., Anthropometric data of elderly people in Australia, Applied Ergonomics, Vol. 31, No. 3, June 2000, pp.329-332.
18. Kramer, A. F., Hahn, S., Cohen, N. J., et al. Ageing, Fitness and Neurocognitive Function, Nature, 1999, 400, pp. 418-419.
19. Logan, J. M. et al., Under-Recruitment and Non-Selective Recruitment: Dissociable Neural Mechanisms Associated with Aging, Neuron, 2002, 33, 827-840.

20. Q-Life (on-line), http://www.informatic.umu.se/~muse/home.html
21. Russell, J. A., A Circumplex Model of Affect, J. of Personality and Social Psychology, Vol. 39, pp. 1161-1178, 1980.
22. Seeman, T. E., Social Ties and Health: The Benefits of Social Integration, Annals of Epidemiology, Sept. 1996, Vol. 6, No. 5, pp. 442-451.
23. The Economist Intelligence Unit's Quality-of-life Index (on-line), http://www.economist.com/media/pdf/quality_of_life.pdf
24. Yang, Y-H. L., Lin, Y-C., Su, Y-F., Chen, H. H., Music Emotion Classification: A Regression Approach, IEEE Int. Conf. on Multimedia and EXPO (ICME2007), Beijing, China, July 2-5, 2007, pp.208-211.
25. Zhao, H., Universal Usability Web Design Guidelines for the Elderly (Age 65 and Older), University of Maryland, College Park, MD 20742 USA, http://www.otal.umd.edu/UUPractice/elderly/