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INNOVATIVE MUSICAL INSTRUMENTS DESIGNED FOR MICROGRAVITY: COSMICAL SEEDS

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ABSTRACT

A pair of musical instruments named "Cosmical Seeds" suitable for weightlessness, was selected by the Japan Aerospace Exploration Agency (JAXA) to represent the theme of Cultural and Artistic Utilization of the International Space Station (ISS). The instruments were successfully launched on October 31, 2011; and NASA astronaut Daniel C. Burbank, Expedition 30 commander, operated and played the instruments on the ISS on February 10, 2012. The two pieces of music performed were a collaboration between an astronaut and ambient music specialists Akira Takahashi and Jaakko Saari.

This paper will present:
- Motivation which led to the creation of the musical instruments
- The concept of the project
- The results of the mission at the ISS
- Future possibilities

The astronaut played the instruments along with music repeatedly for 15 minutes and improved his skills beyond what was outlined in the procedure manual. Taking movies and audio recordings was very successful, and the video will be shown at this session.

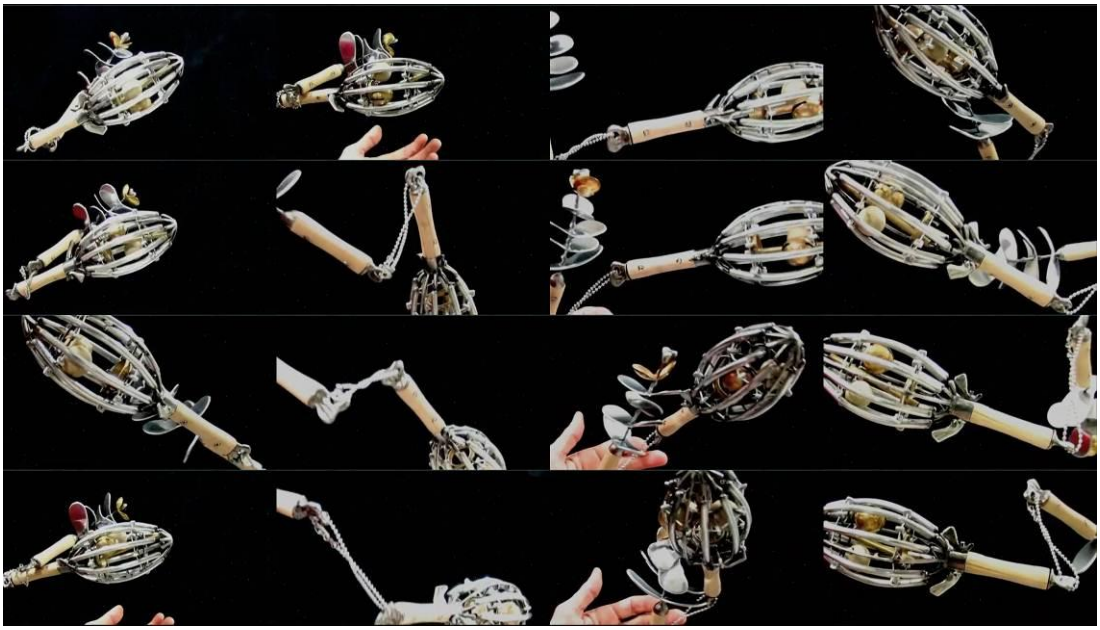

Fig. 1: Video stills of the instrument played on board the ISS by astronaut Daniel C. Burbank, February 10th 2012 (© Ayako Ono / So Negishi / JAXA, Image collage by Irene Lia Schlacht).

I. INTRODUCTION

A metal artist, So Negishi and a space artist and a PhD candidate in behavioral medicine, Ayako Ono developed the musical instruments together since 2009.

I.I Purpose of Theme

Space Musical Instruments - Cosmical Seeds were developed for use in microgravity, and were expected to enable the discovery of new sound expressions caused by different gravitational physical phenomena. Such discoveries have a possibility to inspire people and make opportunities for new unique musical instruments. We developed a pair of metal instruments, played in a similar manner to maracas and handbells, which could be played easily by anyone.

This theme, space musical instruments, will be a hobby and provide amusement during long-term space missions, now and in the future. Artistic expression could be a kind of tool for communication, and discovering this method of utilization is one of the objectives, as well.

I.II Background Concept

The long-term mission in the International Space Station (ISS) is now underway, but noise, sleep changes, danger, monotony, interpersonal issues, and isolation in the close-quartered environment cause significant stress. Stress related to psychiatric issues has been identified as possibly engendering problems in space [1–7]. Many psychophysiological stressors are associated with space flight [8–12]. Even if extremely healthy astronauts and cosmonauts are selected, some have experienced anxiety, depressive mood, and temporary amnesia in excessively stressful environments [4, 12, 13]. Therefore, psychophysiological supports for coping with stress during long-term space missions are important.

Art in space could offer a topic of conversation among crew members, as it does with people on the Earth. It could be a psychological support during the mission, because concentrating on creative activities allows individual time and self-reflection, and is therefore helpful to cope with isolation. By having this creative outlet, crew members will be able to improve interpersonal relationships, which could strengthen teamwork.

II. DESIGN OF THE INSTRUMENTS

II.I Design Concept

When deciding features of musical instruments suitable for microgravity environment, we considered the portability for launch to the ISS, as well as thinking of operability, size, and durability.

We designed the sound to be beautiful in microgravity using strings to simulate an aerial environment. In order to make different sounds, we used several materials: aluminum, brass, stainless steel, and wood. Therefore, the movement of each piece of the instruments will have different speed and sound because of its mass and the Law of Inertia

Two Instruments

Ellipsoid Bell has mainly three parts: the outer structure consisting of bars, like a cage; free floating contents consisting of one hollow brass ball with a slit and one wooden ball; and central inner structure consisting of a brass pipe and a brass ring which limits the range of motion of the pipe. The free floating contents, both of which have different mass, are supposed to hit both the inner and outer structures. (see Fig. 2)

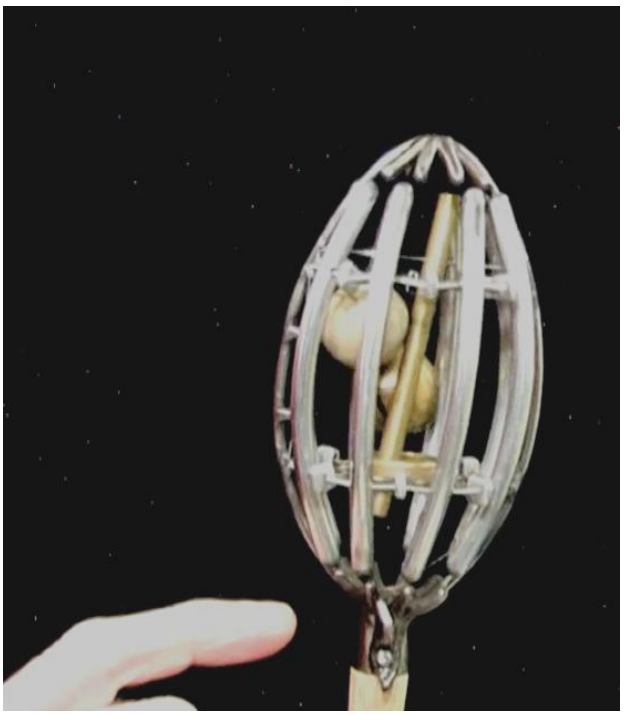

Fig. 2: Ellipsoid Bell (© Ayako Ono / So Negishi / JAXA)

Fractal Bell has five concave wing-like plates which rotate around central axis (Y). These plates have some freedom on the Y axis and hit each other but they are restricted by stoppers. (Fig. 3)

Fig. 3: Fractal Bell (© Ayako Ono / So Negishi / JAXA)

These two instruments could be combined with a ball chain to create variations of method of play, and would offer dynamic and interesting movement.

Visual Impact

The instruments have an organic and artistic shape. Genius architect Antoni Gaudi used organic design elements in his architectural projects, and it offers comfort because it feels more natural for viewers. The interior of the ISS is mechanical and artificial, so we believe that the organic shape would offer comfort.

Wooden Fragrance and Tactile Stimuli

We also took olfactory and tactile stimuli into consideration, so we used cypress wood (Thujopsis dolabrata) which has fragrance that is said to have healing effects. It is well known that astronauts/cosmonauts enjoy touching plants during their missions, and we wanted to offer natural tactile stimulation [14].

The instrument can stimulate auditory, visual, olfactory, and tactile senses.

II.II Materials and Settings

All material (see Table 1) and how to connect were checked if they are no problem for the ISS environment, before start creating final version of the instruments.

Instruments	Size (mm)	Materials
Ellipsoid Bell Fractal Bell	230×70×70 204×85×30	aluminum, stainless steel, brass, cypress
Scilencer (Ellip.) Scilencer (Fract.)	140×90×86 137×100×75	stainless steel, cotton
Ball chain	230×6×3	stainless
Black background	1410×860×2	cotton

Table 1: Cosmical Seeds, size & material list, Scilencer (Ellip. = for Ellipsoid Bell, Fract. = for Fractal Bell), ball chain and black background.

The wooden material off-gas tested by JAXA and passed. To connect metal materials, tungsten and inert. gas were used to weld. Also, stainless wire was used for Ellipsoid Bell.
Total weight was 0.84 kg.

Fig. 4: "Space Musical Instruments - Cosmical Seeds" Ellipsoid Bell (left) & Fractal Bell (right) with each silencer, ball chain.

We asked the astronaut to play in front of the airlock and to record a video with an on-board high-definition (HD) camera while the instruments were played. The set up was tested beforehand in the mock-up of Kibo Japanese Experiment Module (JEM) at JAXA. (Fig. 5)

Fig. 5: Testing the camera angle in the mock-up of Kibo Japanese Experiment Module (JEM) at JAXA (© Ayako Ono / So Negishi / JAXA, photo by JAXA, edited by Ayako Ono)

II.III Process and Ingenuity

Since we needed to develop the instruments on the Earth, we used strings to determine the placement of connecter holes while still maintaining a beautiful resonance similar to a Xylophone.

The strings were also used to simulate an aerial environment like in microgravity.

III. MUSICAL INSTRUMENTS IN ORBIT

III.I Implementation in Orbit

The instruments were successfully launched on October 31, 2011; and this theme was implemented at Japanese module (Kibo) of the ISS on February 10th, 2012. NASA astronaut Daniel C. Burbank (Fig. 6), Expedition 30 commander, operated and played the instruments. (Fig. 1, 2, 3)

Fig. 6: NASA astronaut Daniel C. Burbank, Expedition 30 commander; plays a guitar in the Tranquility node of the International Space Station.
(© NASA)

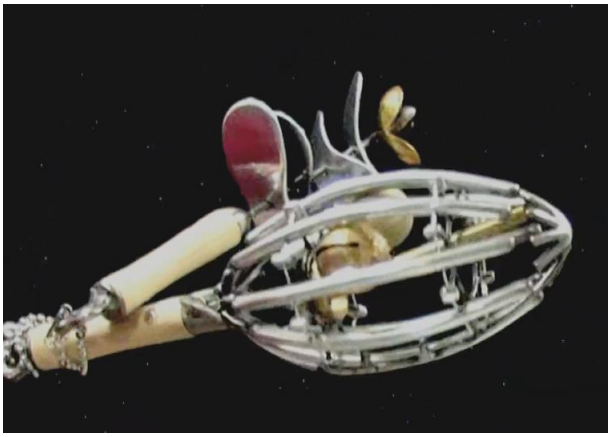

Fig. 5: "Space Musical Instruments - Cosmical Seeds"
Ellipsoid Bell (left) & Fractal Bell (right) with each silencer, ball chain. (© Ayako Ono / So Negishi / JAXA)

III. II Remarkable Results

Two collaborative pieces of music were provided by two artists. One is the special edition for the instruments, named "Dream Starts" composed by an artist, Jaakko Saari; and another is a two minute edition of "Kiyoraka na sora" composed by an acclaimed pianist, Akira Takahashi.

Rather than the planned 2 minutes each, the astronaut played the instruments along with music repeatedly for about 15 minutes and improved his skills beyond what was outlined in the procedure manual, and we saw his improvement. The astronaut invented how to play. A video was recorded in front of a black background on board the ISS. The HD video camera onboard the ISS has broken pixels because of cosmic radiation. The pixels look like stars. (Fig. 2, 3, 5)

Discovery

Slow and gentle movement was good, as expected: the instruments sounded clear and beautiful. Because they were floating, the resonance was not dampened by contact with another object.

Ellipsoid Bell: The strength of the treble tone was expected to stand out due to the brass pipe and brass sphere. Cypress wood seemed to work to limit the sound of brass, and we felt the combination was balanced.

Fractal Bell: There is a beautiful combination of the treble tone echo of the brass plate and the soft sound of echoing aluminum plates. The movement was more complex than had been expected.

VI. FUTURE POSSIBILITIES

VI.I Outreach Plan

The images which were recorded on the ISS will be shown in workshops, museums, websites and international congresses. By seeing these images, people can imagine what musical instruments in weightlessness are like. The video images will be shown together with 1G version, so that the actual phenomena in microgravity can be understood easily.

We will develop, and encourage the development of, new musical instruments and communication tools to make free time enjoyable on-board.

V. CONCLUSION

There were differences between assumption and results. The astronaut inventing his own method of playing was beyond our expectations and was more interesting than the planned procedures.

The space musical instruments may help to develop interest about space and science, and also encourage people to imagine a better future to live, play and work in space.

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