

# Low-Cost Experiment for Microgravity Research

## The First Parabolic Flight of SGAC

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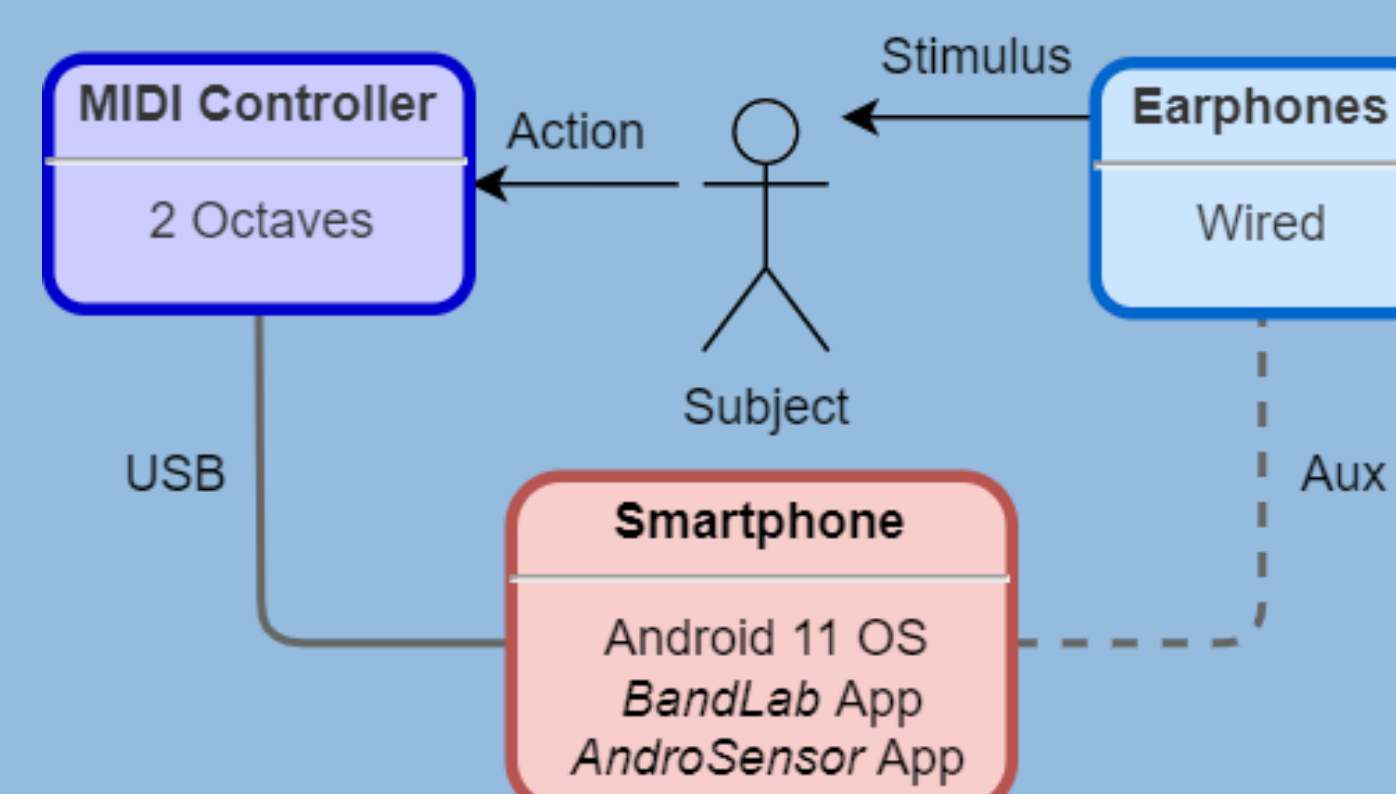
### Introduction

In early 2022, the Space Generation Advisory Council (SGAC) partnered with Aurelia Institute to provide one of its members with the opportunity of taking part in a microgravity research flight under the **Au Horizon 2022 - Aurelia Gateway Program**.

A competition was put up and the winning proposal aimed at giving a short piano performance in microgravity while measuring the reaction times. To that end, an experiment was designed to measure the impact of different gravitational environments in the perception-reaction chain of playing the piano at a given tempo.

### Apparatus

The test apparatus resorted to readily available consumer-grade off-the-shelf components, consisting in a low-cost solution. It is designed to minimize latency, ensuring timely sound perception by the test subject.



Experiment apparatus flowchart



Experiment apparatus hardware

### Auditory Stimulus

The experiment consists in a modified version of the **auditory Psychomotor Vigilance Test (aPVT)** [1]. An action is made upon perception of an auditory stimulus, presented to the subject through earphones wired to the smartphone. The sound frequency is of 988 Hz, corresponding to the key B5. Only this frequency is emitted at a variable tempo, i.e. only the beat-per-minute (bpm) count varies. The subject is intended to act upon perception of this sound by pressing a single key on the 2-octave keyboard with the index finger of the dominant hand. The reaction time is measured and recorded.

The subject reacts to both *predictable* and *random* tempo variations, allowing to study both cognitive perception of a repeating pattern varying in time, and pure reaction to auditory stimuli.

#### Progressive Tempo Variation

At least 5 consecutive 0.25-second-long tones [2] at 50, 62.5, 83.3, and 125 bpm are emitted at a progressive tempo. Two sound sets are built, repeating approximately 3 times in 20 seconds:

- i. Progressive I (P1): increasing tempo ranging through 50, 62.5, 83.3, 125, and repeating upon return to 50 bpm.
- ii. Progressive II (P2): the inverse of P1, ranging from 125 to 50 bpm.

#### Random Tempo Variation

After 1 second of silence, a 0.2-second sound [2] is emitted at a random starting time varying between 0 and 1 with step of 0.1. This process is repeated 20 times to create a pattern. Such pattern is replicated 3 times in 20 seconds. Two random sound sets are built – Random I (R1) and II (R2) –, which are played at 50, 60, and 70 bpm.

### Procedure

Each run comprises both hyper- and microgravity stages in each parabola. The flight test sequence, designed for 12 parabolas, is as follows:

- i. Mars 1-2: Mars gravity for 2 parabolas, running sets P1 and P2
- ii. Moon 1-2: equivalent to Lunar gravity for 2 parabolas, sets P1 and P2.
- iii. Zero 1-2: microgravity environment for 2 parabolas, sets P1 and P2.
- iv. Zero 3-8: same microgravity environment running R1 and R2 at 50, 60 and 70 bpm.

The test sequence is also recorded in the day before and after the test flight so as to establish a reference. Generation of MIDI files and post-processing takes place in *BandLabs*, while acceleration is recorded in *AndroSensor*. Reaction times are retrieved from the MIDI files.

### Outcomes

#### Auditory Perception

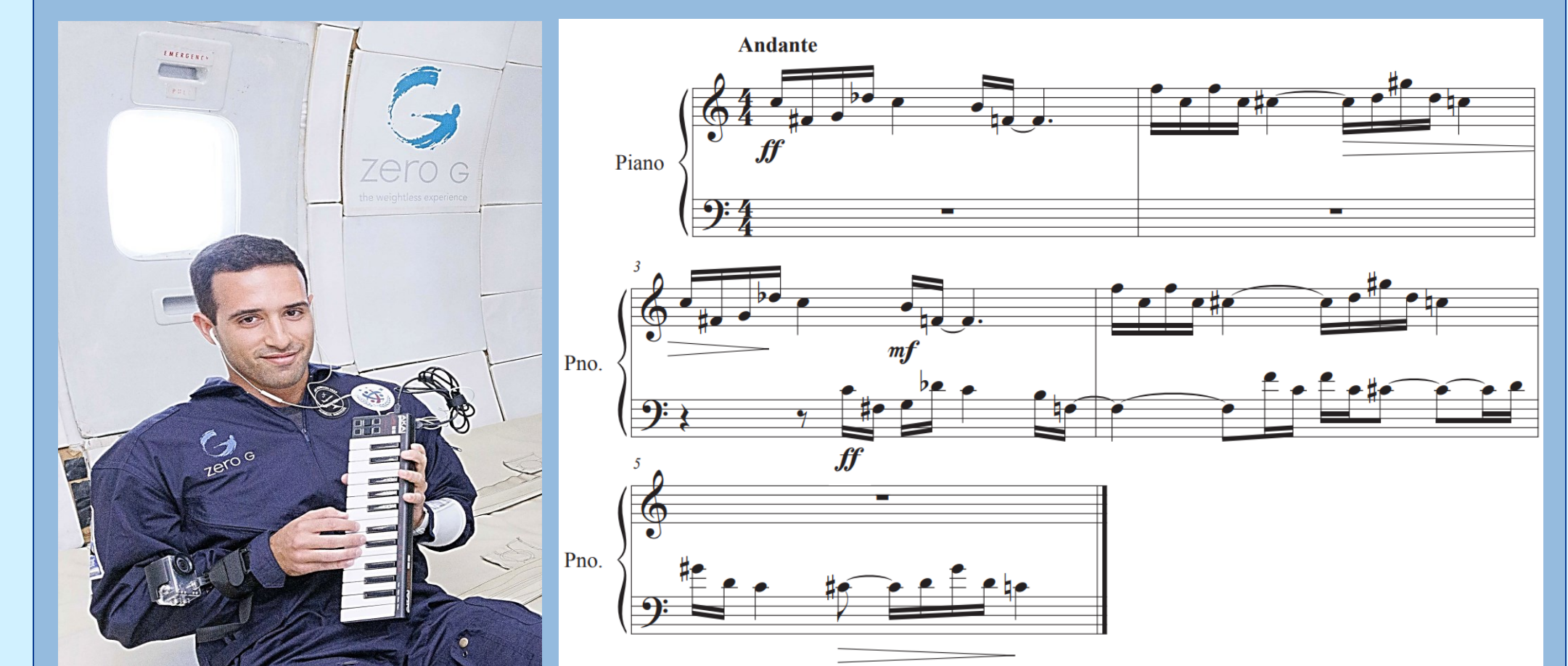
The experimental apparatus allows for an accurate recording of the delay between the auditory signal emission and the action of pressing the MIDI controller keyboard.

It is worth noting that there is a finite latency in the smartphone system that contributes to this delay and which can be determined and accounted for in *BandLabs*.

#### Musical Rendition

This setup also allows for artistic renditions in microgravity, enabling simple music performances in weightlessness. To that end, a custom music piece was created by Portuguese music school, fulfilling requirements such as duration of at most 20 seconds while being played with only one hand.

The composition rationale is supported by matching the word *PARABOLA* with interval and rhythmic patterns embroidered in the contrapuntal standard of a *canon*. As the composition is created as a timely repetition of the main *theme*, it can be recorded as played by one handed and post-processed by lowering one octave to create the intended polyphony.



SGAC participant – photo by Steve Boxall/Zero-G

*PARABOLA* by António Laertes & Bárbara João  
Music Conservatory of Setúbal, Portugal

### References

- [1] D. Dinges and J. Powell, "Microcomputer Analyses of Performance on a Portable, Simple Visual RT Task During Sustained Operations", *Behavior Research Methods, Instruments, & Computers*, vol. 17, no. 6, pp. 652-655, 1985.
- [2] V. Gabel et al., "Auditory Psychomotor Vigilance Testing in Older and Young Adults: a Revised Threshold Setting Procedure", *Sleep and Breathing*, vol. 23, no. 3, pp. 1021-1025, 2019.