**Feedback sheet for final version of sonification on chemical sensors:**

***Introduction video:*** <https://www.youtube.com/watch?v=-I8y_FUYg9Q>

***Example 1:***

<https://soundcloud.com/yuna-787448399/v5-alertrange-10-chn1-4/s-HQE30pUJp6k?in=yuna-787448399/sets/sonificationprotoptype_version5/s-WHKBASX0Ivy&si=2b560095393745fc87f8b96d57587715&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing>

***Example 2:***

<https://soundcloud.com/yuna-787448399/v5-alertrange-10-chn13-16/s-yKxnrnSGiLA?in=yuna-787448399/sets/sonificationprotoptype_version5/s-WHKBASX0Ivy&si=c5822d37fdd84bcbbae5d8128362c990&utm_source=clipboard&utm_medium=text&utm_campaign=social_sharing>

**Questions:**

1. Do you think this design helpful for monitoring data during a calibration session?

In principle, yes. For calibration what is usually done is to stop measurements between calibration steps (which is going to increase or decrease the reading values), and allow the standard solution added to mix well. Then the measurements are resumed. In this case, there should be a jump in the values recorded and during the first seconds the signal may be unstable but should stabilize shortly after. As I understand, the pitch may be going up or down (due to the jump in value over the threshold) depending on the type of ion (cations go up while anions go down) and if the sensor is working properly, and in some cases create a click sound, but just in the beginning if there is some instability. Therefore, knowing this, this design works for calibration.

2. Can you observe abnormal behaviours in data streams through this design? If yes, do you think you rely more on pitch information or click sound?

Yes. If it is not stable, I can hear the pitch going up and down (high range). And if the sensor is not behaving properly (too noisy), I can hear the click sound on a regular basis.

After the last meeting with Yutian, I can say that I would rely more on the click sound for regular noisy sensors.

Regarding the pitch information, an abnormal behavior would be the lack of pitch change in the calibration process (after standard additions) in one sensor, while the others are changing as expected.

3. Do you think that the click sound mechanism can accurately reflect the severity of problems in data stream?

In principle yes. However, it may be interesting to study more in detail the threshold considered. And the relationship with the rest of the sensors.

For example, in channels 13-16 the second one, which is a failing sensor, we can hear the clicks on a regular basis (more than in the others), so this way we can discard in-situ the data provided or replace it with a new one if possible. Two of the other sensors are not working properly, however, they do not have clicks because they are not changing values drastically. In fact, they are not changing as expected, keeping similar values after standard additions (should trigger jumps), or even going downwards instead of upwards. So, in this case, we would rely on pitch sound (lack of change).

4. Can you easily deduce from this sonification whether there are any problematic sensors within a group and subsequently identify them?

Yes, but with a little bit of training. In particular, how it sounds when the sensor is failing and how it is a sensor that it is working. As I have the original data, I knew what sensors were not working, and I was listening in detail. After my last meeting with Yutian we were discussing it. One of the failing sensors has more clicks than the rest because it is noisy and going up and down. In addition, you can hear a dramatic change in pitch. All together indicates that the sensor is failing and that they need replacement. In other cases, there are no click sounds, but lack of change in pitch, as the clue to know that a sensor is failing while in the calibration process. After the addition steps during the calibration process two sensors are keeping similar values or going downwards instead of upwards. So, there are no changes in pitch, when there should be.

As you can identify the sensor, you can decide to continue collecting data with the rest of the sensors or replace the failing ones if possible. That is on the user of the sensors. This would be clearly beneficial in the field. Otherwise, you only know if the sensor is failing when processing the data in the lab after all the work of collecting. This would be too late if all the sensors were failing, and a waste of time.

5. Do you feel it hard to notice any changes in sonified data after listening to it for a period of time?

It can be a little bit monotonous, but this is good, as the change in pitch means that something is not right, except if collecting calibration points. The clicks are something good because it provides critical information. A large change in values on a regular basis (when it should be flat) means that the sensor is failing.

6. Any other suggestions/questions/description of feeling:

The introductory video is good, it provides the information needed to understand the sonification of the data, but some other information could be added.

After having an online meeting to discuss the feedback I realized that I was completely wrong with the concept. I did not understand some of the music concepts and part of the information provided in the introductory video.

As an observation, I would like to suggest incorporating some more information in the instructions to understand the sonification process.

For example, the assignment of the pitch to a range of data. Indicating what is the data range and the pitch going from the lowest to the highest the user would have the whole picture of the data related to the sounds.

I did not realize until Yutian said so, that this way we will be able to know, with the pitch, what is the concentration range of the sample.

So, with the sonification process we will be able to know if the sensors are failing: With the click sound, if the sensors are too noisy (up and down >10 mV); with the pitch, if they are not changing during calibration process; and on top of that, we will be able to know the calibration range when sampling in the field.

Overall, it is a very good job. I like it, and I think it is useful to apply in the field.