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The Instinctual Placement of Parameter Knobs on Electronic Audio Equipment

One of the most inconspicuously complicated questions in the field of hardware electronic instrument design is simply, "Where do you put the knobs?". Despite the deep technical knowledge and creativity needed to even comprehend what is underneath the surface of the instrument, this question seems to always be a point of contention when it inevitably comes up at some point throughout the design process. It seems to be a problem that just weighs on a designer with choice overload or analysis paralysis and leads to an outcome that can always feel slightly off or unsatisfying. This leads right into this paper's research question, *"Is there an instinctual placement of parameter knobs in hardware audio systems, especially in audio majors vs non-majors?"*

This question can come off immediately as quite broad and unfocused, which is why this research experiment took a much more focused approach at answering the question and focused on just two examples of audio systems to look at. It took a **Guitar Amplifier** and a **Digital Synthesizer** to use as test interfaces and attempted to understands test subject's preference on the placement of parameters for these two systems. More will be talked about the specifics of the experiment and results, but these two systems were the main focus of this test. By analyzing how these parameter preferences were shown, this topic can be opened up slightly more and lead to further, deeper research to help all future designers which is the ultimate goal for this research question. To help empower instrument designers and hardware engineers, to give them knowledge on the decisions they are making. Not only could this research help when that nasty, "Where do you put the knobs?", question crops up from earlier, but can improve the instrument interaction for all users as well.

Looking back at some past research and experiments, there is a very good amount of information related to the field of interface design and parameter placement, especially in the field of electronic instruments. One of the most useful articles for me was the article “The importance of parameter mapping in electronic instrument design”, which helped to elucidate some of the consequences of questioning the traditional one-to-one parameter mapping styles. They talk about the importance of parameter mapping as part of an instruments fundamental character and state ideas such as “Indeed this paper hopes to stress that by altering the mapping, even keeping the interface and sound source constant, the entire character of the instrument is changed,” and, “Surprisingly perhaps, they were nearly all extremely frustrated and angered by the 4 physical sliders. Comments abounded such as ‘I should be able to do this, technically, but I can't get my mind to split down the sound into these 4 finger controls’. Some users actually got quite angry with the interface and with themselves” (Hunt et al., 2003). These lines really helped clear up some of what I was feeling with parameter design and show a new way of looking at and approaching this topic. Another really good article was “Mixploration: Rethinking the Audio Mixer Interface”. This article actually dealt with the specific act of questioning an existing interface design and attempting to find if there was a more fitting alternative for different goals. Their approach involved using a different interface that somewhat leaned itself into making higher-level, abstract changes easier, but small fine-tuning harder. By experimenting with this, they were able to see how users interacted with the new parameter mappings and what they found most useful in that interface. From there, they could devise a plan to use parts of the new interface with parts of the old one to revitalize the user experience. Some of the good quotes from this one are, "We wanted users to trust their ears by listening to the whole mix, rather than trusting their eyes by focusing on individual parameter settings reported by a level meter or knob," and, "From the participants' feedback, it seems that many users found the proposed interfaces great for 'exploring possibilities quickly', 'finding ideas I hadn't anticipated', and ideas that they 'would not necessarily think of' themselves" (Cartwright et al., 2014). There\ are great things to pull from the other articles as well that I have listed below here and can do a much more thorough review of all of them in the future.

With knowledge of the past experiments and research understood, designing the experiment for this research question was going to be much easier and allow it to be more focused in on a specific issue. To reiterate the research question, *"Is there an instinctual placement of parameter knobs in hardware audio systems, especially in audio majors vs non-majors?"* Based on this research question, the Null Hypothesis (H_0) would be "There is no instinctual tendencies for placement of parameter knobs in audio systems." And for the Alternative Hypothesis (H_1), "Audio Arts majors will show commonality in where they place specific parameters, but there will be very little commonality between nonprofessionals." The experiment should be designed to address these specific hypotheses in order to provide the most clear and concise results. First was making sure the population fit these criteria, so the experiment used Audio Majors and Non-Audio Majors from Columbia College Chicago, all 18-25, in order to directly compare these two populations. The independent variable for this experiment was the different interfaces and parameter orientations of the knobs, while the dependent variable was going to be the subject's preferred location of each parameter on the interfaces. Since each subject was going to tested on every parameter orientation, this sampling strategy would be using within-subject design.

The design of the experiment is meant to simulate a hands-on interface for the subject in order to help them really understand which location they find best for each parameter they are given. In order to simulate this sensation of a hand-on instrument experience, a 3D model was made to fit a set of 1-inch knobs which can be rearranged on the fly to try out different locations. This was the compromise between having a physical interface to interact with,

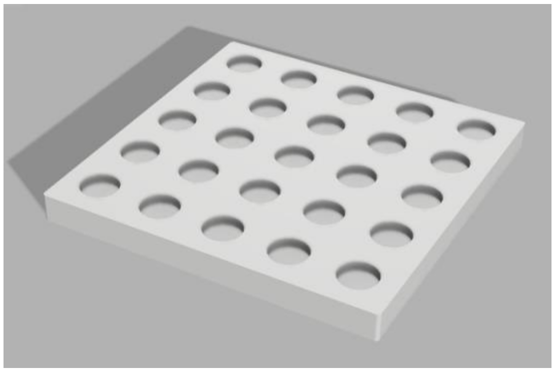


Figure 1 - Physical Interface

while not building over 20 different full-fledged designs with potentiometers and knobs. The process the experiment would take is the subject would start off by taking a small survey to get some basic info such as age, major, and handedness. After that they would be talked through the

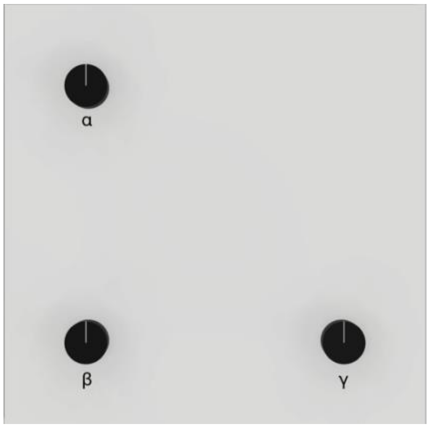


Figure 2 - Orientation Example

whole process which was being told the audio system they were simulating (amplifier or synthesizer), reading the parameters for that system (in a random order), getting audio examples of each parameter, and lastly being presented an interface orientation in which they will pick which knobs control which parameters. The last step was repeated for several different orientations and the whole process was repeated for each audio system (except for the beginning survey). All these different orientations are featured in the appendix page 7. The four different audio systems were as follows:

- Guitar Amplifier with 3 Parameters – Volume, Tone, Gain
- Guitar Amplifier with 5 Parameters – Volume, Tone, Gain, Tremolo, Reverb
- Digital Synthesizer with 3 Parameters – Volume, Frequency, Filter
- Guitar Amplifier with 5 Parameters – Saw Volume, Triangle Volume, Frequency, Filter, Vibrato

This whole process is ripe for bias to be presented since presenting an order to the subject from the perspective of the interviewer my lead them to be more inclined to follow this order. To help avoid this, the parameters were printed on pieces of paper, shuffled, and picked by the subject themselves in order to ensure a random order. Care was also taken to make sure to never refer to a knob order that was not addressed by the subject first.

The data for this survey was collected by recording the subject's preference for each knob, in each orientation, for audio system. This made the actual process of taking the survey extremely simple but, in hindsight, was not very ideal for actual data analysis. In order to prepare the data for actual analysis and visualization, for each orientation a set of 5x5 matrices was made (one for each parameter in the orientation) which represented each potential position on the physical interface. From there, then data was taken from each orientation and each time a certain parameter appeared in *A*x*B* position, 1 was added to *A*x*B* cell. This essentially created a frequency chart for each parameter and from there, it was possible to glean information. With these frequency charts made into .csv files, they could be made into heatmaps using the Seaborn library in Python. All these heatmaps are featured in the appendix pages 1-6. Please refer to them as the data is discussed in the next paragraph.

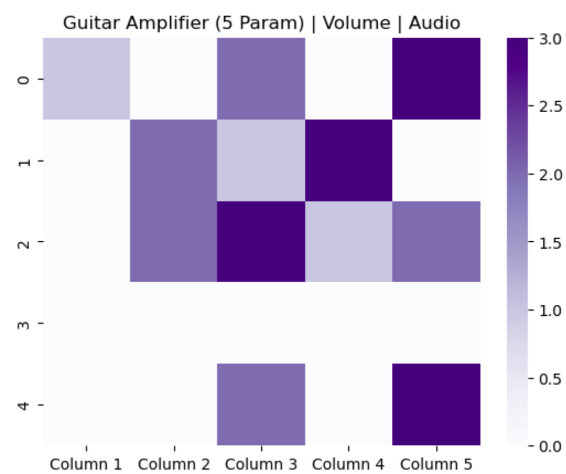


Figure 3 - Heatmap Example

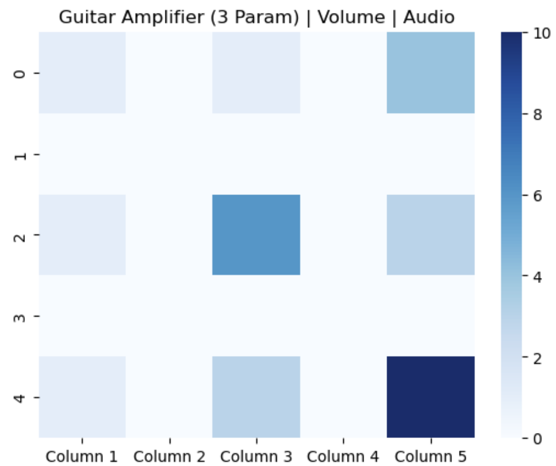
Looking through these heatmaps can give a strong idea of certain tendencies between the subject groups. One example is with the 3-Parameter Guitar Amplifier in which there is a strong consensus between the Audio Group of where each parameter should likely go horizontally - Volume on right, Tone in the middle, and

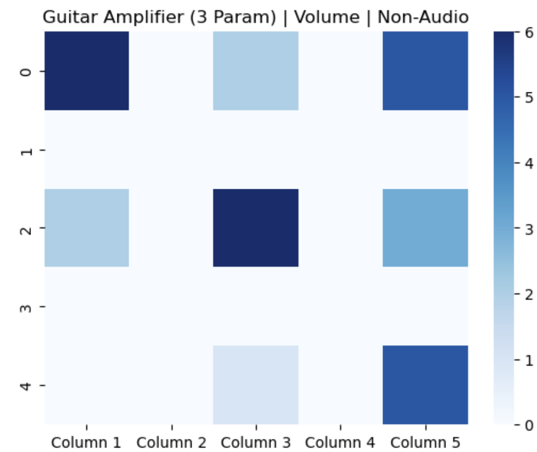
Gain on the left. The Non-Audio. This is much less strong in the Non-Audio group where the Volume heatmap is very spread between all the squares horizontally. We see this tendency continue to the 5 Parameter Guitar Amplifier with the Audio Group tending towards Volume on right, Tone in the Middle, and Gain on the Left. Even agreeing that Tremolo is more bottom-left oriented and reveb is more bottom-right oriented. The Non-Audio group was a bit weaker horizontally, but still generally agreeing, for the horizontal nature of the first 3 parameters, but agreed with the audio group on the verticality of the three. They also agreed that Tremolo leans bottom-left and Reverb leans bottom-right. For the 3 Parameter Digital Synthesizer, the results were a bit weirder in the sense that the Audio group were interested in the verticality mostly for Volume, but horizontality for the Filter parameter. The Non-Audio group seemed to only differentiate vertically for these 3 and disagreed with the Audio group on Volume, but firmly agreed with Frequency. For the 5 Parameter Digital Synthesizer, the Non-Audio subjects stuck closely to the verticality preferences of the last parameters, but were generally unsure of where to place vibrato. The Audio group actually changed Volume to a much more vertical preference for this interface and also was somewhat unsure about Vibrato, but leaned to a downwards preference.

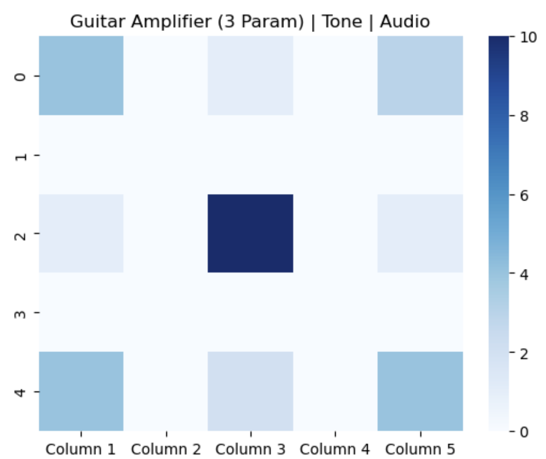
With all this data parsed and visible, it is clear to see that there are trends illucidating themselves and starting to form even in the small sample size collected here. There seems to be preferences that subjects have when it comes to the instrument interfaces and whether they are due to industry standard, marketing, or something more inate, the idea shows promise. Unfortunately, with this experiment there is just unfortunately not enough data to fully disprove or prove any hypotheses. There would need to be quite a few more subjects and a little bit more in-depth analysis in order to fully understand this topic. It is important to keep pursuing this research as the necessary needs and use cases mentioned in the introduction of this paper are still true and very important to the world of electronic instruments and interface design. One quote I liked from “Principles of User Interface Design: Important Rules that Every Designer Should Follow”, is the one they end the paper on which goes, “In conclusion, it should be noted that no list of rules can be characterized by maximum exhaustive because the cognitive characteristics and capacity of individuals, including affinity to the use of technology, the contexts of use, objectives and tasks of the users are very different. These factors can be added the ever-changing desires of users, which in some cases are subject to ‘fashion’ trends. However, compliance with the basic principles of design to improve the usability of the user interface of the software product, and hence to provide some degree of confidence o users that work in a correct manner with the application and can fulfil his/ her end goals” (Nacheva 2015). This is an ever changing field and there will never be a “correct” answer for any problem. But it is imperative that research is done in order to make finding the answer that fit best for each design.

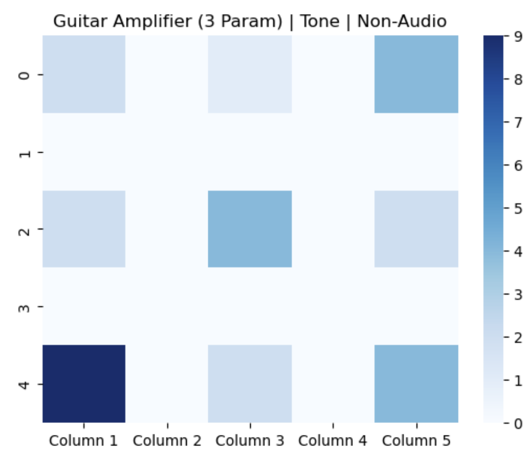
Appendix

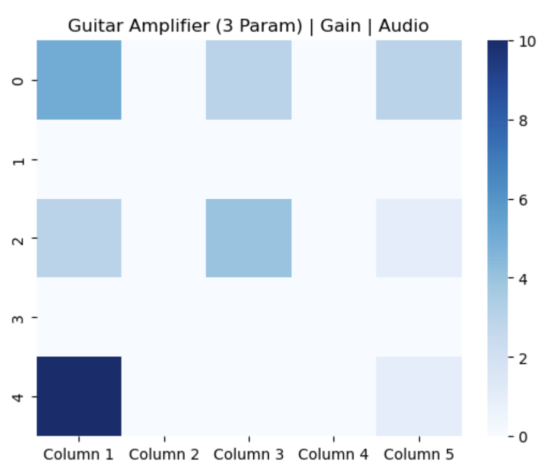
Guitar Amplifier – 3 Parameters

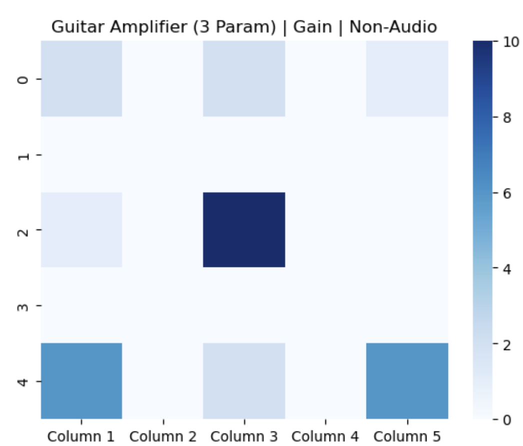




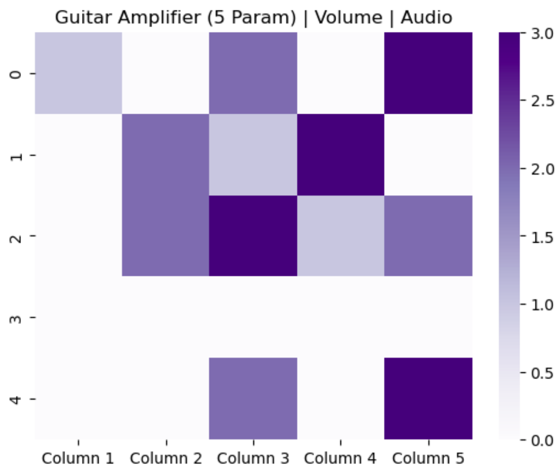


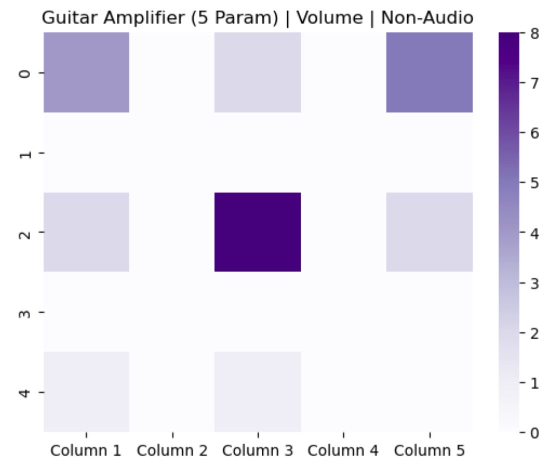


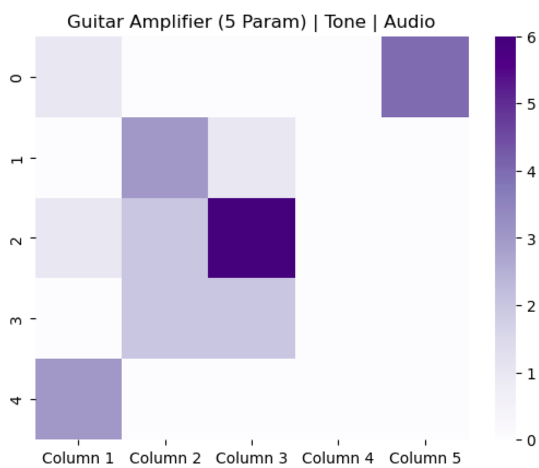


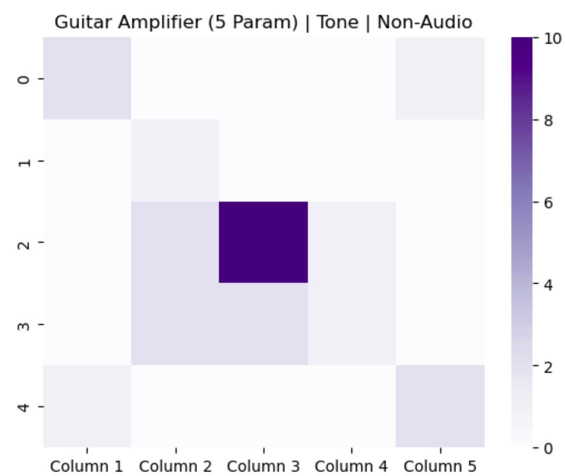


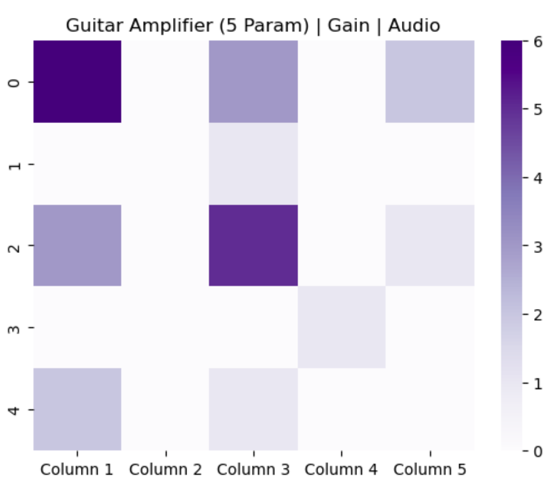
Guitar Amplifier – 5 Parameters

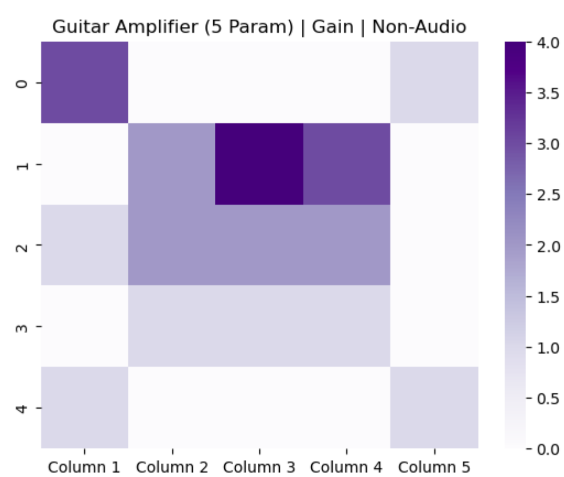












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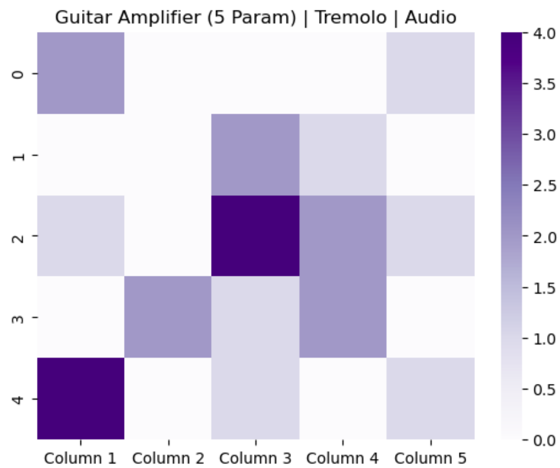
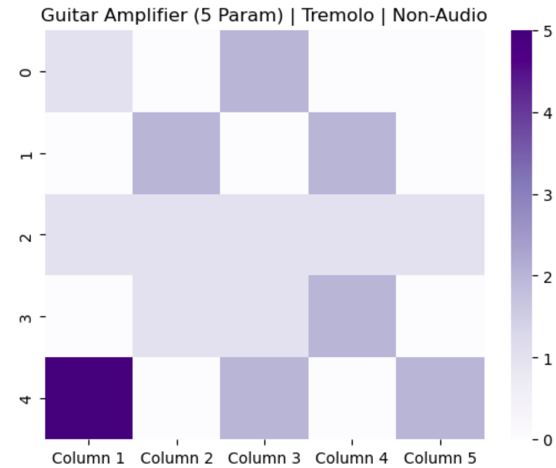
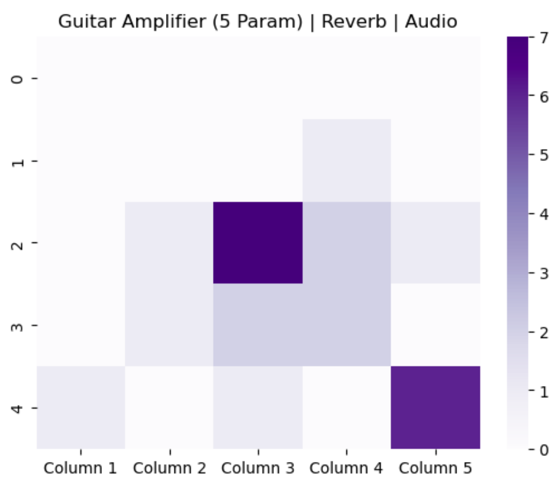
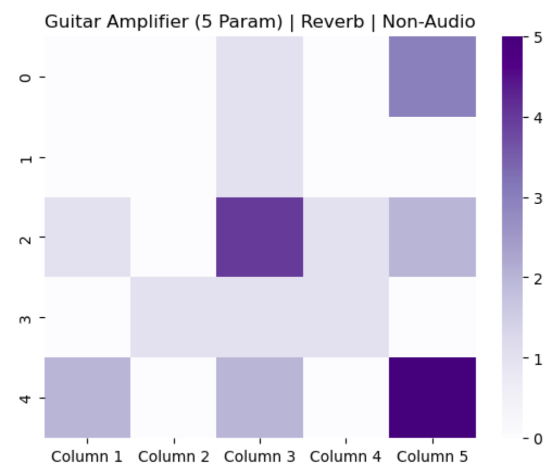
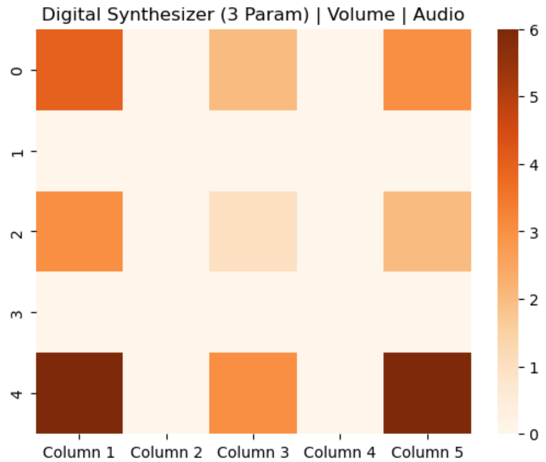








Digital Synthesizer – 3 Parameters


Digital Synthesizer (3 Param) | Volume | Audio
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Column 4
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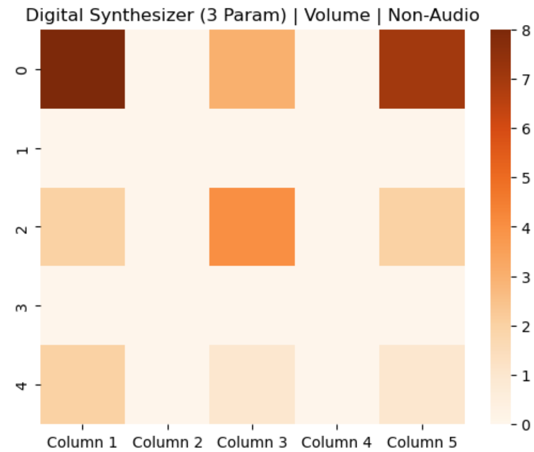
3
2
1
0


Digital Synthesizer (3 Param) | Volume | Non-Audio
0
1
2
3
4
Column 1
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Column 4
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7
6
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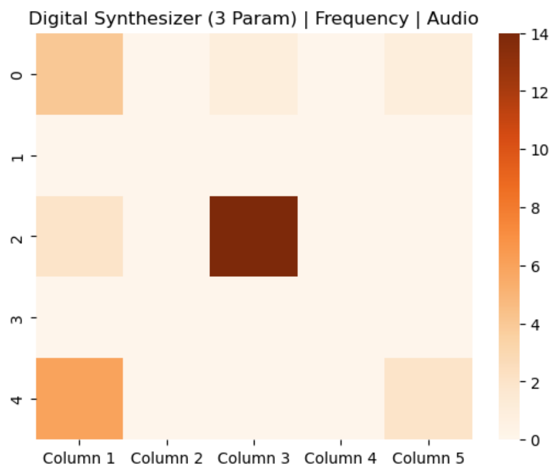
4
3
2
1
0


Digital Synthesizer (3 Param) | Frequency | Audio
0
1
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3
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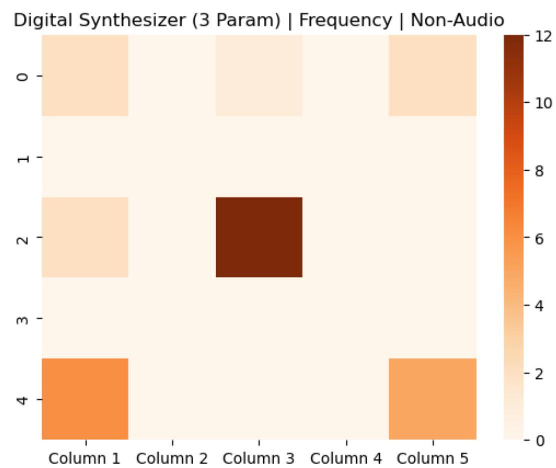
Column 1
Column 2
Column 3
Column 4
Column 5
14
12
10
8
6
4
2
0


Digital Synthesizer (3 Param) | Frequency | Non-Audio
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12
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2
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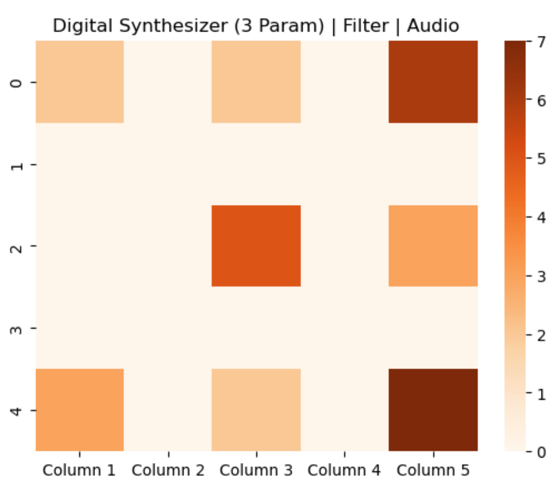
Digital Synthesizer (3 Param) | Filter | Audio
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4
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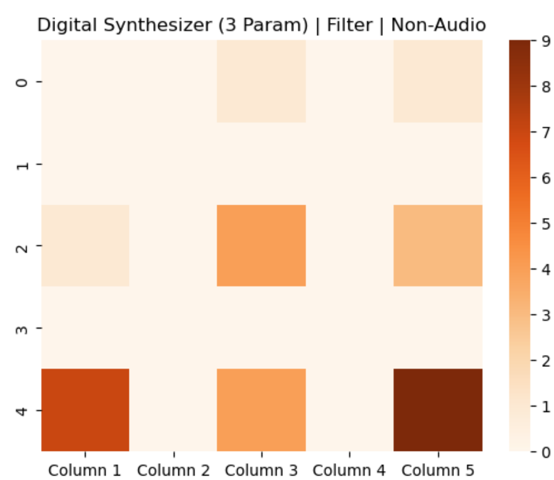
2
1
0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1
2
3
4
Column 1
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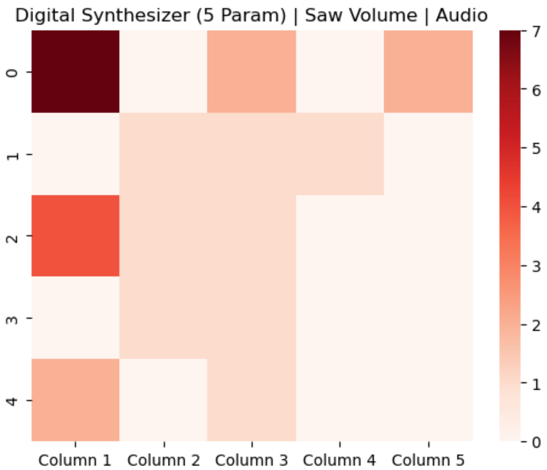
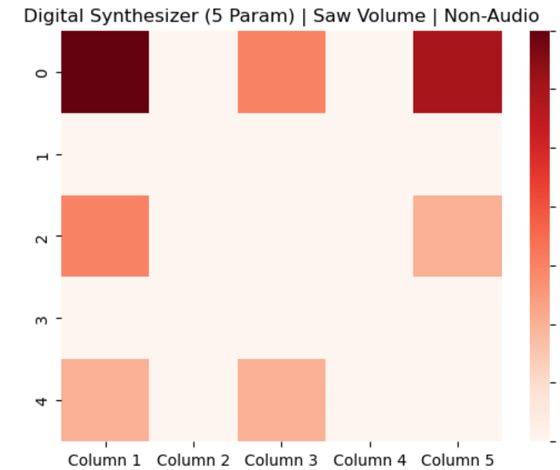
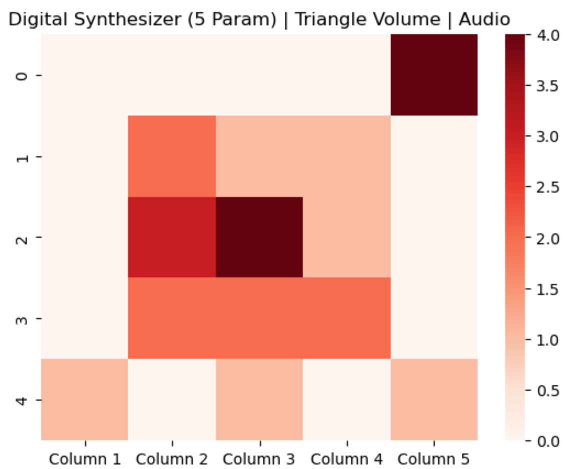
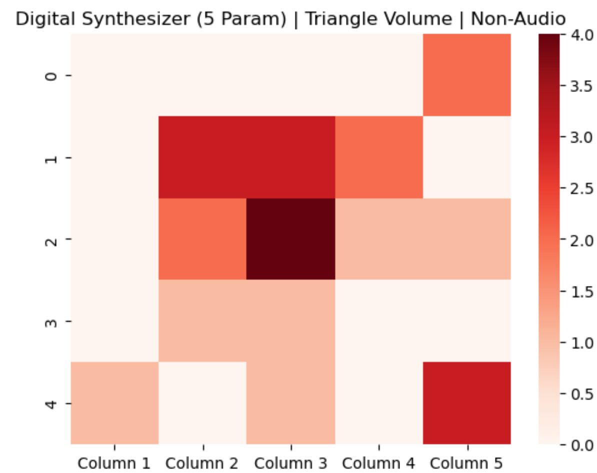
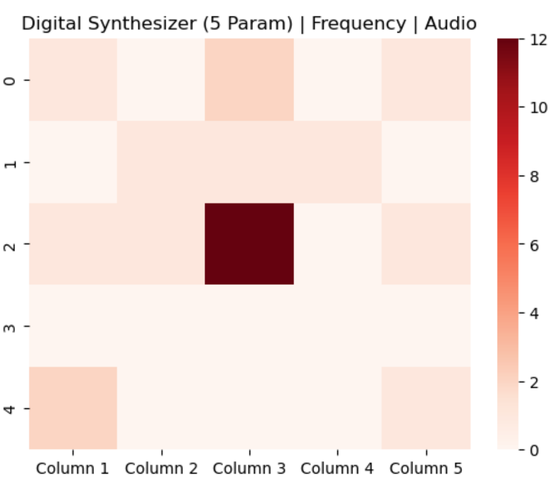
Digital Synthesizer – 5 Parameters

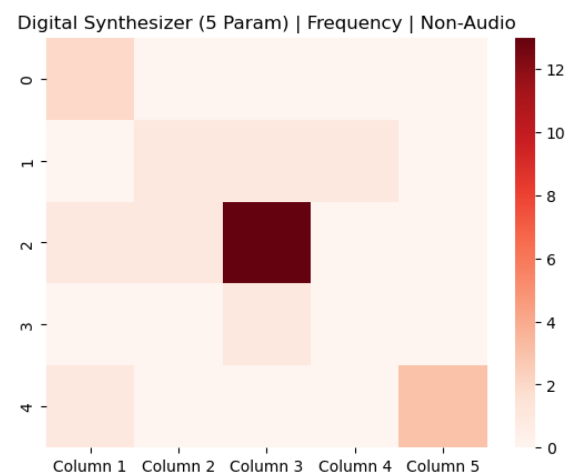












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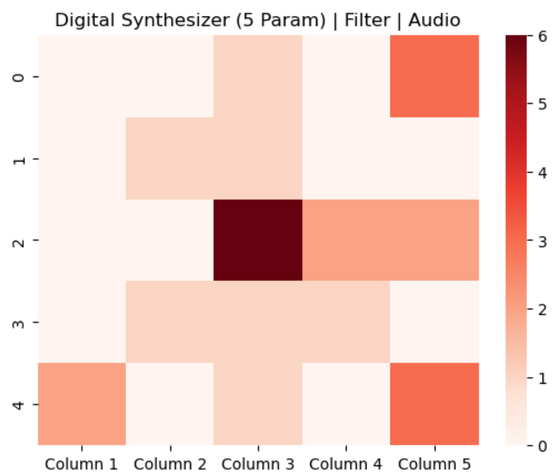
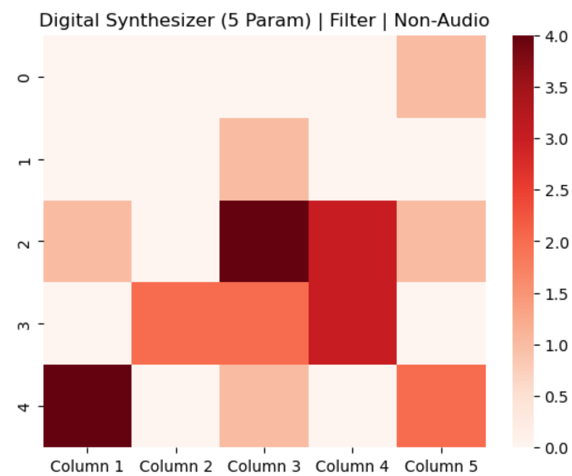
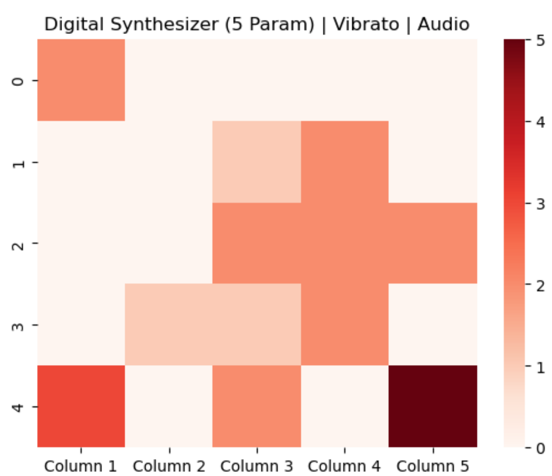
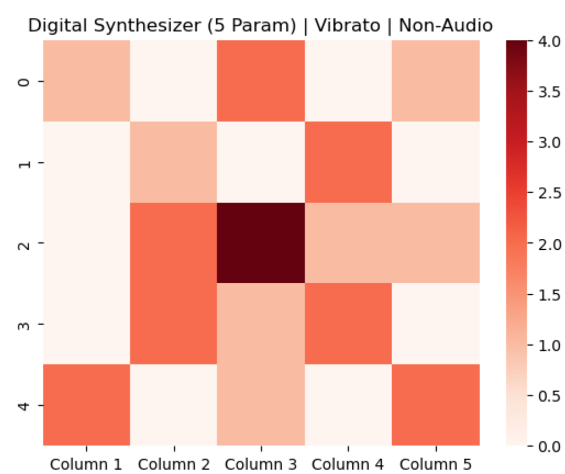
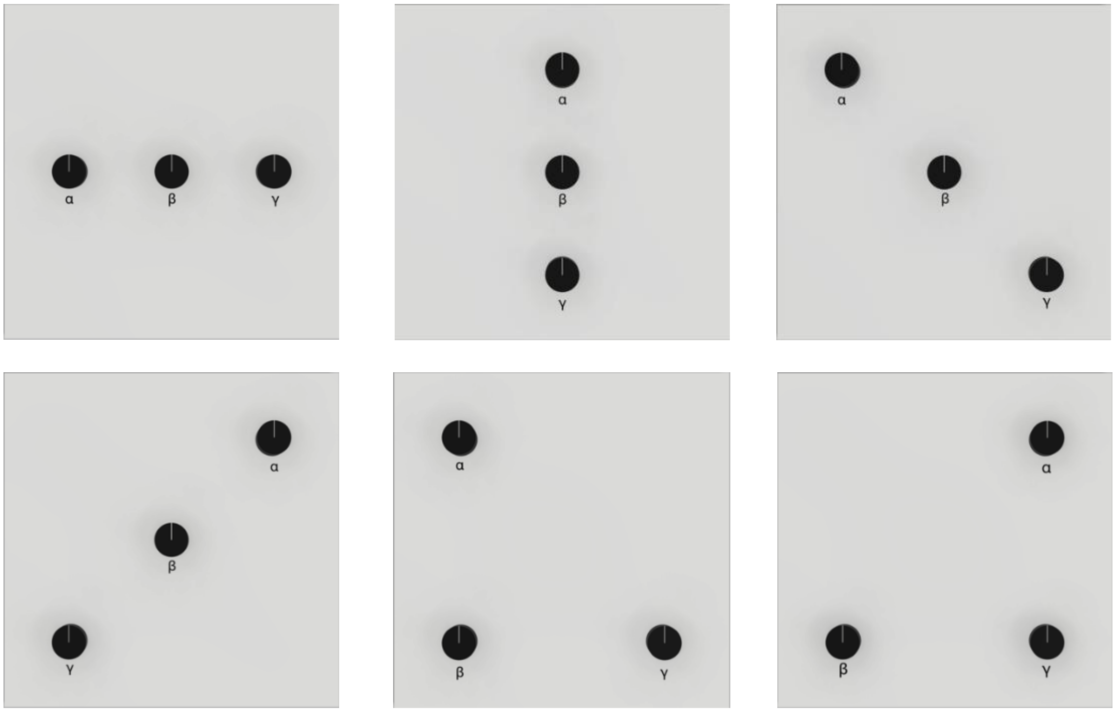








3 Parameter Orientations



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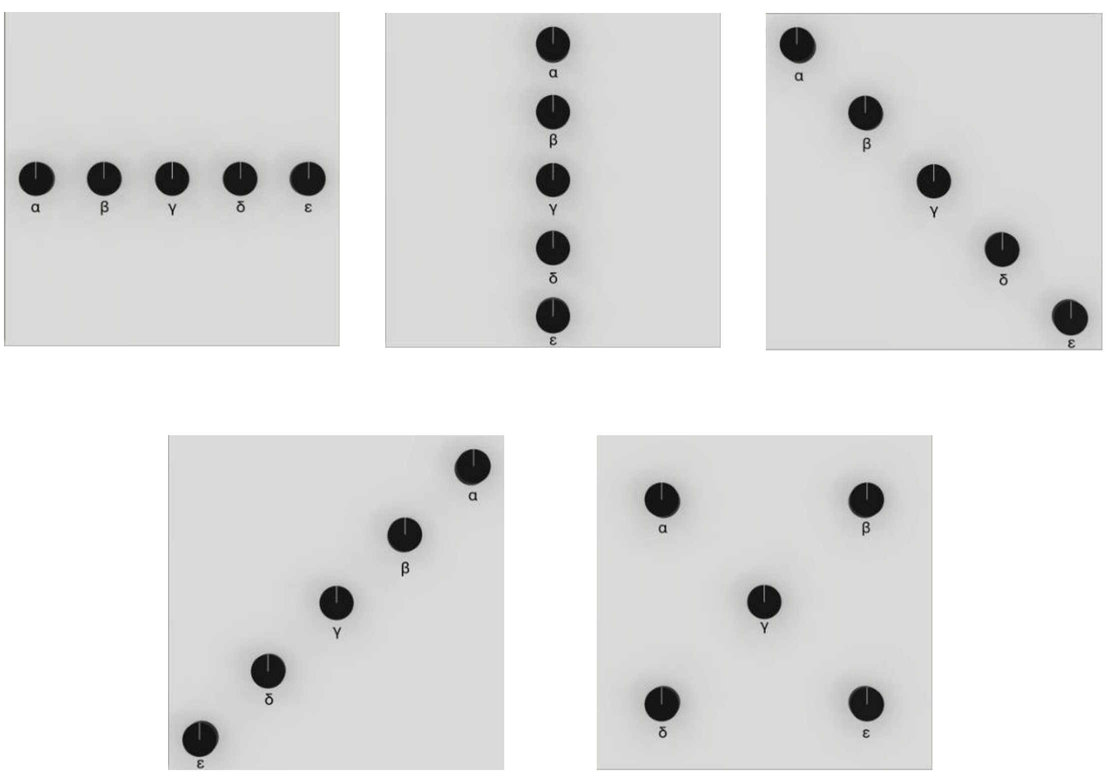

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