

Interactive comment on “ElectroMagnetic Music: a new tool for attracting people interest in Geosciences, while sensitizing them to planet sustainability” by Antonio Menghini et al.

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I will begin by acknowledging that my background is in music with a profound, yet tangential interest in science. I read the manuscript and I watched and listened to the included videos of the various events as they were included within the paper.

Thus, as I went through the process, I made notes based on my own questions and as the manuscript and the music triggered my own curiosity.

I am including portions of the particular paragraphs from where I extract my thoughts. It is these notes that I am forwarding to you. Please use them to the degree that they

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might illuminate your own perspectives on the subject. Since the format of the does not allow for different fonts or any other way to assist the reader in differentiating the manuscript's text from my own comments, I did place quote marks around the extracted words from the original paper.

“Since the beginning, a band of musicians experimented the EMusic giving concerts all over the world covering different geological locations. The sound representing each scenario was recovered in situ with the above-mentioned methodology.” No explanation YET as to how exactly the sonification took place. Did the musicians translate the data by providing their own personal interpretation? Were voltages used to assign amplitudes (loudness/dynamics), frequencies (pitch values), lengths of individual sounds to create rhythmic patterns? There is no clarification given to the reader who might not know what sonification exactly is. “The audience can experience a journey into the Earth by riding the eddy currents produced by the EM field. Not only it is a travel in space, but also in time, as we explore through EMusic older and older geological formations. . .” That is a beautiful thing. It needs to be recognized and further emphasized that this represents an effort from both, scientists and musicians, to engage the intellect and emotions from the intended audience, and that the combination of sonified transformation of the aforementioned voltages, along with the involvement of musicians and sound artists, will be what will trigger their curiosity and emotional response. The sonification alone will only awake the interest of a relatively small crowd. Only to the type of listener for whom the mostly static quality of sounds is attractive and understood at an emotional level will be able to keep their attention for a sustained period of time. To them the hypnotic, meditative, and trance-like quality as the sounds progresses from one moment in time to the next will certainly be attractive. Interestingly, traditional ragas from India do possess these qualities. Traditionally, far East cultures do have a different sense of time and a different philosophy about life. Perhaps, at present, and with the revival in the West reading the emphasis toward our learning to live in the here and the now” and through the explosion of the “mindfulness” movement the ability to listen and assimilate static sounds will become more widespread.

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“The source of the sonification (a voltage) depends upon the electrical behavior of the rocks (i.e. the resistivity). Following this assumption, the basic principles were codified by Menghini and Pontani (2016). Thus, it is not out of place to claim that we can extract the effective “Sound of the Earth”. Similar to other sonification process, we adopt a mathematical rule that allows us to translate the geophysical data into audible frequencies.”

Translations based on someone’s codifications (such as the ones by Menghini and Pontani) are, by necessity, biased and will be interpreted in radically different ways. Thus, there has to be a recognition that different musicians will arrive at different interpretations of such data. A musician or group of musicians whose musical training came from having studied at a traditional Western institution, (such as at a music conservatory) will most likely be very different from someone who studied jazz, pop or rock or whose background comes from the “popular” musical traditions of parts of Latin America, India, Africa or elsewhere.

“It would be therefore more correct to say that we can produce pitches, rather than sounds.” At this point in the paper, the reader doesn’t know if these pitches are based on natural harmonics, or based on the Well-tempered system, microtones or some other tuning system. Clearly, any of these choices/translations/interpretations will produce different results.

“The musical notes can be played by any kind of instrument, also by a human voice.” Clearly, and by no means wrong, this is an arbitrary choice of timbre. If the intention of the project is to bring awareness to our planet, it really doesn’t matter how literal the translation of the data provided by the voltages is. Evidently, as the title of the article clearly states, it is intention to attract people’s interest to geoscience while, in the process sensitizing us to planet sustainability. If, in the other hand, the sonification can to be used as a tool to “prevent risks” and assist in the reading of a particular phenomenon occurring at a certain part of our planet, there has to be a consistent array of sounds or textures that could quickly and easily be understood by people,

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scientists in particular. I would equate these as type of “sonic fingerprints” mentioned in line 145 of the article. I presume that there already many other tools are in place to measure potential earthquakes, eruptions, pollution of aquifers, seawater intrusion along the coastlines, seismic risk, drought and permafrost melting, etc.

The involvement of the musicians is direct, as they have to arrange an improvisation or a composition, by using these pitches provided by the Earth: the EMusic data are the bricks that will be used to build any musical performance (some examples have been reported by Menghini, 2016, 2018 and Duncombe, 2019). This allows to achieve an effective connection between Art (Music) and Science (Geology), in a way that can be easily understood by common people. “How easily understood by “common people” will depend as to how the musicians are translating the data. During the 20th century, various composers have made numerous translations of natural phenomenon. A few of them, not mainstream, and “easily understood by common people” are listed below. Some other examples are cited in the Introduction of this paper just below. Chares Dodge (Earth Magnetic Fields) <https://www.youtube.com/watch?v=j5MHsnc67yw>

Larry Austin (Canadian Coastlines) <https://www.youtube.com/watch?v=2zs5rEbXbmU>

Mickey Hart (from the musical group the Grateful Dead) Sounds of the Universe. Also, of Brain and heart impulses interaction between music and medicine <https://www.pbs.org/newshour/show/big-bang-cosmic-vibrations-grateful-deads-mickey-hart-plays-rhythm-universe> Mickey Hart (from the iconic musical group the Grateful Dead) Sounds of the Universe claims to have captured the vibrations of the cosmos and has invested time in sonified these vibrations while also over imposing his own musical interpretations clearly influenced by his Rock & Roll background. Mr. Hart has also done work with Dr. Deepack Srivastava from Gladstone Institutes at the University of California in San Francisco where a team of stem cell researchers has been working on identifying impulses generated by brain and heart cells to convert the electrical energy generated into sound to be able to map difference between deceased cells and healthy ones. <https://www.pbs.org/newshour/show/big->

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Particularly interesting are the electro-acoustic works of Iannis Xenakis, composed utilizing environmental sounds a few of them are listed below” Iannis Xenakis (Di-amorphoses) <https://www.youtube.com/watch?v=b7235DNkd0> Iannis Xenakis (Concret PH) <https://www.youtube.com/watch?v=S9zMalhuMgo> Iannis Xenakis (Orient-Occident) <https://www.youtube.com/watch?v=PzVoYt78iZ0>

“Finally, Geoscientists can be considered in all respect as composers, or rather as the medium between the Earth and the performers. . . “ Nice!!

“ . . .also by providing some keywords” (keywords? -not quite clear to me. . .) “on the history of the geological site inspiring the musicians.”

We are also implementing a project, named Georisonanze, to bring the EMusic in secondary schools to introduce students to the investigation of Earth with modern techniques while sensitizing them to planet sustainability.” (I assume that this is an adaptation, or an extension or the sharing of the experiments mentioned above. Am I right?) “This paper describes in detail the method of sonification. . .” Never in the manuscript do I get a detailed description of the sonification method that is clear to me.

“We describe also the potentialities of the methods from a science communication perspective, even though we never conducted a survey to test the efficaciousness of the methods.”

What exactly do they mean by testing the efficaciousness of the method? “Nevertheless, we preview in a near future to experiment the method in schools to have the opportunity to conduct a survey for investigating the efficaciousness of the method (we are implementing a project named Georisonanze)” What exactly are they looking to find through these experiments in schools? Are they looking to measure how students respond and get sensitized in regards to planet sustainability? Is it by simply bringing attention to the subject? Early in the manuscript, a clear recognition needs to be

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made to the fact that a marriage of sonified interpretations of the voltages generated by earth’s subsurface materials does take place with the involvement of performing musicians that embed these data with an emotional element that thus gets enhanced. As I listened to the shared video (shown right below) the points that I made above made it clearer that the paper itself.

<https://www.youtube.com/watch?v=qsTIMZsGoBE&feature=youtu.be>

“As the transient works out within a few milliseconds, we adopted a time expansion that can be chosen depending on how long we want to arrange the composition (usually we use values between 100,000 and 1 million). Otherwise our ear would hear a single chord formed by all the gates/pitches.”

From a musical point of view, the formation of chords, which is precisely the manifestation of a collection of pitches occurring simultaneously, represents a welcome element within the musical discourse. Their activation through arpeggiations and other means to create accompaniments as the middle ground of a composition is something that composers and performers pay close attention. The expansion over time as explained above makes sense. Their distribution over longer periods of time, as explained in this paper and demonstrated throughout the link to the video allows for easy analysis of their frequencies making it easy for musicians use this information to create melodies that are coherent with these collections.

“In order to make comparable sonified transients, we prefer to use the same range of voltage, i.e. fixed values for minimum and maximum response: this device allows to compare different geological scenario and different EM systems in an objective way. This approach can be similar to the choice of the edges of a colour scale to figure results.” Although it is stated that fixed values are used to assign to the various transient’s particular pitches in an objective manner, it is not quite clear how these pitches are arrived at. The analogy comparing it with edges of a color scale does help to assume that gradations have been arrived with a certain logic, most likely translating

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numerical values into audible frequencies that retain precise intervallic relationships. The explanations right below help in confirm that amplitudes (louder sounds) will come from the stronger responses and vice versa, and that higher frequencies (pitches) will correspond to stronger responses. Inasmuch as I tried to find a clear correspondence between the pitches given in Figure 3, arrived at as transformations of the voltage's responses, and the so-called "score" utilized by the saxophonist to interplay with these collected sonified transients. Although there is no explanation as to how the player choose these particular chords as the basis for his improvisation, while listening to the two elements interacting with each other, I found that the performer did utilize pitches that beautifully harmonized and complemented the clusters created within the sonified textures. While crossfading, alternating pitches within the sonification produced a sense of chromatic movement extending beyond the traditional harmonizations found in "traditional" Western music, and closer to the textures of musicians experimenting with pure intonation and microtonalism.

"Another modality is to group the pitches according the different layers crossed by the EM signal. The musicians can use it to compose original pieces or to address the improvisation into more restricted musical scale/chords." This sentence, finally, further emphasizes the degree of involvement, and the limits set to the players as they choose the pitch- sources for their improvisations. It helps the reader to understand how it all can work in various modalities.

"During EGU2018 Assembly we presented a PICO poster ("Diatomites sound like a B13 chord"), showing an excerpt of an EM concert in the Ancient Roman Theater of Ferento, Central Italy 155 <https://www.youtube.com/watch?v=laQLhoEQi84&feature=youtu.be>"

Upon listening to this second example it became even clearer that the musician's choice of notes for their improvisations took into consideration the intervallic relationships present in the sonification, yet allowed themselves the freedom to expand from such collections.

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"As the subsurface was formed by very resistive rocks (lava and scoriae of the last activity in 1944) the signal was weak, so that it fell very quickly into the background noise. Moreover, due to the high resistivity, the pitches were low. We extracted only 6 useful gates and this outcome greatly limited the possibility to arrange a full concert of more than 1 hour. We involved the audience in the contingencies of the case, having also the opportunity to discuss with people the limits of Science. Scientists can get unexpected results, not always positive. Being aware of this risk, we had already thought to use a second TEM sounding collected over a more favourable situation: in fact, this test was carried out in a quarry where we had the opportunity to characterize the historical pyroclastic flow responsible of the destruction of Pompei, until the older layers of the Somma volcano that preceded the Vesuvius building. Thus, we were able to split the transient into 3 different pieces. The full concert is available on YouTube, starting at about minute 40." https://www.youtube.com/watch?v=Xh_tY22E1_A&feature=youtu.be&fbclid=IwAR0bqdEHslrUp8z_uiMQ7dxvODISckwIDhZOe4slWlwyvMIZ7JGaU_I Evidently , there is an effort to bring the public into the experience. Aware of complex circumstances, scientific team and the musicians make choices to make a concert practical and enjoyable. The participation of Jazz musicians is a good choice, since many people relate to their musical vocabulary. As explained by one of the organizers, the improvisation for this event is based on the Eb Phrygian mode. The explanation given at about the 42minute explanation by one of the organizers and with the pianist playing the notes that correspond to the sonification help in making connections much easier than by reading the essay. As the camera moves through the stage, we see the reference notes in the music stand of the sax player. And as we hear the music, we quickly realize that the sonification are but a departure point for all 5 musicians(double bass, piano/synthesizer, percussion, saxophone and guitar) to improvise. Notes other than the ones transformed from the readings of the voltages are added as neighboring tones, suspensions, to enrich and embellish the texture. As I was listening to the excerpts, I looked for the notes in my piano at home and confirmed that the

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sonifications traveled through various chords creating very interesting progressions, particularly when combined with the notes added by the musicians. "Since we have never conducted a survey, for the moment we can only suppose that the EMusic have great potentialities for raising interest of people on Earth sciences studies, while sensitizing them to planet sustainability. Our supposition is based on the people's mood we perceived during our several experiences around the world. Eventually, EMusic can stimulate people to get interested even on the functioning of sophisticated equipment and the physics beyond a complex method like TEM. At the same time, EMusic can stimulate people's curiosity on how rocks are characterized by different physical parameter (in this case resistivity) and how geoscientists exploit this feature to explore the subsurface. The presence of musicians can stimulate people to study in deep the relationship between frequency and musical notes, the use of the tempered scale (in theory we could assign to any pitches the effective frequency, i.e. microtones, and not the closest one listed in the twelve-tone scale commonly used in Western Music, since Bach's time), how a series of pitches can suggest a mood reflecting a specific formation, how the musicians face the improvisation rules."

It only becomes clear in the area of the document labeled "Feedback" when the authors expose the fact that the pitches chosen are arbitrarily, and with no direct relation to the readings of the voltages read by their instruments, based on the well-tempered scale commonly used. As the authors point out, it will be interesting to explore the reactions of the people should they choose to assign microtonal intervallic relationships, or based on just intonation, ancient Arab, meantone, Pythagorean, etc. The overtones that I heard I listened to the sonifications do include already intervals smaller than the half step, thus creating fascinating chords, textures and timbres. I venture to say that , because of the places where these events take place, and because of the experimental quality of the context, audience will be more open to listen to the music being created, so long as it doesn't veer to much away from what they are used to listen to. Active performance participation by students through the Georisonanze project will also open them to both, accept music that is outside of their current comfort zone and to develop

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the type of sensibility toward our planet, which is, of course, the principal goal of this project.

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