

PRE-PRINT VERSION

Bauer, Christine & Waldner, Florian (2013). Reactive Music: When User Behavior Affects Sounds in Real-Time. Proceedings of the CHI 2013 Extended Abstracts on Human Factors in Computing Systems. 27 Apr – 2 May, Paris, France, pp 739-744.

DOI: 10.1145/2468356.2468488

The final publication is available at ACM via
<https://doi.org/10.1145/2468356.2468488>



Reactive Music: When User Behavior Affects Sounds in Real-Time

Christine Bauer

Institute for Management information Systems
Vienna University of Economics and Business
Augasse 2-6, UZA 2
1090 Vienna, Austria
chris.bauer@wu.ac.at

Florian Waldner

Faculty of Business, Economics and Statistics
University of Vienna
Bruenner Strasse 72
1210 Vienna, Austria
florian.waldner@univie.ac.at

Abstract

It is a natural predisposition of humans to respond to the rhythmical qualities of music. Now, we turn the setting around: The music responds to the user's behavior. So-called 'reactive music' is a non-linear format of music that is able to react to the listener and her or his environment in real-time. Giant Steps is an iPhone application that implements such reactive music in correspondence to a jogger's movements and the sounds in her or his environment. We hope that our approach contributes to a better understanding of 'machine to user' adaption, and to mobile sports applications in particular.

Author Keywords

Reactive music; context-adaptivity; human-computer interaction; music controllability

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces.

General Terms

Design; Experimentation

1 Introduction

Since its beginning in the 1990's [12], the goal of research in context-aware computing was to develop machines that intelligently adapt to people – be it their characteristics and/or their behavior. However, should machines perfectly adapt to people? Or are people better off if they adapt to the machine? And is there actually a general answer to these questions? Or do the effects of machine reaction and preferences for or against it depend on individuals' situational context or their personal preferences? We want to investigate these higher-level questions by looking concretely into the effects that reactive music has on people.

Music is one of the best-researched examples, where humans intrinsically adapt to the presets: The natural predisposition of humans to respond to the rhythmical qualities of music



The final publication is available at ACM via <https://doi.org/10.1145/2468356.2468488>

has long been acknowledged [6]. With reactive music, we turn the setting around: The music responds to the user's behavior.

A particular setting, which we are interested in, is listening to music while jogging. Here, the use of music is a common approach for regulating pace and motivation [4].

2 Related Work

Music is omnipresent. It is not only listened to for entertainment, but also frequently deployed for certain purposes that are as versatile as for pacification or to stimulate buying behavior in supermarkets. In the domain of sports, music has long been considered a motivational tool [5].

Commercial products and research prototypes have been developed using music to motivate individuals when walking, jogging, or running. The Nike/iPod Run [1] is an MP3 player that does not only play music, but tracks an individual's exercise performance. In particular intervals the music stops and the user's progress (speed and distance) is reported verbally, such that she or he is able to monitor the performance on the go without looking on the device. MPTrain [10] is a device that monitors heart rate and speed. Depending on these parameters, the tool selects music with a particular tempo to encourage the user to slow down, speed up, or keep pace. DJogger [2] calculates a runner's pace and adjusts the musical soundtrack accordingly by selecting a song with appropriate beats per minute (BPM) and/or by adjusting the BPM of the current track to suggest the desired pace.

3 Reactive Music

Reactive music is a non-linear format of music that is able to react to the listener and her or his environment in real-time [9]. Instead of distributing linear sound files to the listener, reactive music is software that uses input data and transforms it into audible formats for the listener. This mechanism allows the generated music to adapt to the listener and her or his environment by using, for instance, the built-in sensors (e.g., camera, microphone, accelerometer) of mobile devices.

In contrast to existing 'adaptive music players' [e.g., 2, 10], reactive music does not select predefined linear songs from a database based on the user's behavior (e.g., pace) and/or adjusts the BPM (as far as technically possible such that the song is still okay to listen to). Instead, reactive music is generated in real-time.

4 Giant Steps

In order to use reactive music while jogging, the audio interface has to suit a mobile, outdoor setting. It is important that it is simple (easy to use), lightweight, and allows users to focus on their visual environment [8]. While jogging could also be performed using a treadmill, we decided for a mobile, wearable system because ride rate is determined by treadmill velocity [3].

In contrast to existing setups, where prototype devices were specifically built to fit the purpose, we use a device that is familiar to many people – partly also for listening to music: a smartphone. A smartphone is mobile, wearable (with the help of an armband), and has a set



The final publication is available at ACM via <https://doi.org/10.1145/2468356.2468488>

of sensors (e.g., microphone, camera, positioning system, accelerometer, gyroscope, magnetometer, luxmeter [13]) already integrated into the device. Accordingly, we have developed a smartphone application called “Giant Steps”, which is described below.

In this application, not only user movements trigger a certain music reaction, but also events in the auditory environment are picked up by the device’s microphone and incorporated in the music.

4.1 The Application

The Giant Steps application (**Figure 1**) is an iOS application that runs an interactive music format for mobile devices, which has been developed by Reality Jockey Ltd. (www.rjdj.me). Using this technology it is possible to playback music capable of reacting to the listener in real-time.

The application uses the iPhone’s built-in 3-axis accelerometer to capture the level of a user’s movements (combining the values of all 3 axes). This data is translated into five different physical activity levels, where slow walking corresponds to activity level 1 and fast running to activity level 5. Musical arrangements are structured to react to the respective physical activity level. Additionally, the accelerometer data is used to compute the jogger’s step frequency.

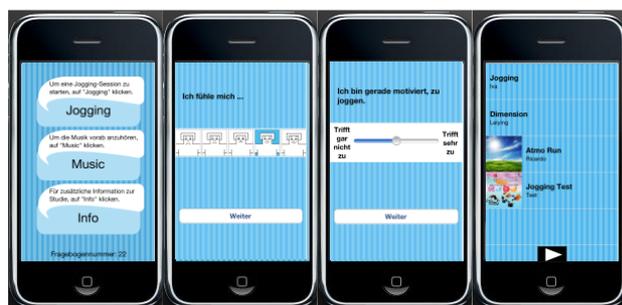


Figure 1. Screenshots of the application Giant Steps.

The application is especially designed to fit a scientific experimental setting. For instance, it includes short questionnaires, which are directly transferred to a secure database, ready for analysis. Moreover, the application provides further analytics such as logging of session time, piece of music listened to (including the playtime duration and zapping between pieces), frequency of steps made per session, average tempo per session, etc.

4.2 Technical Setup and Implementation

The application requires iOS 5 or later on iPhone 3GS (or later), or iPod Touch (3rd generation or later). We opted for iOS (instead of Android) due to the extensive variation in hardware of Android devices. The interactive music format used would make it necessary to tailor musical content to all devices individually, which, of course, is a time- and resource-consuming process.

The technical setup consists of an iPhone or iPod Touch, headphones or earphones, and an armband (**Figure 2**). The device is worn on the arm (**Figure 3**) because the accelerator

The final publication is available at ACM via <https://doi.org/10.1145/2468356.2468488>

measurements were found to be more precise than when worn, for instance, in a pocket. Furthermore, it allows the users to move their arms freely while jogging.



Figure 2. Technical setup.

During a jogging session (20 minutes), generated data is stored on the device. After having completed the 5-question post-jogging questionnaire, the application automatically transmits all generated data in JavaScript Object Notation (JSON) wirelessly via wireless local area network (WLAN) or over a 3rd Generation (3G) network to a server.

4.3 Music Implementation

What makes the music for this experiment different from conventional recorded music is the fact that it is the music itself (and not the playlist) that is being affected in real-time by the jogger. Owing to this, musical content for the Giant Steps application has to be custom made to be capable of adapting to the physical activity level of the jogger. The varying levels of physical activity during the course of a run shape the musical arrangements individually for each jogger.

Instead of linear sound files, music in the Giant Steps application is basically software that generates the music while listening to it. Thus, it is possible to generate an individual musical experience that reacts to the physical activity level of the jogger. The production of this type of software music, which is closely related to generative music, is radically different to conventional music production. In our case, the music is implemented in the Pure Data digital signal-processing framework (**Figure 4**). Pure Data is an open source graphical programming environment that is widely used by musicians, composers, and sound designers [11].

The final publication is available at ACM via <https://doi.org/10.1145/2468356.2468488>

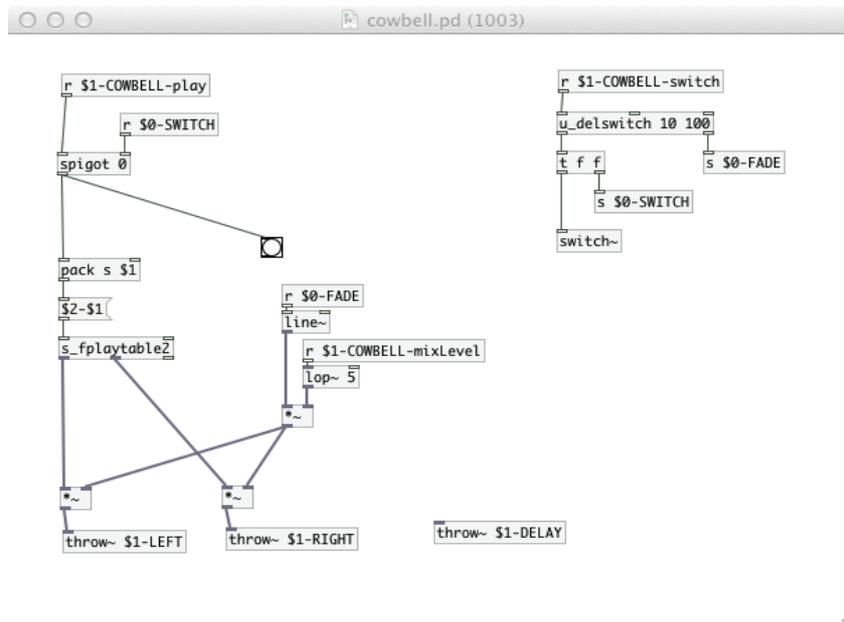


Figure 4. Example of Pure Data (Pd) notation.

All music available in the application is composed specifically for a decent jogging experience. The pieces were composed and implemented in collaboration with the Department of Composition and Electro-acoustics at the University of Music and Performing Arts Vienna. Students majoring in Media Composition and Applied Music were asked to compose reactive music for jogging structured into five levels, which will be triggered by the physical activity level. In terms of style, the music is intended to cover a variety of musical genres.

5 Experiences

In discussion with experts from the fields of jogging and reactive music and in our own trials of jogging with early versions of Giant Steps, we could gain fruitful knowledge and experience, what has to be considered when using the application for jogging purposes. For instance, there are still performance problems with Pure Data when using Bluetooth headphones. When wearing the device at the backside, the accelerator does not perform properly. Wearing it on the arm is therefore to be preferred. Further, we found that Giant Steps is primarily targeted at casual joggers who enjoy jogging (while listening to music). For competitive runners or people who prepare for a marathon, the application seems not to be useful in its current form because professional training sessions adhere to sophisticated schedules of endurance sessions, sprint, and rest.

6 Relevance to the Research Community

Giant Steps is a novel demonstrator in the area of ubiquitous computing in sports. With this demonstrator, researchers can learn about machine adaptation in a setting that is typically known for “human adapts to machine” instead of “machine adapts to user”. It will generate



results on how people perceive reactive music in a sportive setting. While our demonstrator utilizes the motivational benefits known from music while jogging, it seems plausible that this concept can be used in other than sportive contexts. Examples are, fitting music for concentration, evoking emotions or even in medical settings.

7 Future Work and Discussion

We aim to conduct an experimental, comparative study to measure the effects of adaptation in contrast to the effects of non-adaptation. Generally, two randomly selected groups of participants will use the Giant Step application on their devices while jogging. In one experimental condition, the music adapts to the participant's movements (activity levels) using the functionality of the Giant Steps application (reactive music). In the other condition, participants do not have the reactive music functionality. Instead they have an "autopilot" version of the very same music as in the first condition. Instead of reacting to the participant, the music switches between different "modes" of music at random, as pre-defined in an algorithm. While one group will have reactive music in the first test phase, and non-reactive music in the second phase, the second group will go through the two conditions in reverse order. An extensive questionnaire before and after the experimental period as well as a short questionnaire (~3-5 items) before and after each completed jogging session (within the Giant Steps application) will generate the data to contribute to answering the questions raised in the introduction. Additionally, analytics such as frequency of steps, switching behavior between music pieces, etc. will be captured and analyzed. Essentially, we will analyze the impact of reactive music on participants' emotional states [7]. Amongst others, we will control for personality traits, musical education, taste in music, listening behavior, jogging behavior, etc.

There are still a number of open questions that will be addressed through our ongoing work and particularly in pretests. First we have to make sure that the switching between music pieces performs smoothly without lengthy loading times. Second, we will have several test joggers, who we will interview concerning user perception of adaptivity, fit of music for the jogging purpose, usability issues, etc.

We believe that our work on Giant Steps can contribute to a better understanding of mobile media use, and sports applications of Human-Computer Interaction (HCI).

8 Acknowledgements

We thank Reality Jockey Ltd. (www.ridj.me) for the support and Sarah Spiekermann for her helpful comments. Further we thank Univ.-Prof. Reinhard Karger and all his students who contributed music to the experiment.

9 References

- [1] Apple. Nike + iPod. (accessed 14 February 2013), <http://www.apple.com/ipod/nike/>.
- [2] Biehl, J. T., Adamczyk, P. D. and Bailey, B. P. DJogger: a mobile dynamic music device. In *Proc. CHIEA '06*, ACM (2006), 556-561.



The final publication is available at ACM via <https://doi.org/10.1145/2468356.2468488>

- [3] Karageorghis, C. I., Jones, L. and Low, D. C. Relationship between exercise heart rate and music tempo preference. *Res Q Exerc Sport*, 77, 2 (June 2006), 240-250.
- [4] Karageorghis, C. I. and Priest, D.-L. Music in the exercise domain: a review and synthesis (Part 1). *International Review of Sport and Exercise Psychology*, 5, 1 (March 2012), 44-66.
- [5] Karageorghis, C. I. and Terry, P. C. The psychophysical effects of music in sport and exercise. *J Sport Behav*, 20 (1997), 54-68.
- [6] MacDougall, R. The affective quality of auditory rhythm in its relation to objective forms. *Psychological Review*, 10, 1 (1903), 15-36.
- [7] Mehrabian, A. Framework for a comprehensive description and measurement of emotional states. *Genetic, Social, and General Psychology Monographs*, 121, 3 (August 1995), 339-361.
- [8] Mueller, F. F., O'Brien, S. and Thorogood, A. Jogging over a Distance. In *Proc. CHIEA 2007*, ACM (2006).
- [9] Nordgren, A. Epilogue Reactive Music and Invisible Interfaces. In D. Barnard, J. Bondo, D. Burcaw, D. Kaneda, C. Kemper, T. Novikoff, C. Parrish, B. Ellis, K. Peters, J. Siebert and E. Wilson (eds.) *iPhone User Interface Design Projects*, (2009), 235-238.
- [10] Oliver, N. and Flores-Mangas, F. MPTrain: a mobile, music and physiology-based personal trainer. In *Proc. MobileHCI 2006*, ACM (2006), 21-28.
- [11] Puckette, M. Pure Data. In *Proc. International Computer Music Conference (ICMC 1996)*, International Music Association (1996), 224-227.
- [12] Schilit, B. N. and Theimer, M. M. Disseminating active map information to mobile hosts. *IEEE Network*, 8, 5 (Sep-Oct 1994), 22-32.
- [13] Schirmer, M. and Höpfner, H. Smartphone Hardware Sensors (2011), (accessed 14 February 2013), <http://www.uni-weimar.de/medien/wiki/images/Zeitmaschinen-smartphonesensors.pdf>.

