Final Paper
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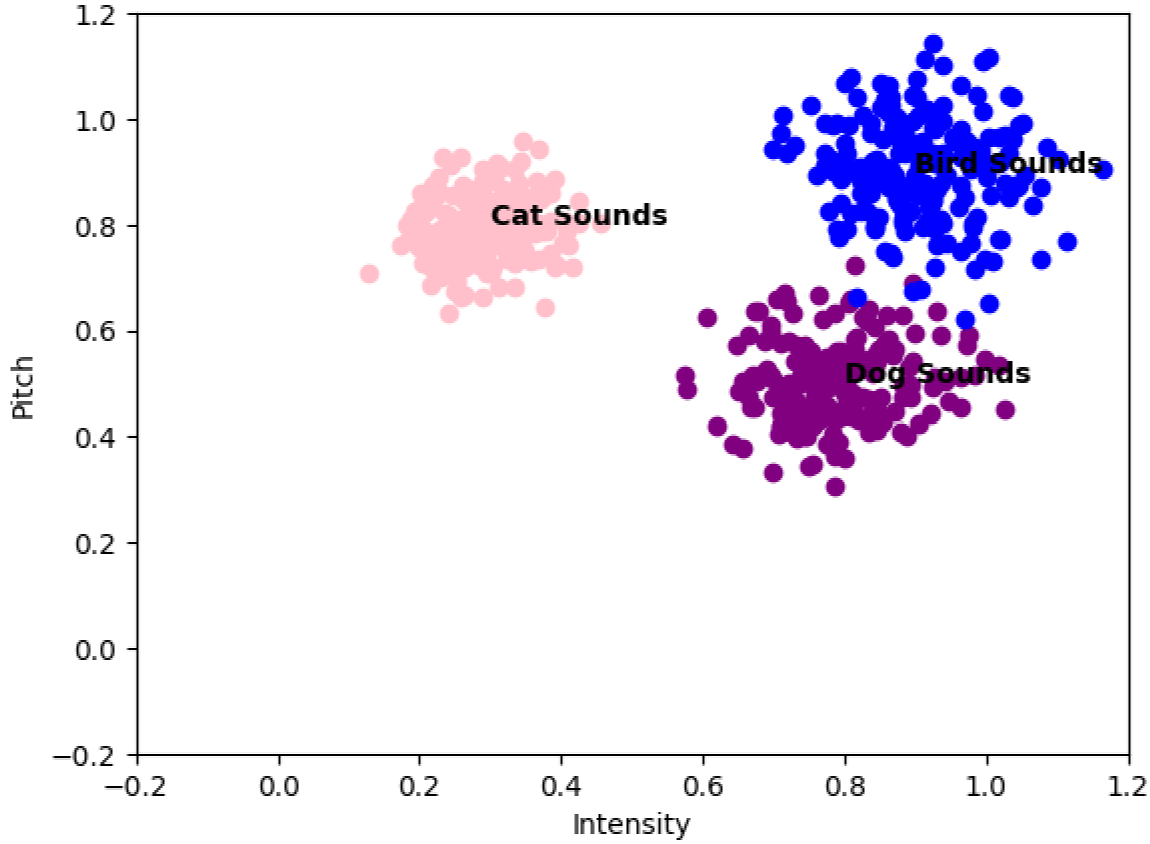
What happens in my brain when I perceive sounds

1. Introduction

I will explore how an artificial neural network can be used to explore how my brain's biological neural networks process animal sounds, specifically how my brain perceives dog sounds, cat sounds, and bird sounds. I love animals and as someone who owns pets, I am fascinated by their mannerisms and how I have been cognitively engineered to respond accordingly. I understand that animals use sounds to communicate their needs and boundaries to people. I will discuss what happens in my brain when I hear different sounds how my mind gauges and classifies those differences in sounds and how it thinks and reacts to them.

2. Sensory Processing

I will be classifying different animalistic noises using a 2- dimensional perceptual space, where the dimensions are intensity and pitch. Intensity is measured by the loudness of an animal's sounds on a decibel measurement level. Pitch is quantified by the frequency of an animal's sounds and is measured on a Hertz measurement level. This figure was created by me for exploratory purposes and is not correlated with any real data, it is merely a model I have made. Each dot you see in this figure correlates with a specific animalistic sound such as a cat's meow. The different colors and labels indicate what animal they belong to respectfully. As seen in the figure below, cat sounds tend to have low intensity but be higher pitch. Whereas we see that dog sounds such as a dog bark produce higher intensity db waves but a lower pitch frequency. A bird’s sounds such as squawking are perceived in this data as being both higher in intensity on a db level and higher in pitch on a hertz level.



By simply analyzing this figure we can see that the cat’s sound category is linearly separable from a dog's sounds and bird's sound groups. We can determine this because we can draw a line down the middle to separate the cat's group from the other animalistic sound groups. However, even though the dog and bird groups differ in pitch frequency, we do see an overlap between the two groups. While they have different pitch hertz levels, the overlap is regarding the x-axis dimension ‘intensity’ due to their similarities in loudness on a db level. These two categories are seen as inseparable from each other because we are not able to draw a line between these two groups and separate them.

To understand the neural realization of this space we will now look back on our sensory dimensions, intensity, and pitch, and consider what brain areas correspond to these sensory processes. Intensity and Pitch can both be seen processing in similar areas of the brain such as the auditory nerve and brainstem areas. However, their specific residence within these areas differs with the pitch being processed within the heschl's gyrus and intensity information being processed within the medial geniculate nucleus.

Research regarding loudness perception which is the basis of measurement for my intensity sensory dimension, discussed how central auditory structures such as the medial geniculate nucleus process loudness so that we can interpret sounds and environmental cues. Neurons within the central auditory system fire at different rates depending on the perceived sound. For example, a neuron's firing rate increases when a sound's loudness increases. According to *"Neuroanatomy, Auditory Pathway", "*combination-sensitive neurons are a subset of auditory neurons that respond variably to different acoustic elements. [..] These neurons are thought to help identify important sound cues necessary for communication". This ties into our communication with animals. By using environmental processing cues and gauging different elements we can decipher when the intensity and pitch of a sound is needed to be perceived as dangerous. It is an auditory process but on the surface level, it is crucial to our social processes as humans living within an animalistic world. Processing within the central auditory structures is crucial for judgment processing.

3. Action and Reinforcement Learning

Actions that are played out based on the pitch and intensity of sound my brain processes lead me to do actions such as feeding, playing, or leaving an animal alone. The neural realization of my perceptual space describes my sensory inputs, intensity, and pitch within the domains of animalistic sounds specifically dog, cat, and bird sounds. Through sound cues regarding pitch and intensity, my mind can infer whether or not an animal is perceived as a threat or if they need something. Due to emotional processing, high-intensity sounds might be perceived as dangerous by the amygdala and induce a fear response which then influences our behaviors such as running away when a dog barks with low pitch and high intensity.

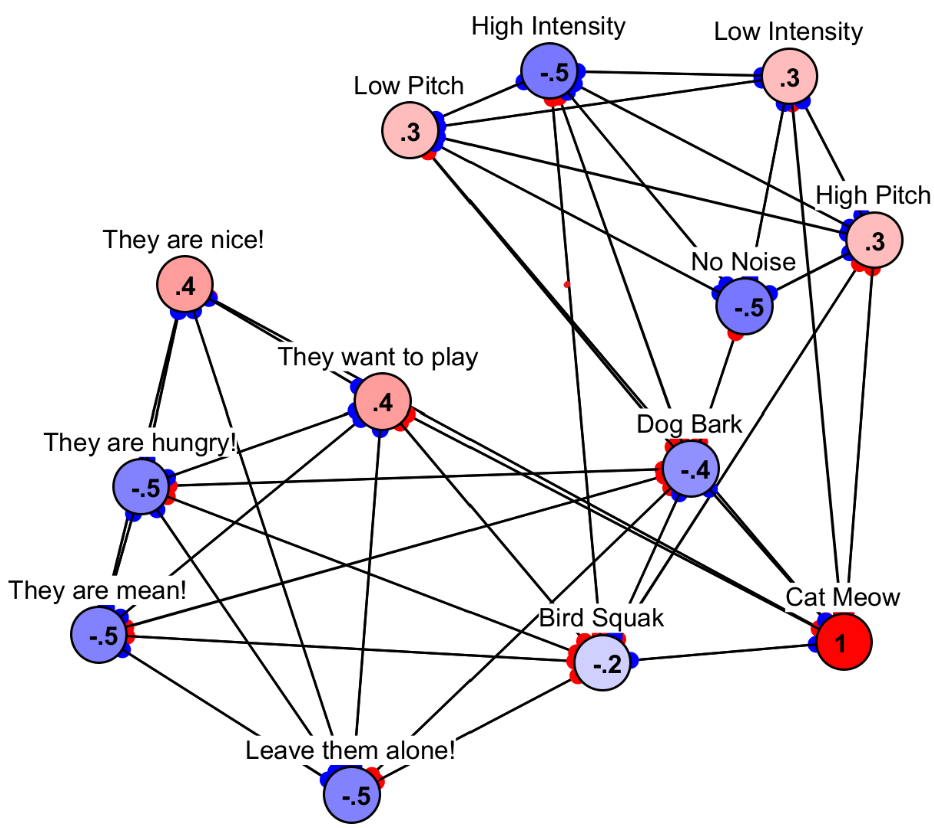
Another example of this is when my pet cat meows in high pitch but low intensity. Since my brain can receive information from my sensory systems such as my visual and auditory systems, it can initiate behavioral actions that are required based on what I perceive. In this example, however, my amygdala would not perceive my cat's meow as a threat and I would infer that based on her pitch and intensity, she is trying to get my attention to do something such as feed her. This would invoke me to do an action such as going to bring her food.

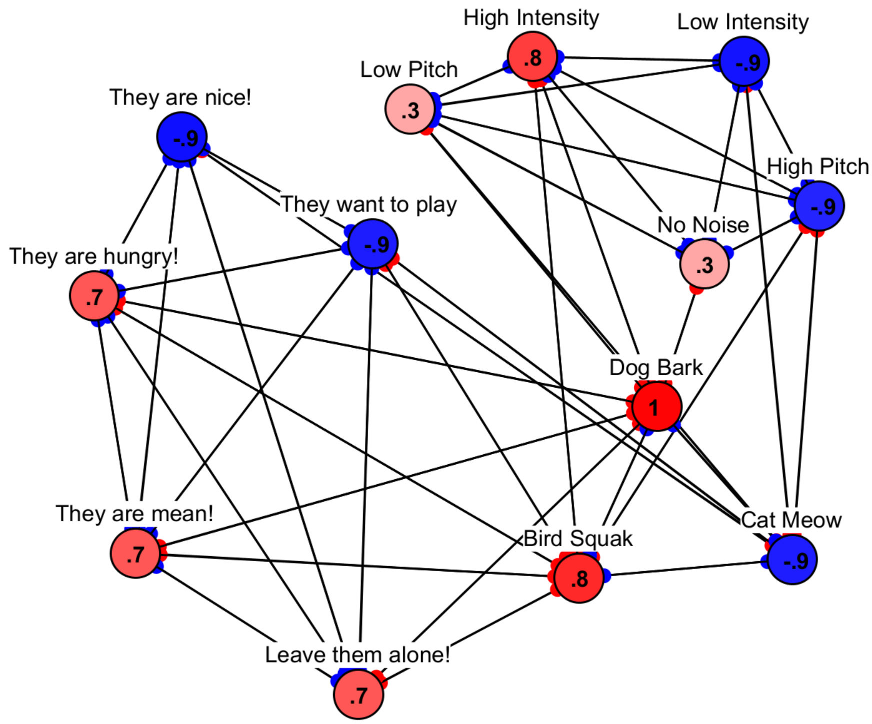
Through the use of motor behaviors using the dorsal stream and spatial information, I would be able to guide my motor cortex into executing the movements necessary for reaching and grabbing her food bowl and placing it in front of her. The use of my dorsal stream later ties into reinforcement-based learning using the basal ganglia. Since I am cognitively engineered to determine which sounds are enacted by my cat when she is hungry, it is only natural that my brain also remembers what actions happen after I have given her the food and any rewards that may be given to me such as my cat thanking me with snuggles. The basal ganglia, which is responsible for “mediating the link between actions and rewards” reinforces my brain to associate the action of giving my cat food when she makes that noise with the reward associated with that behavior (CHATGPT). The basal ganglia is also strengthened by dopamine which is also later received due to the neural circuits associated with the behavior the basal ganglia and dorsal stream had previously worked together to reinforce.

However, the same biological systems that reinforce me to follow positive reward-based behaviors also reinforce me to be cautious or to stop doing an action entirely that has brought insufficient rewards or consequences. An example I can still vividly recall of this is when I was walking home from school and saw a dog that was making a very low-pitched and high-intensity barking sound towards me. The amygdala which is associated with our brain's fear response center, would usually associate these sounds with fear, however, since this was when I was very young, I did not associate the high intensity and low pitch combination as dangerous and I decided to pet the dog. It is possible that my brain did not have enough environmental or experience cues to know to associate this action with fear and instead, my dorsal stream allowed me to extend my arm to navigate the space the dog was in and grab it which had led me to get bitten by it. Due to this, my basal ganglia which works with reward-based learning and decision-making led me to associate this behavior with a negative outcome and associated it with a decrease in dopamine which then "weakened the neural circuits related to the behavior, causing abandonment of the behavior in favor of more rewarding alternatives" (CHATGPT).

4. Thought Processes

My brain conjures up many thoughts concerning different types of animal sounds. For example, when I hear a cat meow usually I start thinking that they want to play with me and that they are nice animals and safe to approach. I will rarely ever leave a cat alone when I hear it meow towards me. When hearing a dog bark I might think to myself whether or not it has low pitch and high intensity or low intensity. From there, I might start thinking that they are mean and to leave them alone or I might think to myself that it is trying to get my attention because it is hungry. When I hear a bird squawking I usually think to myself that they are also being mean and to leave them alone in fear of being peaked at. To run the network, I activated the animal sounds group nodes which were activated as closely to the input cluster from the first figure above as we can see here that dog barks and bird squawking also have similarities within their values.





These networks are connectionist and just like the first figure above it is not representative of real data. This IAC network is used to represent a consensus of what happens in my brain when I am perceiving different animal sounds and their conjunction with pitch and intensity. This is merely a representative model of my perceptions and thoughts regarding animalistic sounds based on the memories that the hippocampus has stored with my emotions and memories.

References

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