

VARVI: A Software Tool for Analyzing the Variability of the Heart Rate in Response to Visual Stimuli

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Abstract

This paper describes a free software tool (VARVI) developed in our research group to facilitate the analysis of heart rate variability (HRV) in response to different visual stimuli. This tool was developed after the realization that this type of studies are becoming to be used in fields such as psychiatry, psychology and marketing and that there are no specific tools for this purpose.

It has been developed in python language and tested on Linux but extensible to other operating systems. It requires the connection of a Bluetooth chest strap Polar WearLink to the subject. The researcher selects a set of videos of any duration and the application shows them to the subject in a predefined or random order, while the heart rate is recorded. The result is a pair of text files that can be read by other HRV tools developed in our group (RHRV or gHRV).

VARVI has been used for analyzing the response to watching the videos of the last Galician election campaign in a group of 90 people. It will be used in a project whose goal is to analyze the impact of traffic accidents prevention campaign in Spain and also in a research with depressed patients, in collaboration with the Hospital of Ourense.

1. Introduction

Heart Rate Variability (HRV) can be defined as variations in sequence periods between consecutive beats, and it is regulated by extrinsic factors to the circulatory system. Variability is the result of adjusting the influence between the parasympathetic (acceleration of heart rate) and sympathetic system (deceleration of heart rate) [1]. Given this relationship, spectral analysis of HRV can be a useful tool for analyzing the cardiac rhythm, since it provides a quantitative analysis and assessment of the nervous system, evaluating both the sympathetic (low frequency components, LF), and parasympathetic (high frequency components, HF) systems [2].

It should be stated that the typical spectrum of a healthy person at rest possesses two fundamental frequency com-

ponents: the LF band (ranging from 0.04 to 0.15 Hz), and the HF band (ranging from 0.15 to 0.4 Hz). The study of this bands, together with other spectral parameters, such as the LF/HF ratio, has been broadly employed as an indicator of the neurovegetative system state [3, 4].

It is well known from several decades that the peripheral nervous system is responsible of different human actions that may appear in reaction to different external stimuli [5]. In this way, different response patterns of the nervous system, such as the heart rate patterns, should be affected by diverse stimuli or inputs causing emotional influence, for example when viewing political ads [6] or in a display of stripes to examine cardiovascular response to motion sickness and perception-based events [7].

Several works focusing on the analysis of HRV when people are suffering emotional visual elicitation have already been described employing the IAPS (International Affective Picture System) database [8] or violence videos [9]. Results have shown a differentiation between the normal situation and the emotional elicitation, and increased parasympathetic nervous activity while perceiving the positive visual stimulus.

From the results obtained in these previous works, it could be interesting to evaluate the effects of visual stimulations employing HRV, applied to several and varied research fields. To perform this task, it should be very useful to have at the specialists' disposal a user-friendly software that could help to determine heart rate patterns and variations in the nervous system when healthy subjects or even patients are subjected to emotional distress. However, the lack of this type of computer programs makes it difficult the automated analysis of HRV, and investigators usually have to develop their own applications, which are not always freely available for the researchers community.

To overcome the limitations of the existing computer application for analyzing the HRV when different inputs produce emotional responses, we have developed VARVI (Variability of the Heart Rate in response to Visual stimuli). It is a software package that allows to study heart rate variations and HRV spectral parameters related with external visual stimuli. In the rest of the paper, features and an example of use of the software tool are presented, as well

as main conclusions.

2. Features

VARVI was designed to meet a need: to have a tool that would allow the analysis of HRV while the subject watched a series of videos. More specifically the functional requirements were:

- Acquisition of the heart rate signal from a specific model of sensor, the *Polar WearLink* chest strap with Bluetooth connectivity [10].
- Synchronization of such acquisition with the projection of a set of videos on the computer screen.
- Possibility of assigning tags to videos to allow further HRV analysis in relation with these labels.
- Possibility of delivering videos in a predetermined or random order on each program run.
- Recording heart rate signal and data associate to each video (time, duration and label) in a format compatible with other applications for HRV analysis previously developed in our group: gHRV [11] and RHRV [12].

For this first version we chose not to include in the requirements the platform independence or the designing of a graphical interface. We wanted to build an application quickly to meet an urgent need. For this, and because we have experience programming in python on linux environments, we chose this technology. Also we took advantage of external libraries and applications to accelerate the development.

VARVI can be downloaded from *varvi.milegroup.net*. It's free and no installation is needed but it has the following requirements:

- A computer running Linux.
- We use *mplayer* (<http://www.mplayerhq.hu/>) for watching the videos, then this application must already be installed.
- For communication with the *Polar WearLink* band *Py-Bluez* libraries (<http://pybluez.googlecode.com/>) are required.

The application consists of only two files, *VARVI.py* and *VARVI_functions.py*, that must be downloaded from the website. It is recommended to place these two files in a folder included in the PATH variable to allow its execution from any folder.

VARVI requires a configuration file which basically indicates the location of the videos to play and labels associated with each video. An example of configuration file, that can be downloaded from the same website (*sample_conf.cfg*), is the following.

```
[Main]
random = 1
#gap = 1.1
nvideos=2
```

```
device=00:22:D0:02:4A:46
```

```
[Media_01]
filename = ../Videos/media2/Coma.mp4
tag = coma
```

```
[Media_02]
filename = ../Videos/media2/Lisa.mp4
Tag = lisa
```

As can be seen it has a main section in which it is showed:

- That reproduction of the videos is in random order (random = 1).
- We are going to play two videos (nvideos = 2).
- The MAC address of the *PolarWearLink* chest strap.
- A pause after each video could also be indicated uncommenting the line containing (gap = 1.1)

Following sections indicate the path of each video file and tags we want to associate to each video. Each section must have a header called *[Media_i]* being *i* the number of the section.

The application is executed from the command line using the following syntax:

```
VARVI.py [-h] [-v] [-d dir] config_filename record_name
```

The *-h* option simply displays a help text, the option *-v* is verbose, the *-d* option is used to specify a folder to store the results (default folder is the working folder). *Config_filename* is the configuration file name and *record_name* is the basis for naming the resulting files, a file with RR distances (*record_name.rr.txt*) and a file with data concerning the videos: initial time, label and duration (*record_name.tag.txt*).

3. Example of usage

To prove the usefulness of VARVI, this software tool was used to study the response to the visualization of political videos of the last Galician elections. Volunteers from the University of Vigo were asked to fill a test with personal information and politic orientation, and then their heart rate was collected while they watched electoral videos of the parties participating in the election. Volunteers ranged from 18 to 60 years old, and they had different politic ideologies. No confidential information about participants was published.

All videos were stored in a directory, and VARVI automatically showed them in a random order for each volunteer. This directory must be included in the configuration file. Figure 1 shows a volunteer wearing the *Polar WearLink* band and watching a video during the test.



Figure 1. A volunteer following the test

VARVI stores the heart rate record labelled with tags corresponding to each electoral video, init time and duration. Two files were created: the heart rate file and the episodes file. In Figure 2 an example of episode file is shown (event corresponds to the acronym of the politic party of each spot).

This information was used as input to another tool called gHRV, described elsewhere [11]. This tool allows the graphical representation of the heart rate signal and episodes or events recorded during its acquisition (see Figure 3). It is a tool designed for analysing heart rate variability, offering standard HRV parameters and statistical information about these parameters.

After the realization of this study, we concluded basically that voters with more extreme ideology have higher values of variability. Nevertheless, regarding to the episodes of visualization of different videos, no regular

| Init_time | Event | Durat |
|----------------|-------|--------|
| 0:00:02.002092 | age | 30.032 |
| 0:00:34.036446 | upd | 30.385 |
| 0:01:06.423749 | scd | 30.835 |
| 0:01:39.260994 | bng | 30.140 |
| 0:02:11.402979 | cxg | 30.588 |
| 0:02:43.993055 | pp | 30.183 |
| 0:03:16.178011 | psg | 30.187 |

Figure 2. File containing the visualization order of the videos, init time, acronym, and duration

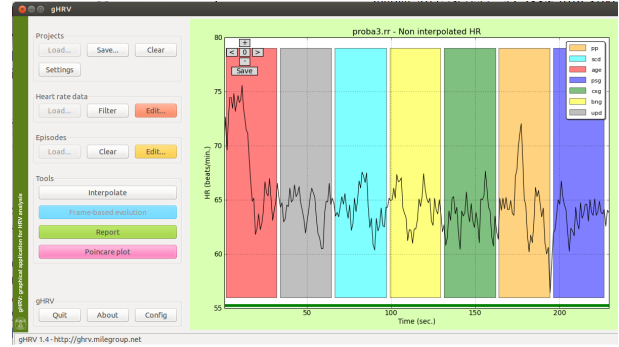


Figure 3. Visualization of the data of one participant with gHRV (heart rate and episodes)

pattern was observed. Furthermore, it seems that videos have no influence in undecided voters. It must be pointed out that this experiment used data from university volunteers; it is necessary to expand to other populations to verify these preliminary results.

Despite the description of this particular study, we want to emphasize that VARVI supplies an easy and simple way to develop an experiment where its aim was to obtain heart rate signal during different episodes. The obtained data is used as input to another tools as gHRV.

4. Conclusions and future work

In this paper we present an open source application specifically designed to analyze the HRV in response to different visual stimuli presented through a sequence of videos.

The application requires only to store the videos in a specific folder and write a small configuration file. The result are two files, one with the heart rate data and the other with information about each video, that can be analyzed with other tools like gHRV or RHRV, previously created by our research group.

We believe that this tool covers an important gap and can be very useful to psychologists and professionals in marketing and advertising. In fact we have contacts with some researchers in this field very much interested in using our software in some research projects.

This is a first version we hope to improve in the future, adapting it to different platforms, including the ability to use photos and adapting it also to different hardware devices.

Acknowledgments

We would like to thank the collaboration of students, teachers and administrative staff of the University of Vigo who have collaborated on the first experience with this software.

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