# *Interactive comment on* "Demonstrating change from a drop-in engagement activity through pre- and post- graffiti walls: Quantitative linguistics and thematic analysis applied to a space soundscape exhibit" *by* Martin O. Archer et al.

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The authors have written an interesting paper on quantifying visitors' experience of a soundscape exhibit. To evaluate learning outcomes is crucial for designing and developing new and better exhibitions. The authors successfully quantify changes in the visitors' perception before and after the exhibit. I therefore think the purpose of this study is important, and that the study is appropriate for Geoscience Communication. Overall, the writing is short and concise. The structure is logical and flows well. Some sentences are a bit long, and could be shortened

**for increased readability.**

We thank the reviewer for their time in constructing comments and have considered them all, with our responses given below.

**The exhibit is a soundscape and the evaluation is done by using two methods of statistical analyses. Input from the visitors is collected using sticky notes (termed graffiti walls). To me, there are two main points in this study: 1) the use of statistical analyses on engagement reviews and 2) measuring the learning outcomes in a soundscape. I think the statistical analyses have been well-covered by the other reviewers. However, I would have liked to see the authors place their findings more in the context of the exhibit. The intended and the measured learning outcomes seem somewhat detached, while the paper raises several interesting questions regarding the learning outcome. E.g. if the exhibit aimed to teach visitors about plasma waves or space weather, in what way did the authors capture that?**

The development of a high quality public engagement activity should ideally be defined by its purpose. These do not necessarily have to be linked to learning specific information, but can encompass many possible intended outcomes (see https://www.artscouncil.org.uk/measuring-outcomes/generic-learning-outcomessection-1 for a helpful framework of describing the myriad of potential outcomes in informal learning and public engagement). The purpose of this activity was to provide young children and their parents (as key influencers) an accessible and immersive experience that would enable participation and spark discussion. Such experiences can contribute to children building an association and identity with science, a key part of a person's 'science capital'. This could not be fully explored due to the word limits of the GC Letters format, but we will clarify our position on the purpose of this exhibit in the revised manuscript as follows:

The purpose of the space soundscape was to provide young children and

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their parents/carers (as key influences upon them) an accessible and immersive experience with space research that would enable participation and spark discussion. Such experiences may, when taken in conjunction with all the other formal and informal interactions with science afforded to a young person, contribute towards developing their science identity and hence build their 'science capital' (Archer and DeWitt, 2017). Using a generic learning outcomes framework (Hooper-Green, 2004), the main intentions for the activity fall within the realms of 'Enjoyment, Inspiration, Creativity' and 'Attitudes  Values', with 'Knowledge  Understanding' being only a secondary aim.

**Measuring "change" is vague, and I think it should be specified what kind of change they were looking for. This would also be important knowledge for others in the future when deciding on methods to apply.**

As stated in the introduction, demonstrating impact requires some measure of change. While it is possible to have a very specific change, and thus impact, in mind and thus only evaluate for that, we felt that in this case such an approach was too reductive. Furthermore, given the challenges in evaluating impact at all for drop-in activities generally, as outlined in the introduction, we therefore felt it was better to be open to any sorts of changes that might have resulted from before to after, as we certainly didn't feel we could predict all possible responses in advance. Our approach thus took a more exploratory and data-driven view of the qualitative data capture and analysis. The grounded theory approach of thematic analysis, for example, exemplifies this as it looks for patterns that emerge from the qualitative data itself, as outlined on lines 105-106 and in Appendix B, rather than only looking at the data with a very specific lens.

**I had some questions whether graffiti walls are accurate enough to adequately capture details in the visitors' perception. In general, space is empty, slow and**

**silent. Is there a risk here that the visitors mixed near-Earth space weather and conditions in outer space?**

The graffiti wall provides an open opportunity for participants to reflect upon and respond with their own perceptions and associations with space, a point we will add to the manuscript. The benefits of graffiti walls as evaluative tools are provided in the references contained within the introduction. This method was chosen specifically due to its suitability for evaluating drop-in activities, ability to be integrated within the activity itself, and alignment with our intended overall experience. We will add these points to the manuscript.

We are unsure of exactly where the reviewer is referring to with the term "outer space" since this technically applies to everywhere above 100km altitude. The satellite measurements used here are taken from geostationary orbit, within Earth's magnetosphere. However, similar dynamics and waves are present throughout the entire heliosphere, the Sun's region of influence due to its solar wind (which streams at several hundreds of kilometres a second), which is highlighted on lines 30-34. All stars have their own stellar winds, again leading to similar conditions at other stellar systems. Finally, the interstellar medium is another example of a space plasma, which is in fact denser than the outer regions of the heliosphere as confirmed when Voyager 1 crossed the heliopause in 2012. Therefore, we do not see much risk here as space plasmas are ubiquitous throughout the universe. We will briefly mention these other space plasmas. While it is always possible for participants to draw incorrect conclusions from any activity or form of communication, the activity was carefully designed to avoid this, e.g. with the placement of researchers at the end of the research to enter into dialogues with participants.

**Or that plasma waves are sound waves?**

While not all plasma waves are equivalent to sound (with high frequency plasma waves being driven by the electric fields between ions and electrons kinetically), the ultra-low

frequency waves concerned in this paper are. This is because they, like sound waves in a gas, arise from the fluid (magneto)hydrodynamic equations. The only difference is that in plasmas magnetic effects, such as magnetic pressure, are also included whereas these are not present in a fluid consisting of electrically neutral particles. Nonetheless, a sound wave which propagates from a neutral gas to a magnetised plasma will become a magnetosonic plasma wave. Ultra-low frequency plasma waves are thus even more analogous to sound than even seismic waves, where the medium is not a fluid and the wave propagates due to stresses (via the inter-atomic and inter-molecular bonds present) rather than simply pressure, despite many members of the public being comfortable equating seismic waves to sound. Therefore, we again do not see major issues here. We will add a reference to an article (Archer, M. O.: In space no-one can hear you scream...or can they?, ENT Audiology News, Volume 28, Issue 6, 2020) which discusses these aspects about the nature of the plasma waves in the context of sound and other waves, as we feel such a discussion detracts from the point of this paper.

**Not all change is positive, so would there be any way the authors could measure this in their method?**

The analysis could indeed have captured negative impacts. The quantitative linguistics could have revealed a decreased diversity of words following the soundscape. Additionally, the changes in the qualitative codes might have shown an increase in codes related to misconceptions about space rather than a decrease. Finally, the generation of the qualitative codes drawn from the data itself, rather than using preconceived themes/codes, could have highlighted negative themes. None of these were found, however. We can point this out in the paper.

**The bell-jar experiment was mentioned as an example that people falsely think space is silent. However, my understanding of the bell-jar issue is that people think only air propagate sound, and that space is silent because there is no air.**

The misconception with the bell-jar experiment is particularly related to the "vacuum", as a bell-jar never becomes completely devoid of air. This is discussed in the referenced paper of Caleon et al. (2013), presenting a more nuanced description of the experiment in near-vacuum conditions and how it should ideally be presented. We will highlight this slightly more in the manuscript. As to sound requiring air, many school curricula discuss the propagation of sound through other mediums, such as water. Indeed, most people will be aware that you can hear sound underwater from swimming. The misconception the reviewer describes is something we have never encountered.

**That waves propagate in plasma, and that these waves can be sonified to be audible for humans, is very complex information. To make sure that visitors did not confuse any of these concepts seems to require targeted questions from the evaluators? The authors' reflections and insights on this would be appreciated.**

The reviewer seems to have assumed learning objectives surrounding the concept of the exhibit itself. However, this was not the case as highlighted in our previous response about its purpose. The complex information/discussions that the reviewer describes were generally not warranted. It is clear from the changes in the qualitative codes before and directly after the soundscape that simple concepts of space not being empty, sound being present, dynamics occurring, and electricity being present were innately communicated to the participants simply through listening to the data. It was only these sorts of simple messages that would have been reinforced by the researchers in their dialogues afterwards. We will note that the reviewer interactions were specifically designed to cement or clarify conceptions in a tailored and audience-focused way, e.g. only going into an appropriate level of detail depending on the individual or group.

The series of targeted questions that the reviewer suggests would have run contrary to best practice in the evaluation of drop-in activities, as outlined in the introduction, since they would not have been commensurate with the activity and would risk interfering with participants' experience. As highlighted in our previous responses, we will clarify why we chose this method of evaluation and its benefits in this context.

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**I was not familiar with the term graffiti walls for sticky notes, this should be explained. It would also be interesting with a brief explanation of why this method was chosen.**

We will add a description of a graffiti wall in the introduction.

**The term young families is not defined, but I assume these are young children and that many of those cannot write? If adults write for them, would this bias the responses to e.g. show higher vocabulary complexity? Line 91 states that Zipf's shows different trends for children and adults. The analysis using Zipf's is presented for the entire dataset. How would the age distribution affect the result, and could shifts in the age distribution before/after affect these? I was wondering whether the increased diversity in words afterwards, but fewer respondents, could be caused by a larger proportion of adults participating (e.g. because the children were too tired?). Some clarifications or reflections on this would be helpful.**

Young families is a common term for families with young children. For ethical reasons we did not collect personal characteristics from participants, as stated on lines 76-77, therefore we purposefully do not try to give specific age ranges for those that might have attended. Observations did not highlight that adults were largely writing on behalf of their children, as younger children had to the option to draw as well as write. In fact, as noted on lines 78-79, it was observed that in families typically only the children contributed to the graffiti walls rather than the adults. While one might expect different absolute values of the Zipf exponents if the data could be subdivided by age, here we are interested only in changes to the Zipf exponent from before to after rather than the exponent's specific value. The changes presented, however, are robust since we observed no substantive difference in those filling in the graffiti walls before or after the activity. Furthermore, the number of responses show that the vast majority of respondents (83%) participated in both graffiti walls. The exhibit, as a drop-in activity, lasted mere minutes and we saw no evidence of children becoming tired due to it. We

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will clarify all of these points in the paper.

**Line 50: Museum is misspelt ("Musueum")**

We will correct this.

Interactive comment on Geosci. Commun. Discuss., https://doi.org/10.5194/gc-2020-41, 2020.