



Webinar: Recording Great Electrocardiogram (ECG) Data: Recording Great Data and RSA & HRV Analysis Combined QA

This Q&A is divided into to the following sections:

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Data Analysis

1. Q: How can you use the participant's own respiration rate instead of a standard when analyzing the ECG data?

A: It is possible to record respiration rate in real-time with the use of one of the BIOPAC respiration transducers and amplifiers. We have options available for wireless ([BN-RSPEC](#) + [BN-RESP-XDCR](#)), tethered ([RSP100C](#) + [TSD201](#)), and MRI ([DA100C](#) + [MECMRI-DA](#) + [TSD221-MRI](#)) applications. Please contact BIOPAC for specific pricing and specifications.

2. Q: Are there any statistical applications in the *AcqKnowledge* system?

A: *AcqKnowledge* takes the analysis to the point of extracting measurements from the data but it does not provide statistical analysis of the results. It does, however, have options for [HRV](#), [RSA](#) and [time-series statistical measures](#).

3. Q: Why use the 35Hz Low Pass Filter when many prototypes recommend at least signals till 100Hz?

A: The ECG100C amplifier will allow you to set the Low Pass filter to 35Hz or 150Hz to provide the user with good recording options. *AcqKnowledge* also includes offline digital filters for further signal conditioning.

4. Q: Will there be a similar webinar on cardiac thoracic impedance? I am interested in the pre-ejection period in particular.

A: We are running a series of webinars and will offer one on [impedance cardiography](#). We currently have recording solutions for [tethered](#), [wireless](#) and [MRI](#) applications with an automated analysis options.

5. Q: What are tips for recording good data from animals (rats)?

A: We have several solutions for small animals including tethered (using needles or small reusable surface electrodes), and wireless solutions (using [Epoch](#) or [Stellar telemetry](#)). If you are using tethered options, the electrodes should be in good condition and placed in the correct place. Please check with our support team for additional advice.

6. Q: How would you recommend analyzing multiple subjects after checking quality of data? Is there some batch file that could be used?

A: Yes, the *AcqKnowledge* software does include a [scripting](#) option that allows you to batch process many of the analysis options.

7. Q: How do you switch to R WAVE mode?

A: The Mode switch on the front of the [ECG100C](#) and [ECG100C-MRI](#) amplifiers can be set to either R-wave or Norm. If the R-wave position is selected, the signal from the amplifier will provide a nice smooth peak at the point of the R-wave. This was demonstrated during the webinar.

8. Q: What does analogue channel 2 refer to when calculating real time heart rate and R-R interval? How is this related to Lead II?

A: The software needs to know which signal/channel to calculate heart rate from. If you only have one channel of data, it's easier because there is no choice. If you have a number of other signals, you have to set the software to calculate heart rate and R-R interval from the correct channel.

9. Q: What is the best way to quickly go over your ECG data and find bad data/artifacts and then remove them easily so as to clean the data/get rid of noise/artifacts before analysis such as HRV? Is there a way to make a script for it?

A: Yes, *AcqKnowledge* does have a [scripting](#) option that will allow you to automate artifact identification and cleanup. [This link](#) will provide some example scripts.

10. Q: We analyze the data after recording, and the students have trouble knowing the boundaries of each wave when it looks like his data does during the "running phase". Can you describe best practice for showing the students where each wave starts and ends in a situation like that?

A: The presentation includes a labeled waveform that will allow your students to learn the components of the ECG complex. Once the students are comfortable with the morphology of the waveform, they will find it easier to analyze the signals.

11. Q: Sometimes in analysis of our heart rate data, there is a little peak before the R peak (the R peak is divided into a little bump en route to the big bump). Is this a problem in data collection or does this just vary by subject (as is the case with EEG data)?

A: Without seeing the actual data it is difficult to provide you with an accurate answer. However, the P-wave is immediately before the QRS complex and it is a small peak. It is important that the heart rate detector algorithm doesn't trigger on the P-wave and the R-wave because the heart rate will jump dramatically if this happens. We will look at analysis preparation in the next webinar and this subject will be covered.

12. Q: What if R peaks of one participant's QRS waves are too small (or low)? Does it mean the recording was carried out incorrectly?

A: The R-wave does have a normal range for resting subjects that the signal should fall within, but as with most things, there are always outliers. I would recommend checking that the same lead configuration and body position was used to record the data – body position will have an impact on the amplitude of the waveform.

13. Q: Can I use these automatically calculated Heart Rate and R-R Interval? When I use 'Find rate' to get these data, some options are shown such as baseline removal, detect thresholds, noise rejection etc. Are all these options used same for the automatically derived HR and RRI?

A: The standard settings in the Find Rate calculation dialog usually work very well. In the webinar, I used the Rate from resting ECG option and both heart rate and R-R worked fine. However, you can make small adjustments to the settings if the defaults are not working for your data. You may find this [Application Note](#) helpful.

14. Q: What does P-P mean?

A: The P-P measurement is a measure of peak-to-peak within a selected range of data. For example, if you select 1 minute of heart rate data, the P-P measurement will give you the difference between the lowest and highest heart rate values within the selected minute.

15. Q: Can you output the heart rate value in real time into other software such as Vizard?

A: Yes, you can output the HR data in real-time using the [AcqKnowledge Network Data Transform](#) feature. Vizard supports NDT and we use it for virtual reality applications.

16. Q: What is the main difference in recording with one lead vs 3 leads when it comes to data analysis?

A: When it comes to recording ECG, the term lead refers to both the electrode lead configuration and the electrode lead. [Einthoven's triangle](#) is used to determine the placement of electrodes on the body to record the electrical activity of the heart...the lead configuration. A single lead configuration requires a positive, negative and ground electrode. The LEAD II configuration that I recommended follows:

<u>LEAD</u>	<u>Polarity</u>
LEAD II	right clavicle (-) to left lower rib (+)
	OR
	right arm (-) to left leg (+)
Ground	Left clavicle or left wrist

17. Q: Can we use event markers to label different sections of protocol when recording, and then analyze these sections differently?

A: Yes, please see the webinar sections on the use of Focus Areas and Flags. It is also possible to use events from [stimulus presentation systems](#) such as E-Prime and SuperLab. The following [screencast](#) will provide you with additional information about the use of digital inputs from stimulus presentation systems.

18. Q: How can I interpret RMSSD differences between groups? And what other ways are there to look at heart rate variability?

A: *AcqKnowledge* includes three different types of HRV analysis - Statistical - time series, Frequency based and Respiratory Arrhythmia - Peak to Valley. I would recommend reviewing the HRV guidelines to see the recommendations for comparing data across subjects.

19. Q: Is the Fast Fourier Transform handled by this process, or is it a discrete step that should be taken?

A: The HRV analysis automatically takes care of the Fast Fourier Transformation and the frequency information is reported for the standard bands and ratios.

20. Q: How would you identify the signal (Signal to Noise Ratio) in *AcqKnowledge*?

A: The signal to noise rate is typically measured at the amplifier and we specify the number in the [Product Sheet](#).

21. Q: What is the ECG appropriate setup for MP 35 and Biopac student Lab 4?

A: Make sure that the sample rate is set to 1Khz and you use the Electrocardiogram (ECG), 0.5 - 35 Hz channel Preset to record the ECG signal. The latest versions of the BSL software also include the HRV analysis.

22. Q: What calculation steps do you go through to get HF-HRV and how is that different than the steps you go through to get RSA?

A: When you run the HRV analysis the software will automatically provide the frequency power in the different bands - VLF, LF, HF, and VHF. If you use the multi-epoch HRV and RSA analysis option, the software will provide you with results for the four bands as well as RSA.

23. Q: Are there any structured ways in which we could use the accelerometry data to know whether the QRS is legitimate?

A: I'm not aware of any automated routines that use an accelerometer to identify a legitimate QRS complex.

24. Q: What's the difference between R-R and R wave which can be calculated automatically while the data acquisition is being carried out?

A: R-R is the time interval between two successive R-waves. R-wave refers to the R-wave component of the ECG waveform. It is possible to record the R-R interval online by using the Find Rate calculation and setting the output to Interval.

25. Q: Which resources would you recommend specifically for a more thorough review of HRV/RSA analysis options?

A: We recommend viewing the below video:

[HRV Analysis: Fully-automated Routine in AcqKnowledge](#)

We also recommend you review the following Application Notes:

[246 – R-R Interval Processing with the BIOPAC HRV Algorithm](#)

[129 – Heart Rate Variability](#)

[233 – Heart Rate Variability – Preparing Data for Analysis](#)

And the following Knowledge Base entries:

[HRV meaning](#)

[Unexpected HRV results](#)

Electrodes and Leads

1. Q: Do you get one channel with one lead? Is it possible to get 1 channel with three leads?

A: If you are using one of our ECG100C/ECG100C-MRI/BN-RSPEC amplifiers, you will require three electrodes/leads (positive/negative/ground) to record a single channel of ECG. See the PPT for lead placement options.

2. Q: What do you do with the ground in the case of wireless recording?

A: The BioNomadix wireless modules have a ground option included with the electrode lead sets. If you are using the dual channel BioNomadix ECG module, the second channel of ECG does not require a ground lead.

3. Q: Is using wireless electrodes possible? How does wearable ECG work?

A: BioNomadix will provide you with wireless ECG data. There are two options, a combination module for [ECG and respiration](#) and a [dual channel ECG](#) option. The transmitters will pair with either the receiver module that connects to an [MP150](#) system or to the [BioNomadix Logger](#) for remote mobile applications.

4. Q: What are the uses of carbon leads?
A: The carbon fiber leads ([LEAD108](#)) and electrodes ([EL508/EL509](#)) should be used for MRI applications because they are safe to use inside the MRI.
5. Q: Can HRV and RSA be validly calculated if using only Lead II?
A: Yes, you can record [HRV](#) and [RSA](#) from a LEAD II ECG signal. If a respiration signal is also recorded with the ECG waveform, it is possible to use both the frequency based and time-series analysis methods.
6. Q: Is the ground the black line, and is this on the center of the chest?
A: The important locations relate to the Positive and Negative leads. In the demonstration, I recorded ECG from LEAD II and had the Negative lead on the right side of my chest, by the clavicle, with the Positive lead on the lower left by my lower rib. I could have also placed the Negative on my right wrist and the Positive on my left ankle. The ground was located on the left side of my chest, by the clavicle. It could have also been on my left wrist, if I had used wrists and ankles. See the PPT presentation for the diagram of the locations.
7. Q: How can one obtain clean ECG data while recording in an fMRI? How can we reduce the signal to noise ratio?
A: Keys to obtaining clean ECG data while recording include proper electrode placement and participant preparation, as shown in the webinar, use of fMRI – certified components, and taking a sample recording outside the chamber to verify that you have a good signal. We strongly recommend reading this [blog](#) and this discussion of BIOPAC's [Advanced Feature](#) for recording data in the fMRI.
8. Q: What are the best practices in terms of selecting the material for electrodes? (metal? conductive polymer? adv./disadv.)
A: Generally speaking, Ag/AgCl electrodes provide the best electrodes for recording biopotential signals. BIOPAC offers a wide range of both disposable and reusable Ag/AgCl electrodes. If you are recording during MRI, you should always use the carbon fiber electrodes such as the [EL508](#) electrode. The new BioNomadix BioShirt uses a fabric electrode that also provides a good ECG signal. Good electrode placement and preparation are important when using regular disposable and reusable electrodes. We recommend checking the impedance of the electrode contact using an [impedance meter](#) to ensure that you get good clean signals.
9. Q: Do you recommend to use the pad or cream (ELPAD or ELPREP) when ECG will be measured from chest? And what about from ankles and wrists?
A: If you are using reusable electrodes it can be helpful to use the [ELPREP](#) gel, but if you are using disposable electrodes it makes more sense to use the ELPAD Abrasive Pads because the electrodes are already gelled. The pads will work well for both the chest and limb locations.
10. Q: Should we use ELPREP gel? Would it replace GEL100 or be used with the ELPAD?
A: ELPREP gel provides an alternative to GEL100 and the ELPAD. Note that ELPREP has not yet been certified for use in the MRI.
11. Q: Which leads should I use for [SS29L](#) and settings on the [MP36R](#) for obtaining the best HRV data?
A: I recommend a LEAD II configuration as described in the PowerPoint presentation.
12. Q: What are the cost/benefits of different numbers of leads? What about new tech with camera based heart rate measurement?
A: A single LEAD II recording is required to run the ECG analysis routines...you do not have to record additional lead configurations to run them. I can't comment on the accuracy of camera systems for ECG and HRV because BIOPAC does not currently use the technology.

Participant Considerations

1. Q: Are there any things that we have to ask from the participants before the recording in order to avoid artifacts, such as avoid caffeine or exercise?
A: I would recommend checking the literature and guideline papers to ensure that you are following best practice for your application.
2. Q: What if participants sweat a lot? Will it be okay if the electrodes are placed on their chests?

A: BIOPAC offers a range of electrodes and some are designed to handle exercising and sweating subjects. The [EL501](#) has a strong adhesive to help keep the electrodes in place while a subject is exercising. The important thing is to make sure that the electrodes are applied before the participant starts to sweat. It's important to make sure that the electrode leads are not pulling on the electrodes so taping them to the subject and clipping the [MEC110C](#) to the subject's clothing will help the situation.

3. Q: We used the BIOPAC BioNomadix system with 2-4 year olds who were moving around so we'll need to screen out movement-related artifacts. What steps should we take to do this?

A: If the data is already collected and you are analyzing the signals, you can use the Focus areas to select the portions of data to analyze. We will be covering analysis preparation in the next workshop, but in the mean time, you may find these links helpful.

[App Note 233 – Heart Rate Variability – Preparing Data for Analysis](#)

[Knowledge Base – Extracting heart rate from a noisy ECG signal](#)

4. Q: We opted to put 3 lead (BioNomadix) on the back of toddlers (they would rip them off the front), and the data quality appeared to be pretty good. Is there anything we need to do differently in the analysis process to account for this?

A: If you are calculating HR and R-R for HRV, you just need to ensure that you have a good clean signal and tachogram. We will be covering these topics in the next webinar.

5. Q: Are there any ethical considerations I need to be mindful of, especially in regards to participant safety? I am thinking specifically about electrical isolation from the mains when I ask about participant safety.

A: BIOPAC hardware platforms are optically isolated and meet international safety standards for human use. Please contact BIOPAC for further information.

6. Q: When doing ECG in the MRI, can you use the wrist and ankles as well?

A: We recommend recording from the chest because the signals are much stronger at that point and this helps to improve the quality of the signal. BIOPAC has a series of [MR Application Notes](#) that are available upon request.

Data Quality

1. Q: My respiration is clipped, why might this be? It is not nice rising and falling peaks and troughs as you are showing here.

A: Please review this [Knowledge Base Article](#) for a detailed discussion of obtaining good respiration data. While there are several possibilities, one of the most likely is subject movement and/or the respiration transducer is too tight or too loose. Have a test subject exhale completely, tighten the respiration belt snugly, then record a sample. If issues continue, [contact our support team](#).

2. Q: We record ECG in the OR where electric tools create a lot of artifacts—Can you help?

A: It is hard to provide a detailed answer without seeing the data, but generally, we can help to eliminate the noise with good filtering and electrode placement. I would recommend contacting our Support Department and letting them take a look at one of your files.

3. Q: How do we remove outliers in RR intervals?

A: Please see the webinar sections on data quality. Normally, a visual inspection of your data will enable you to readily identify outliers or artifacts. You can then address those using the techniques such as we demonstrated. [BIOPAC Scripting](#) automates much of this effort and sample scripts are available for download on www.biopac.com.

4. Q: Is recording of respiration necessary for RSA determination?

A: If you use the frequency based method you can calculate RSA without respiration, but if you want to record RSA using the Peak-Valley method, you will require a respiration signal.

5. Q: For raw ECG that was first recorded without any filtering, how would you clean up the raw data?

A: Start with a Band Pass filter set between 1-35Hz. This will stabilize the baseline and eliminate high frequency noise signals.

6. Q: How to acquire ECG without interfering in PV Loop Acquisition?

A: Normally and assuming you are using anesthetized animals and needle electrodes, you should not see interference between ECG and PV Loop Acquisition. Should you find ongoing issues, it's best to contact our Support Department at support@biopac.com.

7. Q: Is there minimum length (e.g., 5min) of ECG data to be used as HRV analysis?

A: We recommend that you have five (5) minutes of good ECG data for HRV analysis.

8. Q: How to deal with movement artifacts; identify abnormal beats, and processing HRV/RSA in toddlers/preschoolers, using webcam to find sections to analyze?

A: Collecting good data from toddlers/preschoolers is challenging for a number of reasons. In many cases, it may be advisable to place electrodes and electrode leads across the chest to minimize the temptation for the children to tear them off. Taping the electrode leads can also help significantly. BIOPAC does offer [video monitoring systems](#) that easily synchronize with *AcqKnowledge* so that you can identify focus areas for analysis. We also have electrodes that are gentler on the skin for infants. <https://www.biopac.com/product/disposable-dry-electrode-for-infants/>

9. Q: How can we effectively reduce baseline wandering on ECG and why it is required to resample down to 4Hz for HRV analysis?

A: If you set the amplifier high pass filter to .5 or 1Hz, the baseline of the signal should be nice and stable and make it easier to extract a reliable R-R tachogram from the data. We recommend using a band of between 1Hz and 35 Hz to record a nice clean ECG signal. You should not resample the raw data to 4Hz. The R-R intervals are resampled to a continuous sampling rate in order to extract the frequency information. Cubic-spline interpolation is used to generate the tachogram.

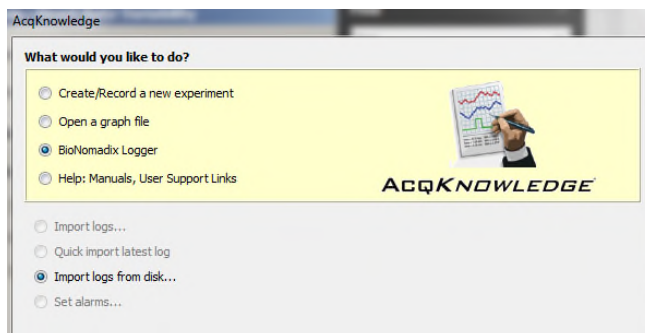
10. Q: What is the best practice in trial-by-trial experiment using ECG recording? Optimal ISI or Intertrial time.

A: If you record the ECG waveform continuously across all trials and stimuli, you have the option to choose the best analysis protocol for your experiment. The important thing is to ensure that you can easily identify the trials and stimuli so that you can synchronize the analysis around the events of interest. I would review the literature to see what is typical for your application.

Data Utilities

1. Q: How to visualize ECG data in a data logger after acquiring the data?

A: If you are using the BioNomadix Logger, you can import the data into *AcqKnowledge* for further analysis. The Logger has to be connected to the computer, via the USB cable that was included with the device. When you launch *AcqKnowledge*, you should select the BioNomadix Logger option and Import logs from disk option. The system will then import the log file from the Logger and display it as a new graph file in *AcqKnowledge*.

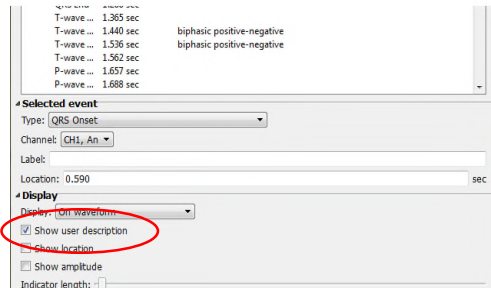


2. Q: Are there also batch utilities for analyzing multiple subjects?

A: BIOPAC Scripting allows the user to automate the analysis and batch process across multiple files.

3. Q: The software setting you demonstrated in the last webinar produce biphasic T waves. What is the best way to reduce this finding since we have been finding this with many healthy subjects as well?

A: The Biphasic labels are easily turned off by going to the Event Palette and turning off the Show user description option. The biphasic label is applied to the waveform when the T-wave appears to be biphasic. The following image shows the Event palette with the Show user description circled.



4. Q: How do you use the zapper tool?

A: The Zapper tool is shown below and circled in red. If you select the tool, you can click on a single event, or click and drag over an area, to eliminate events.



Other

1. Q: Can you put a 1 mV, 2-3 second square pulse across the input of a bipolar lead to document time-constant and frequency response?

A: The [BIOPAC Hardware Guide](#) provides graphs of the frequency response characteristics of the hardware filters. See page 478 -

2. Q: What is the relation between HRV and RSA?

A: RSA is the change in heart rate that naturally occurs during breathing. It's a measure that is available from the Multi-epoch HRV and RSA - Spectral routine. It can also be recorded using ECG and a respiration signal and performing the RSA - Time-series analysis.

3. Q: Is there a description anywhere about the calculation of the measures "sympathetic" and "vagal" in the output reports so that their meaning may be evaluated?. Also, has any evaluation been performed on the meaning of the RMSSD measure?

A: The [AcqKnowledge software guide](#) and the following Application note will provide additional details on the specifics of the calculations.

4. Q: Do you have kids' sizes in the BioShirt?

A: The [BioShirt](#) has a women's extra small which may be suitable, depending on the child's size. [Contact us](#) for assistance