

A Novel Freely Moving Animal Based Blood Pressure, ECG, and Dual Body Temperature Telemetry System for Group Housed Mice in Social Context



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Abstract

- Traditional rodent blood pressure (BP) monitoring required single housing, a known stressor for rodents. We developed a microprocessor based long range wireless telemetry system based on the Stellar™ technology with internal memory that allows rodents to live in groups, interact, exercise and be housed in large enriched environments. BP or ECG is recorded with a solid-state sensor along with core temperature and 3D activity. Heart rate was derived from BP and/or ECG in the Biopac AcqKnowledge 4.4.2 software.
- It is well established that rodent behavior is strongly influenced by social interaction. Moreover, spontaneous hierarchies develop in group housed animals and cardiovascular parameters such as heart rate and blood pressure reflect these conditions. Since animal experimentation most notably in neuroscience and behavior studies gravitate towards group housed colonies also for sake of animal welfare new technologies are needed to allow traditional measurements to be done in these new more refined research environments. Moreover, in the case of metabolic studies where animals tend to huddle in groups when they sleep, a similar adaptive behavior needs to be taken into account when calculating energy expenditure in nutritional and diabetes/obesity studies.
- In order to objectively validate this system we implanted male mice of ca. 20g. After 8 days of recovery the animals entered an exploratory study to compare fidelity and accuracy of the novel solid-state microtipped pressure catheter (450 micron) and BP was recorded for 10s every 15 min for 4 weeks sampled at 200Hz. The BP responses were compared to a control group of 5 animals implanted with a similar conventional implant from a competitor sampled for 5s every minute at 500Hz. Mean dark phase arterial pressures (MAP) at 14 days in the Stellar group were 134 ± 31 mmHg at a Heart rate (HR) of 544 ± 67 BPM versus 127 ± 9 mmHg at a HR of 545 ± 24 in the control group. Further studies on core body temperature are progressing and will be presented.
- We conclude that there are no significant differences in quantitative blood pressure responses between the Stellar digital telemetry device versus a leading analog competing device while being able to record from up to 5 different animals without cross-talk. We also conclude that the short scheduled recordings used for the Stellar device produced equivalent MAP values at better (less) data economy while significantly prolonging implant battery life, thus extending the possible study length as needed for behavioral monitoring in group housed animals to several months.

Background

Wireless transmission of key physiological parameters such as blood pressure, ECG, activity and body temperature in group housed freely moving animals provides the best possible experimental condition to study regulation of blood pressure including the effect of pharmacological interventions and social interaction.

Legacy telemetry systems suffer from the limitations of older analog technologies including cross-talk between animals, sensor drift, limited wireless range and expensive hardware infrastructure, often not compatible with modern experimental cage, limited to paired housing but shy of housing conditions needed to meet or follow current animal welfare regulations.

Objectives

Develop an economical digital telemetry system for physiological monitoring of (blood)pressure, ECG, Temperature & animal based activity, featuring:

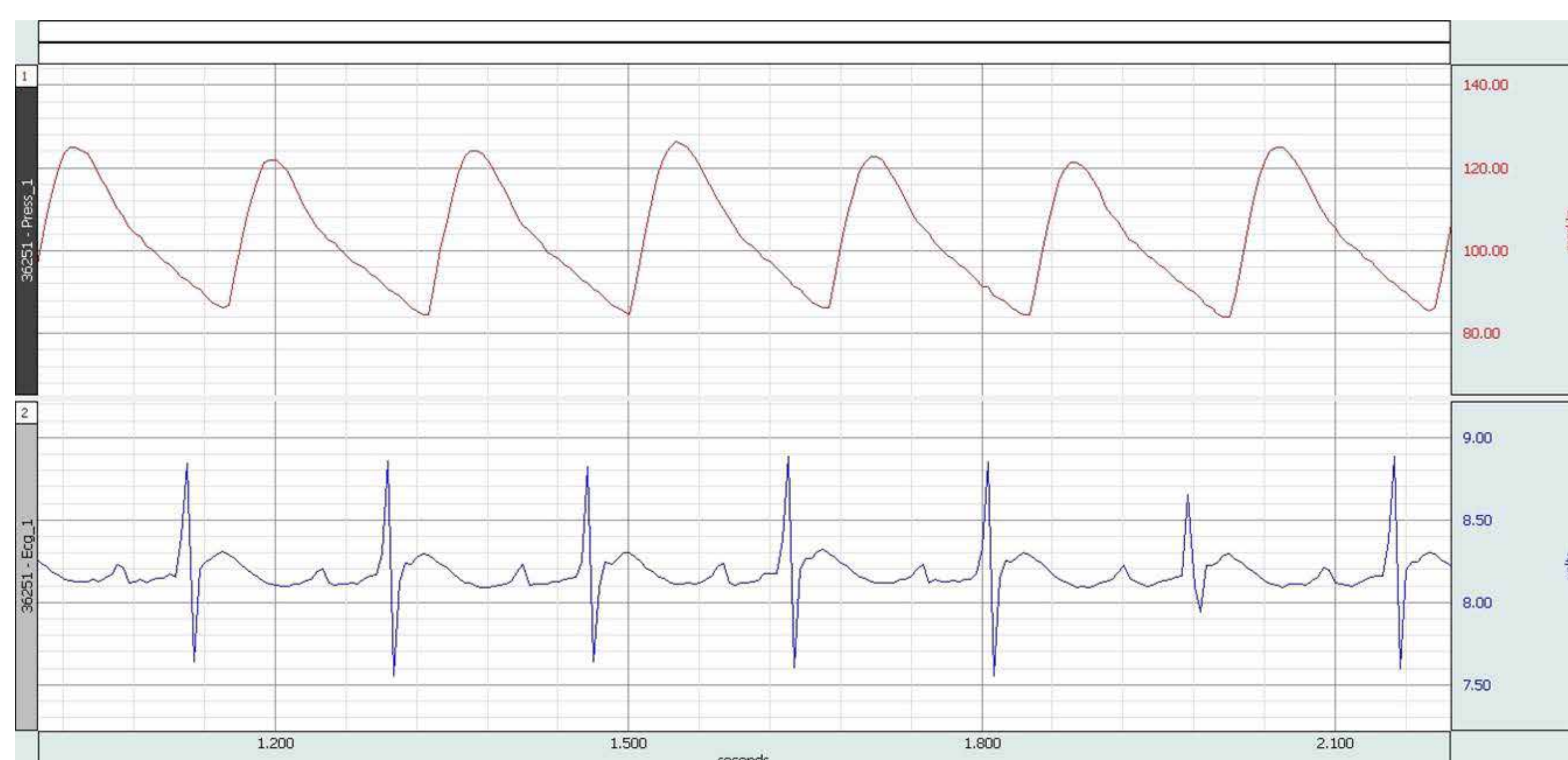
- Larger wireless range, no cage-bound antennas and “out-of-range” data logging” capabilities
- Unique digital animal specific ID with no possible cross-talk between individuals
- Miniaturization, use of solid-state sensors for pressure readings
- Seamless scalable technology from small rodent to large animals
- Allowing group housing of animals

Methods

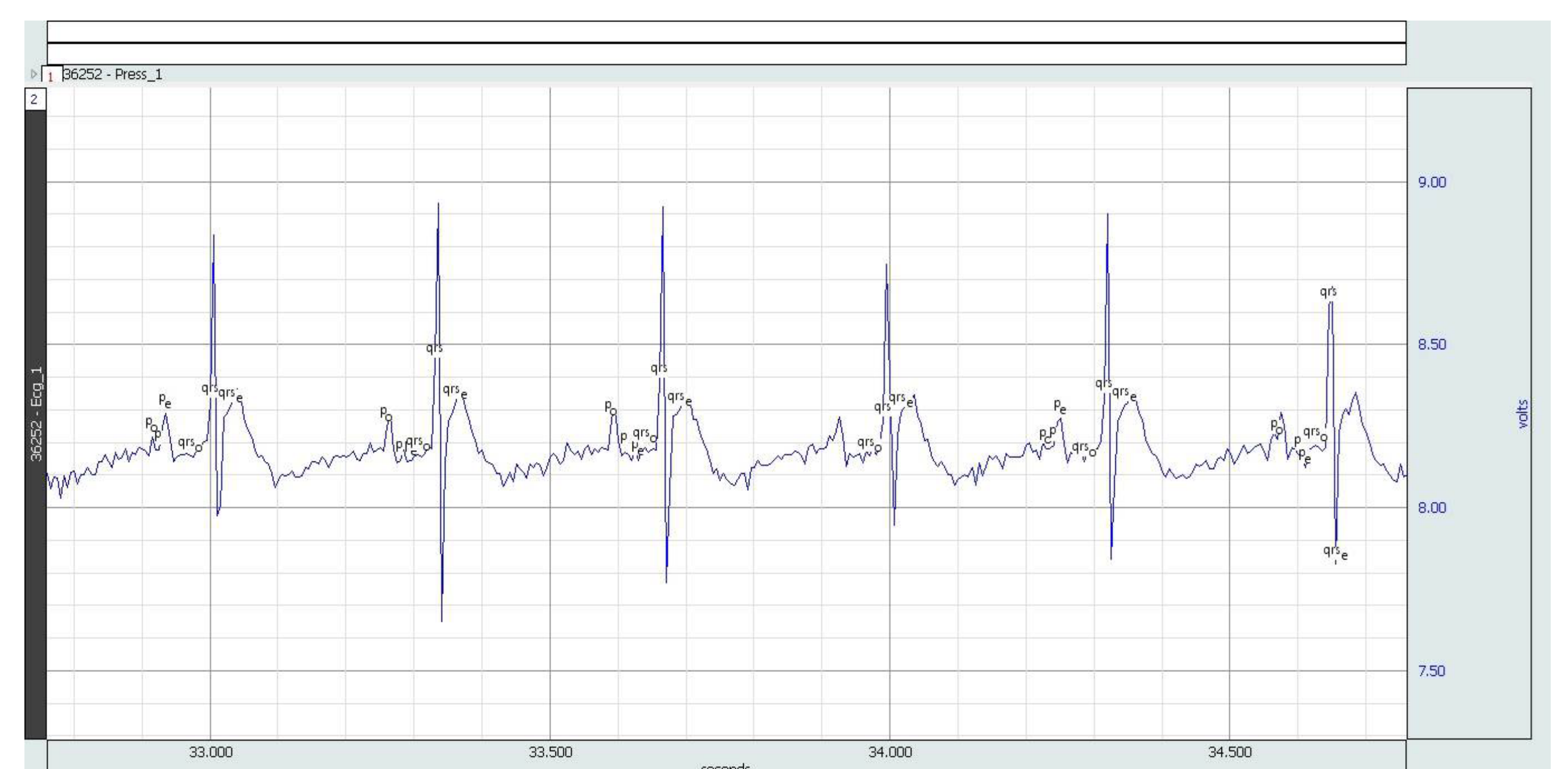
To validate this system, we implanted 12 male mice of ca. 20g BW with a model PTA-XS and 4 mice of ca. 25g BW with the PBTA-S implant. Pressures were recorded both in the carotid and in the abdominal aorta (shown). BTA-XS telemetry implants (TSE Systems) were used for ECG recording as well. All surgery was followed by a one week recovery period. 1-week post-surgery, baseline hemodynamic data and ECG data were collected for approximately 2 hours (10 seconds every 10 min). Mice were co-housed in groups of up to 4 animals (this number does not reflect a Stellar limitation).

After recovery the animals entered an exploratory study to compare fidelity and accuracy of the novel solid-state microtipped pressure catheter (450 micron) and micro ECG leads. BP and ECG were recorded for 10s every 15 min for 4 weeks sampled at 500Hz or 1000Hz. The BP responses were compared to a control group of 5 animals implanted with a similar conventional implant from a competitor sampled for 5s every minute at 500Hz. Mean dark phase arterial pressures (MAP) at 14 days in the Stellar group were 134 ± 31 mmHg at a Heart rate (HR) of 544 ± 67 BPM versus 127 ± 9 mmHg at a HR of 545 ± 24 in the control group.

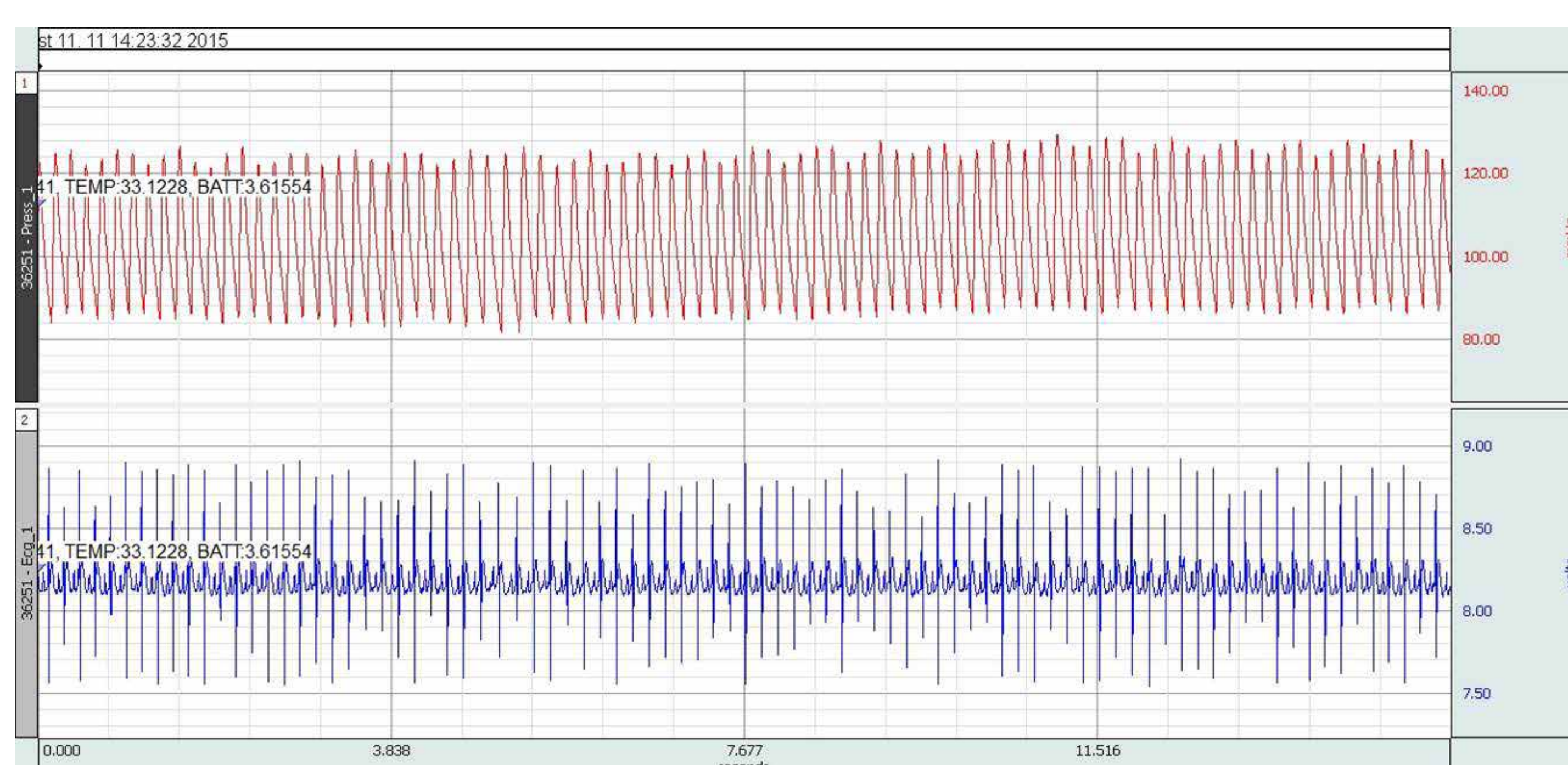
Results



Graph: 1 second detail of Simultaneous Pressure and ECG recordings in Mouse with the new Stellar PBTA-S and PTA-XS Implants at 500-1000 Hz native sampling rate.



Graph: Detailed automated ECG and BP Analysis in Biopac AcqKnowledge.



Graph: 15s scheduled simultaneous Pressure and ECG recordings in Mouse with the new Stellar PBTA-S implants at 500 Hz true sampling rate.



TSE mouse implant models PTA-XS (17g+ BW) and BTA-XS (17g+ BW) on hand. TSE mobile USB powered digital long range antenna & receiver system with Stellar transmitter model PTA-M (170g+ for rat or small animal)

Conclusions

We conclude that there are no significant differences in quantitative blood pressure responses between the Stellar digital telemetry device versus a leading analog competing device while being able to record from up to 5 different animals without cross-talk. We also conclude that the short scheduled recordings used for the Stellar device produced equivalent MAP values at better (less) data economy while significantly prolonging implant battery life, thus extending the possible study length as needed for behavioral monitoring in group housed animals to several months.