iHeartrate: A Heart Rate Controlled In-Flight Music Recommendation System

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ABSTRACT
Travel by air, especially long distance, the enclosed environment of the aircraft cabin causes discomfort and even stress to flight passengers. In this paper, we present a new heart rate controlled music recommendation system. Heart rate is used as a stress indicator. If the user is stressed and his/her heart rate is higher/lower than normal, the system recommends a user preferred calm/uplift music playlist to transfer the heart rate back to normal; An user experiment is done to validate our system. The experiment results not only show that our system keeps the user's heart rate at normal but also show that the passenger's stress level can be reduced by our system.

Author Keywords
Recommendation system, heart rate control, music preference, music recommendation.

ACM Classification Keywords
H.5.5 Sound and music computing

INTRODUCTION
Travel by air, especially long distance, is not a natural activity for humans. Many people experience some degree of discomfort and even stress when flying. Excessive stresses may cause the passenger to become aggressive, over-reactive and even endanger the passenger's health [1].

In this paper, we present a heart rate controlled in-flight music recommendation system. Except based on the user's music preference, music recommendation is also controlled by the user's heart rate to keep his/her heart rate within the normal range. If the user does not like the recommendation, he/she can decline the recommendation and re select the music himself/herself, based on interactions between the user and the system, the system can learn and adapt to the user's latest music preference. The rest of this paper is organized as follows. Firstly, the heart rate controlled music recommendation system is introduced. Then, the user experiment to validate the system design is given. Finally, Conclusions are drawn.

SYSTEM DESIGN

A. Heart Rate
Heart rate is a measure of the number of heart beats per minute. For an adult (age 18 and over), his/her normal heart rate at rest is 60-100 beats per minute. If the heartbeat rhythm is disrupted and is beating lower than 60, it is called a bradycardia. A slow heart beat may cause dizzy spells, blackouts, breathlessness or tiredness. If the heart beats higher than 100 beats per minutes, it is called a tachycardia. When the heart beats rapidly, the heart pumps less efficiently and provides less blood flow to the rest of the body, including the heart itself.

B. Music and Heart Rate
Peter Sleight found that listening to music with a slow or meditative tempo has a relaxing effect on people, slowing breathing and heart rate. Listening to faster music with a more upbeat tempo has the opposite effect - speeding up respiration and heart rate [2]. Steelman looked at a number of studies of music's effect on relaxation where tempo was varied and concluded that tempos of 60 to 80 beats per minute reduce the stress response and induce relaxation, while tempos between 100 and 120 beats per minute stimulate the sympathetic nervous system [3].

C. System Framework
Figure 1 presents system framework design. The system starts by observing the passenger's current heart rate that it wishes to control. This step of perception creates an internal representation of the passenger's heart rate situation. The information in this representation then must be processed in order to determine whether the passenger's heart rate is normal or not; based on this interpretation, refer to the user profile, the system then recommends on a personalized music playlist. The passenger himself/herself is an adaptive system. His perception creates an internal representation of

the music service. This perception affects the passenger's heart rate. During this process, the passenger's heart rate may also influenced by a set of variables which in the control system called disturbances. The change in the passenger's heart rate is again perceived by the system, and this again triggers the adaptation process we have described, thus closing the control loop. In figure 1, if the system recommends music that the passenger does not like, he can reject the recommendation and re select the music. During this process, the system logs the interactions between the passenger and the system. By mining on the log information, the system can learn and adapt to the passenger's latest music preferences.

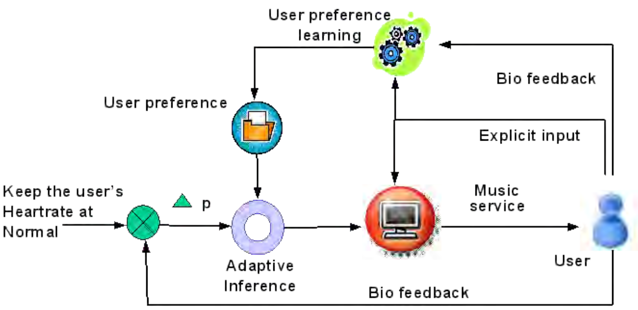

Figure 1. System framework.

D. System Architecture

Figure 2 shows the main components that make up the new heart rate controlled music recommendation system. The whole architecture is divided into five abstraction levels from functionality point of view. The lowest level is the resource level. The second layer is the resource manager layer which includes music service manager, heart rate manager and user profile manager. The third layer is the database layer which constitutes by a database. It acts not only as a data repository, but also enables the layers and the components in the layers loosely coupled. The fourth layer is the adaptive control unit layer which includes user feedback log, adaptive inference and user preference learning components. It is used to mediate between the user profile, heart rate and available music to provide personalized music playlist keep the user's heart rate within normal range. The fifth layer is the interface layer. The passenger interacts with the system interface to get personalized music services.

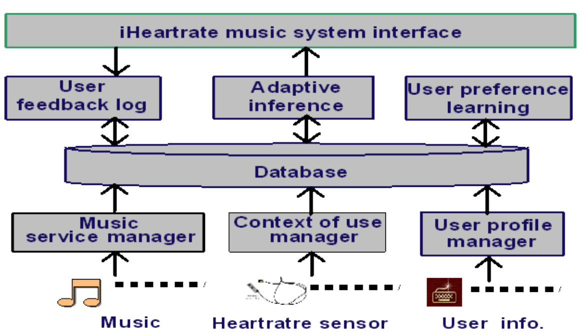

Figure 2. System architecture.

USER EXPERIMENT

A. Setup

The user experiment was conducted in the SEAT flight simulator. The SEAT simulator consists of a small scale aircraft cabin residing on a moving platform, a project section to simulate the aircraft cabin outside sky, and a control room section. The interior of the aircraft cabin is divided into an economy class section, a business class section, a galley and a lavatory. The projection section include a beamer hangs above the aircraft cabin and a projection wall next to the aircraft cabin. The control room is equipped with the state of art of computers to support in-seat computers in the aircraft cabin and long haul flight simulation.

B. Test Subjects

Twelve subjects were invited to participate in user experiments. Six were allocated to the controlled group and others were allocated to the treatment group. The age of the control group ranges from 21 to 33. The age of the treatment group ranges from 23 to 32. Each group is composed by three females and three males.

C. Procedure

A real world KLM KL0895 flight from Amsterdam Schipol international airport (6:20PM) to Shanghai Pudong international airport (10:45 AM <Shanghai time>, 4:55AM <Amsterdam time>) is simulated in our flight simulator on 31st (Friday), July 2009 (the controlled group user experiment) and 7th (Friday), August 2009 (the treatment group user experiment).

A professional flight attendant is invited to serve the flight cabin. Figure 3 is the procedure of the flight simulation.

Figure 4 is a snapshot of our user experiment. Figure 5 shows the Emfit heart rate sensor we have used [4]. It can be embedded in the seat to measure the user's heart rate non intrusively.

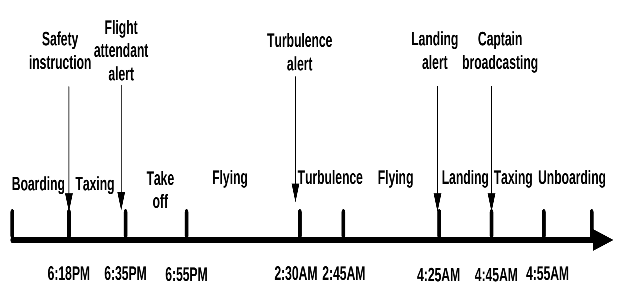

Figure 3. Procedure.

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Eds. A.J. Spink, F. Grieco, O.E. Krips, L.W.S. Loijens, L.P.J.J. Noldus, and P.H. Zimmerman

Figure 4. User experiment.

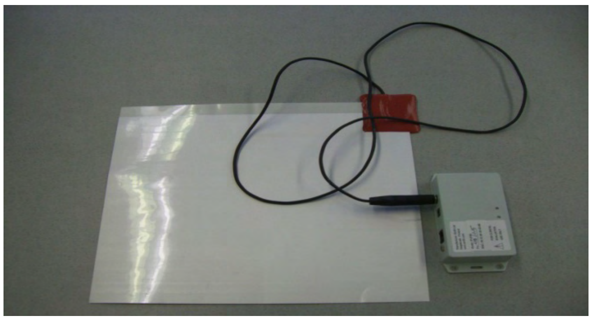

Figure 5. Heart rate sensor.

D. Results

Five patterns have been summarized. These include two uplift patterns, two calm patterns and one keep pattern. Figure 6 is one of the uplift patterns. In Figure 6, after the user listens to the recommended music playlist for four minutes, his/her heart rate is uplifted back to the normal range. Figure 7 is a calm pattern. For the details, see [5].

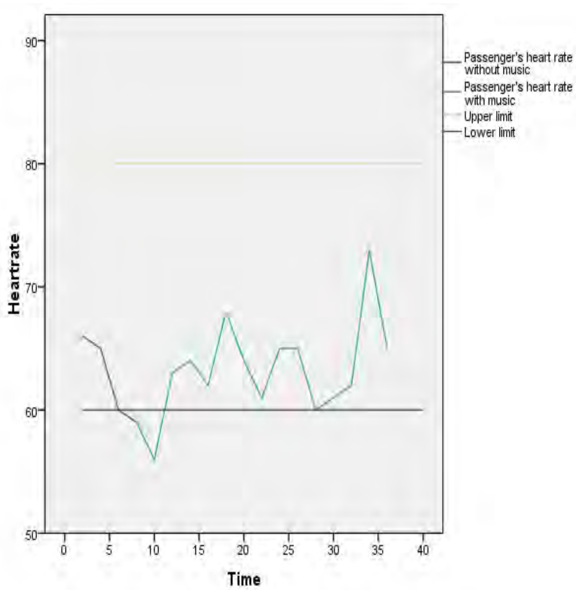

Figure 6. Uplift pattern.

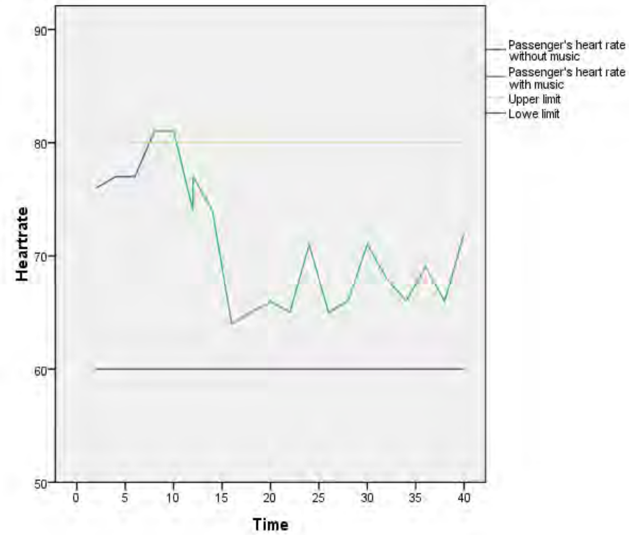

Figure 7. Calm pattern.

Figure 8 is the stress level represented by heart rate variability. The computing is based on five minutes of heart rate. The method used is welch's periodogram where the window is 62s with 50% overlap. The difference between the control group and treatment group is significant (ANOVA, $P = 0.031$).

Figure 9 is the self report stress scales [6] by the passenger each hour. The difference between the control group and treatment group is significant (ANOVA, Sig. =0.001).

Giving the test subjects a high level of long haul flight presence is the precondition of the trustable of the user experiment data. Presence is defined as the subjective experience of being in one place or environment, even when one is physically situated in another [7]. In this

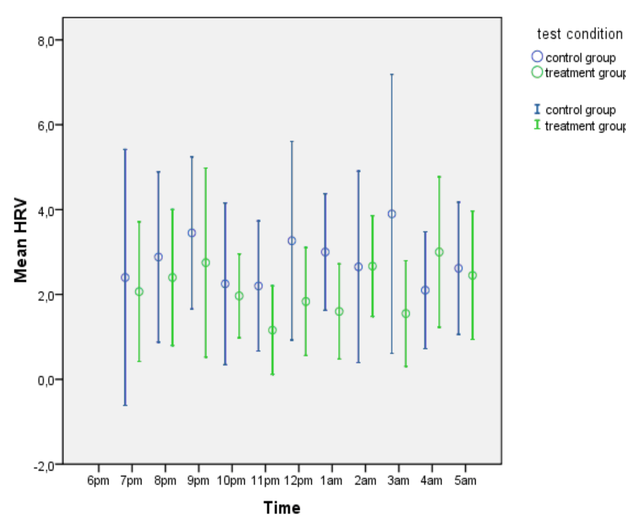

Figure 8. Heart rate variability: LF/HF.

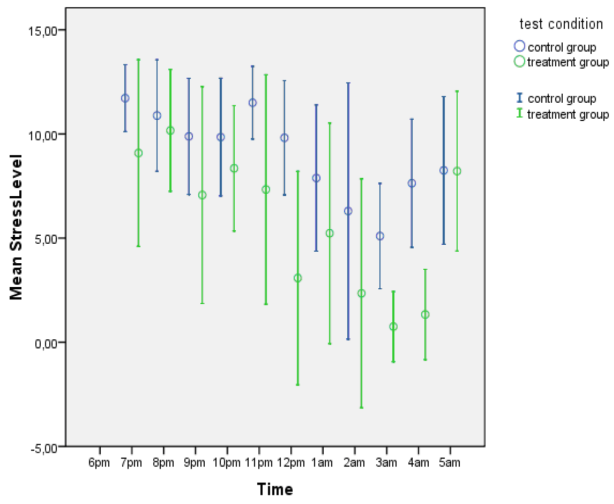

Figure 9. Stress scale.

paper's context, presence means the "passenger's" subjective experience of being in the long haul flight; even when the "passenger's" is physically sitting in set up. The presence questionnaire in [7] is customized to measure the user presence. It is filled in by the test subjects right after the user experiment.

Table 1 presents the result based on the twelve test subjects' answers. All the five questions scored above 3.5.

	N	Mean	Std. deviation
BeingThere	12	4.0000	0.73855
RealFlight	12	3.7500	1.21543
LaboratoryOrSomewhere	12	3.5833	0.79296
LaboratoryFlight	12	3.9167	0.79296
SitLabOrFlight	12	3.5000	1.08711
Valid N (listwise)	12		

Table 1. Subjects' presence results.

CONCLUSION

In this paper, we present a new heart rate controlled music recommendation system. It can regulate the user's heart rate within the normal range with user preferred music playlist recommendation. If the user's heart rate is higher than the normal heart rate, the system recommends his/her preferred calm music to the user to transfer his/her heart rate back to normal; If the user's heart rate is lower than the normal heart rate, the system recommends his/her preferred upbeat music to uplift his/her heart rate back to normal. We implemented the system. The user experiment has validated our design concept.

ACKNOWLEDGMENTS

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