Connectivity result for neurons based on phenotype

1. Hypothesis:

The hypothesis is that neurons type with similar functions (e.g. walking, flying etc…), show similar statistics and that we could find a pattern that could be used to identify what is the function of an unknown neuron.

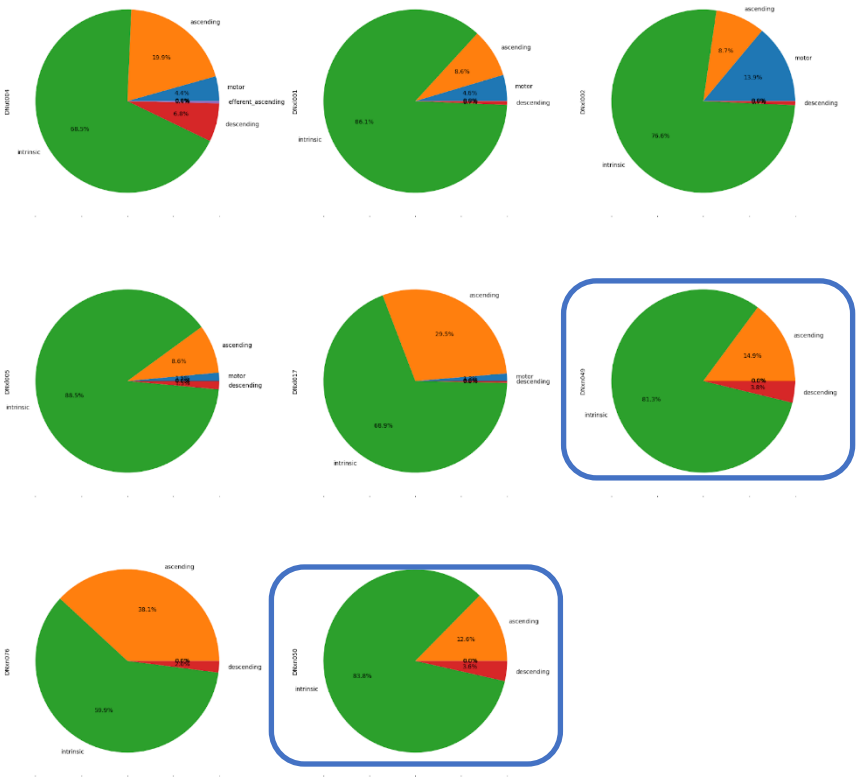
2. Methods:

I used the code I wrote to get the statistics, and used 2 papers to be able to link a particular phenotype to neurons in the brain, and then DNs in the brain into the VNC, to finally have DNs in the VNC linked to a phenotype.

3. Results:

1. Neurons responsible for walking:

I started by getting all neurons type in the VNC that we know was responsible for an action that can be classified as walking.



We observe that most of them target mostly intrinsic neurons and ascending neurons. The first 4 types also target motor neurons.

Dnxn049 and **DNxn050** looks very similar in term of distribution, their graph is almost the same (shown in blue).

Figure 1.1 Repartition of target neurons class

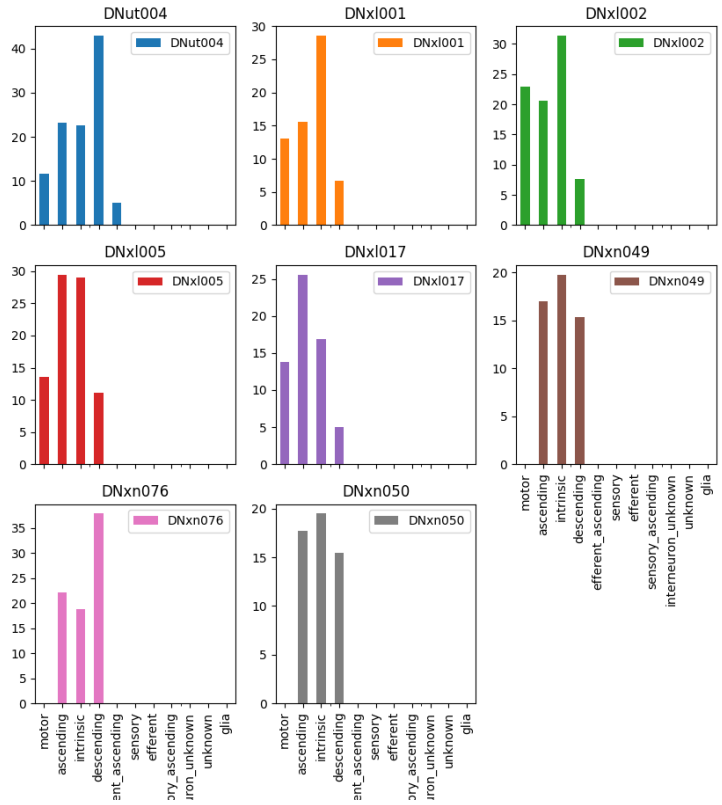


Figure 1.2 Number of synapses per target class (normalized by number of neurons targeted)

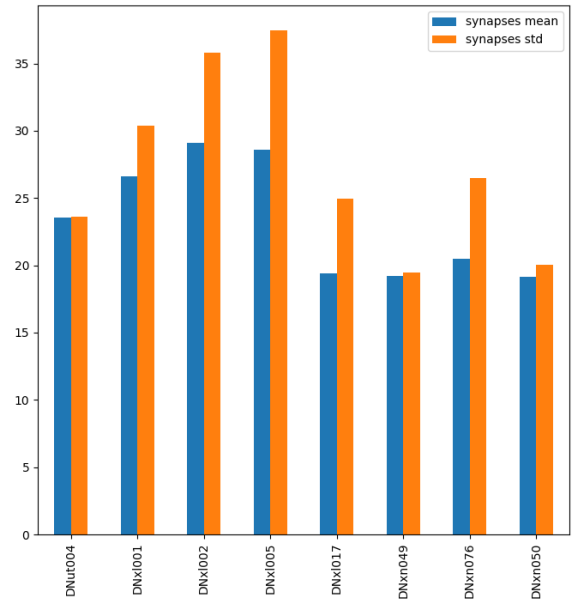


Figure 1.3 average number of synapses and std per neuron

Fig 2.1: It could be that a similar target repartition implies a similar ratio of synapses per target class. **DNxn049** and **DNxn050** have similar target repartition and similar ratio repartition (as well as amplitude of the ratio). But other than that, all the other ratio looks different from one another.

Fig 3.1: As for the synapses average and standard deviation, they all seems to be different from one another, except for **DNxn049** and **DNxn050** that have similar average and standard deviation.

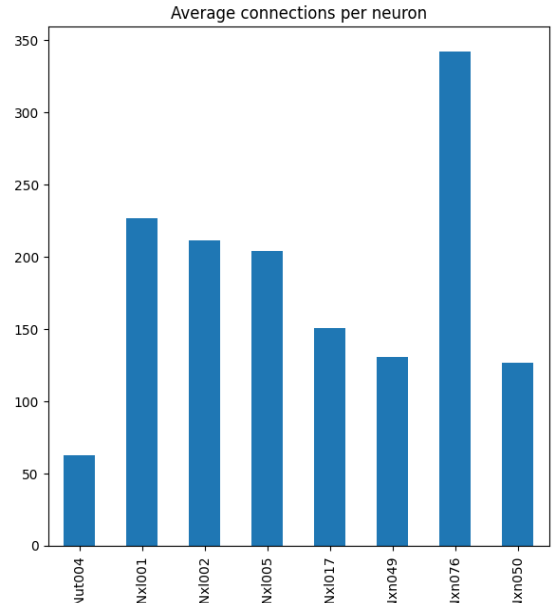


Figure 1 .4 Average connections per neuron

Fig 1.4: Here, it's the same thing, **DNXn049** and **DNXn050** seems to have a similar average connection per neurons.

<u>Conclusion:</u> For neurons responsible for walking there are no visible pattern. Only 2 neuron type show similar pattern. But we can notice that **DNXn049** and **DNXn050** descend from the same neuron type in the brain and show the same specific phenotype (backward walking).

2. Neurons responsible for flying

I then look at all neurons type we know caused flying movement. This time there were more types of neurons and more types that came from the same descending neuron in the brain.

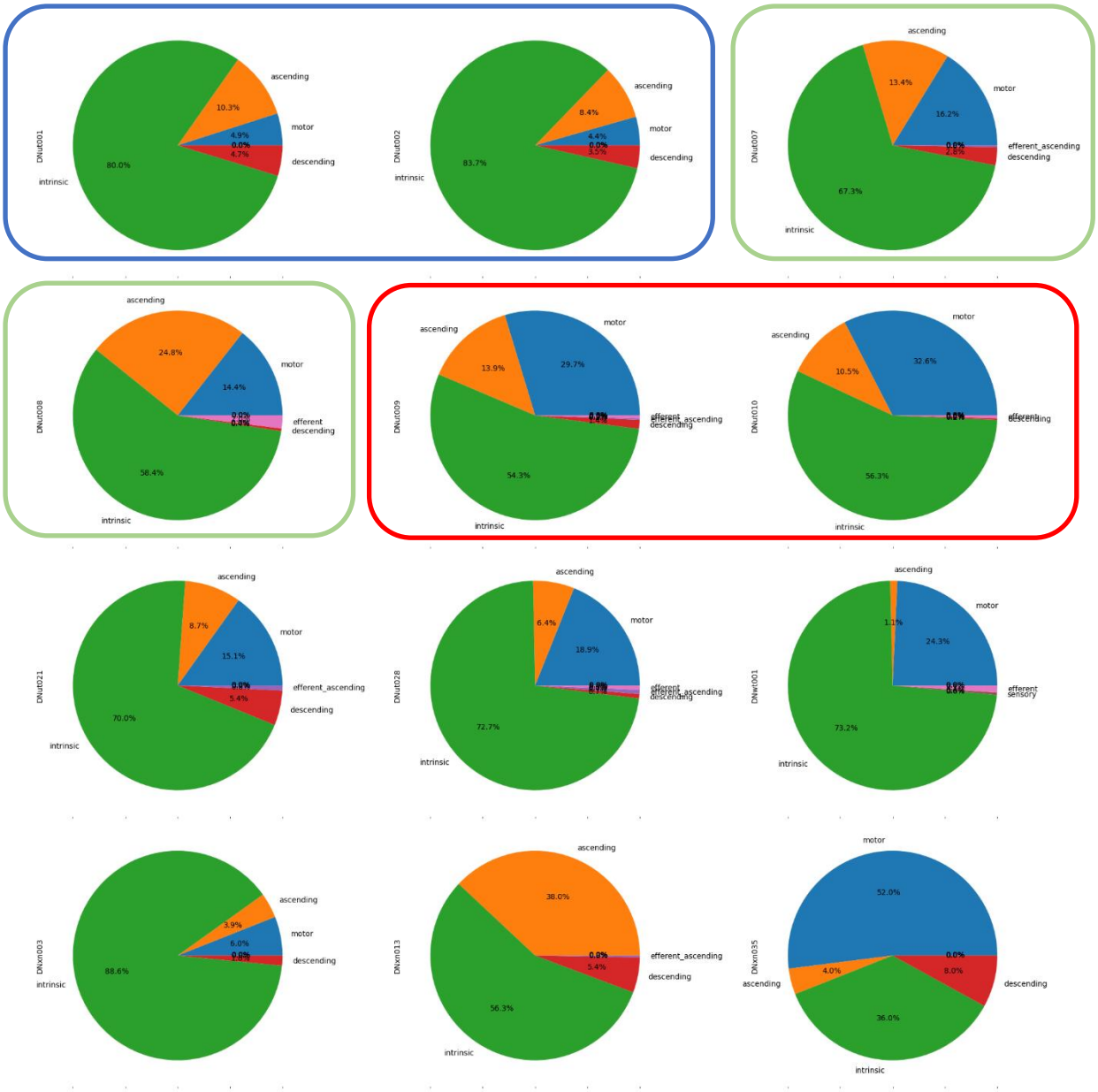


Figure 2.1 Repartition of target neurons class

Here as seen before in neurons responsible for walking, we observe a majority of intrinsic neurons as target neurons, but it seems to have more percentage of motor neurons than before (**DNxn035** targeting a majority of motor neurons).

We also notice pairs of neuron types that display a similar target repartition: (**DNut001** & **DNut002** (blue)), (**DNut007** & **DNut008** (green)) and (**DNut009** & **DNut010** (red)). Like before theses pairs are types that descend from the same neuron cluster in the brain and perform the same function. Only particularity is the green and red pair that are responsible

for the same phenotype (regulate wingbeat amplitude) but don't share a common distribution, it's only the same pairwise.

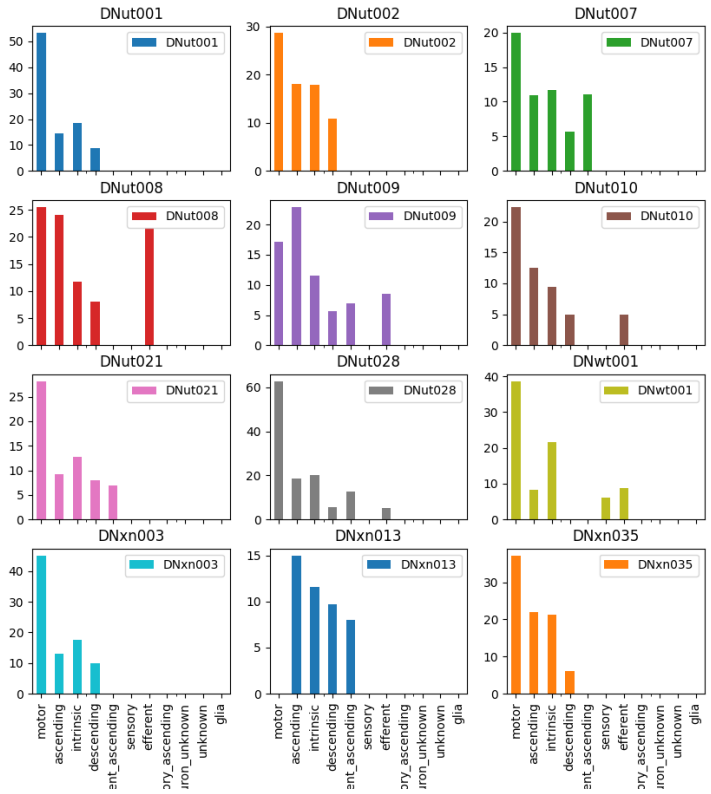


Figure 2.2 Number of synapses per target class (normalized by number of neurons targeted)

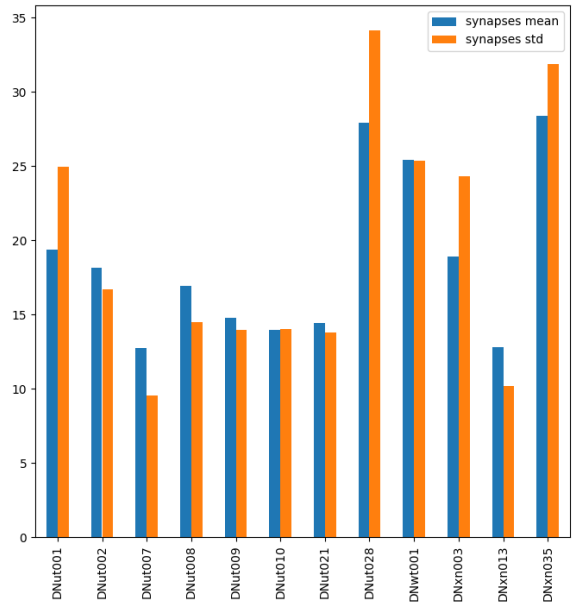


Figure 2.3 average number of synapses and std per neuron

Fig 2.2: Compared to neurons responsible for walking, the ratio is different for similar target repartition. The 2 most similar ratios are of **Dnut021** and **Dnut028**, which have a similar target repartition but not the most obvious one. But they are not responsible for the same specific phenotype.

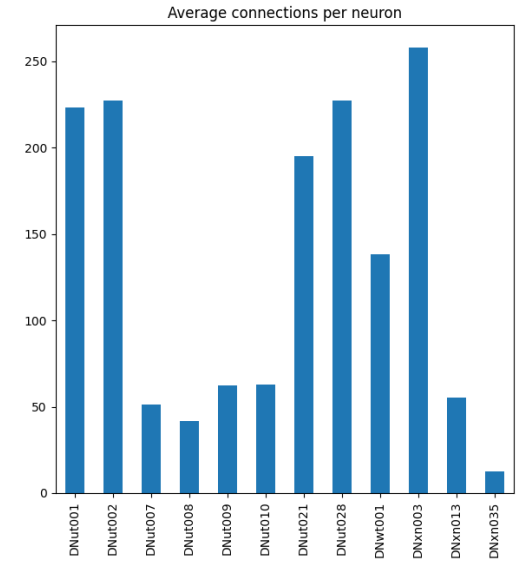


Figure 2.4 Average connections per neuron

Fig 2.3: The average number of synapses and its standard deviation also doesn't seem to display a particular pattern.

Fig 2.4: Here the pattern of fig 5 are also shown in the average connections per neuron in the type. We observe 3 pairs of similar size (**DNut001**, **DNut002** & **DNut028** (~220 connections), (**Dnut007** & **DNut008** (~48)) and (**DNut009**, **DNut010** & **DNxn013** (~60)).

Conclusion: There are still patterns in the target repartition and in the number average connections per neurons for types that display the same phenotype. But no pattern on the other statistics. And no global pattern seems to appear.

3. Neurons responsible for anterior movement

Next, we look at neurons that generate movement we could qualify as anterior, such as ventral head weep and leg rubbing and anterior reaching movement.

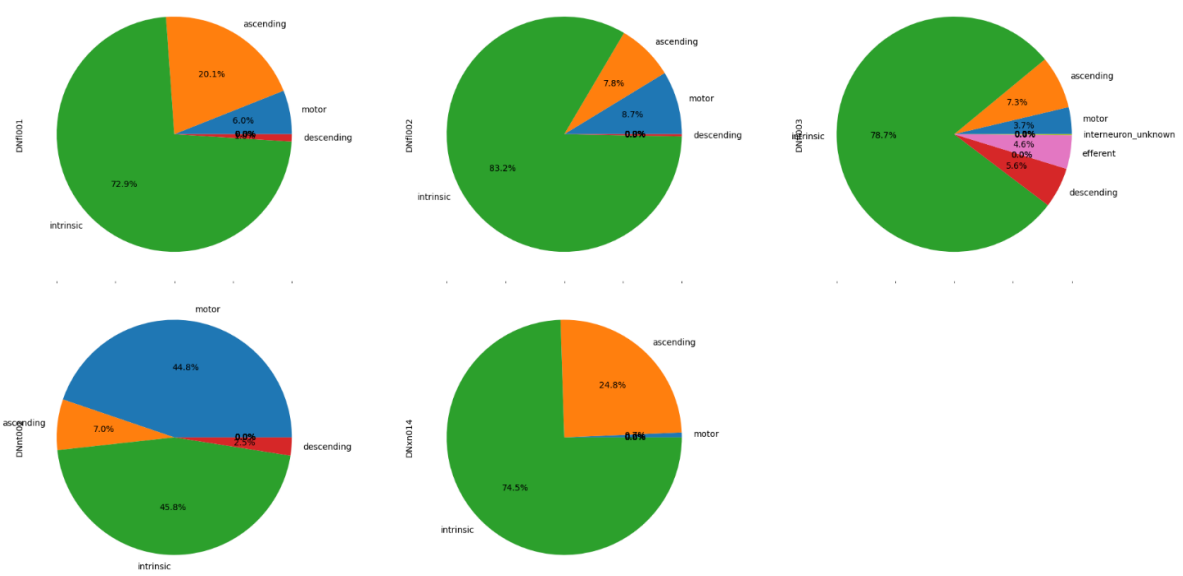


Figure 3.1 Repartition of target neurons class

The neurons type for the particular type of movement displays a lot of different repartitions and it doesn't seem to have a pattern. We can note that this type has little to no connections to descending neurons. **DNfl003** connects to a lot of different class of target neurons, which we haven't seen before. **DNnt002** have a very similar distribution to **DNxn035** (responsible for optomotor response during flight), despite not being responsible for the same type of movement.

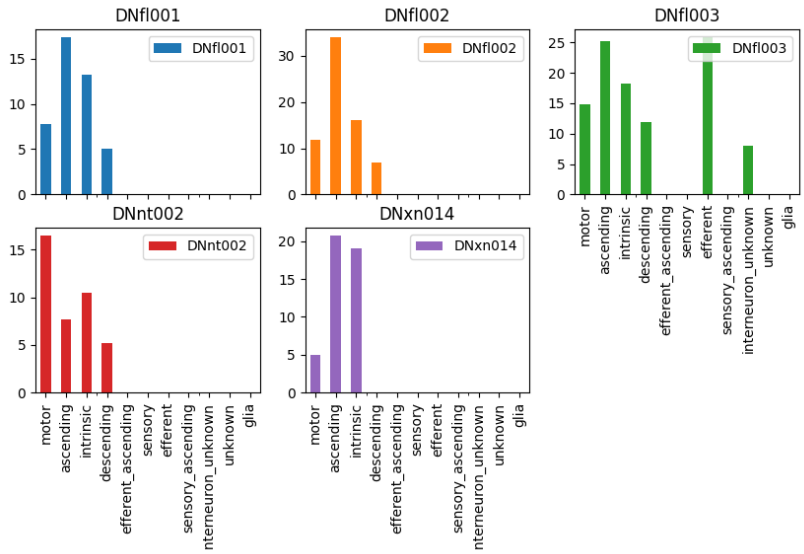


Figure 3.2 Number of synapses per target class (normalized by number of neurons targeted)

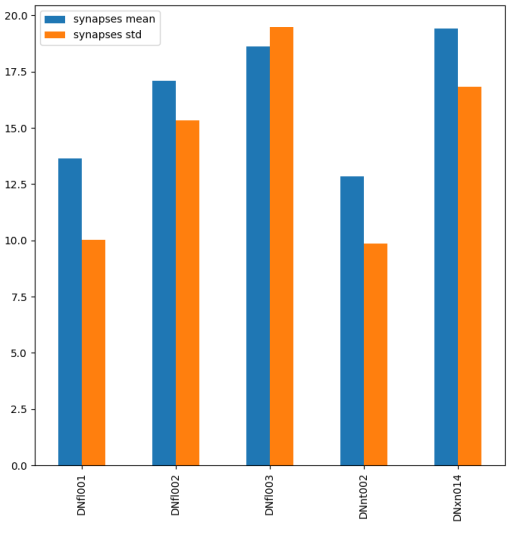


Figure 3.3 average number of synapses and std per neuron

Fig 3.2, Fig 3.3, Fig 3.4: We can't really see a pattern here, most of the values are different to one another.

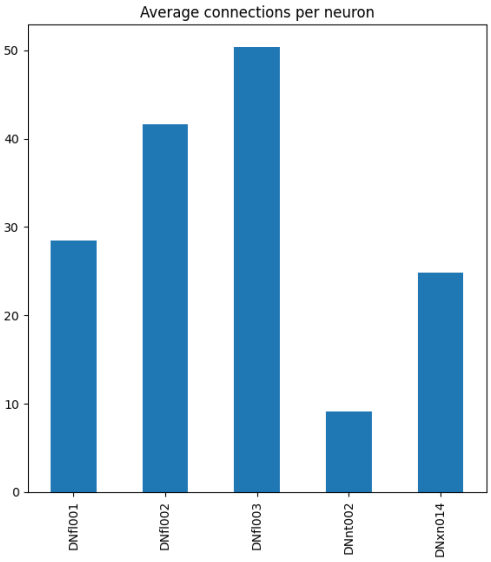


Figure 3.4 Average connections per neuron

Conclusion: compared to the 2 parts, here we don't really see any pattern what so ever. Even for neuron type that came from the same cluster in the brain and a responsible for the same specific phenotype (**DNfl001**, **DNfl002** and **DNfl003**, responsible for ventral head weeps and leg rubbing)

4. Neurons responsible for takeoff

And lastly, we look at neurons responsible for takeoff.

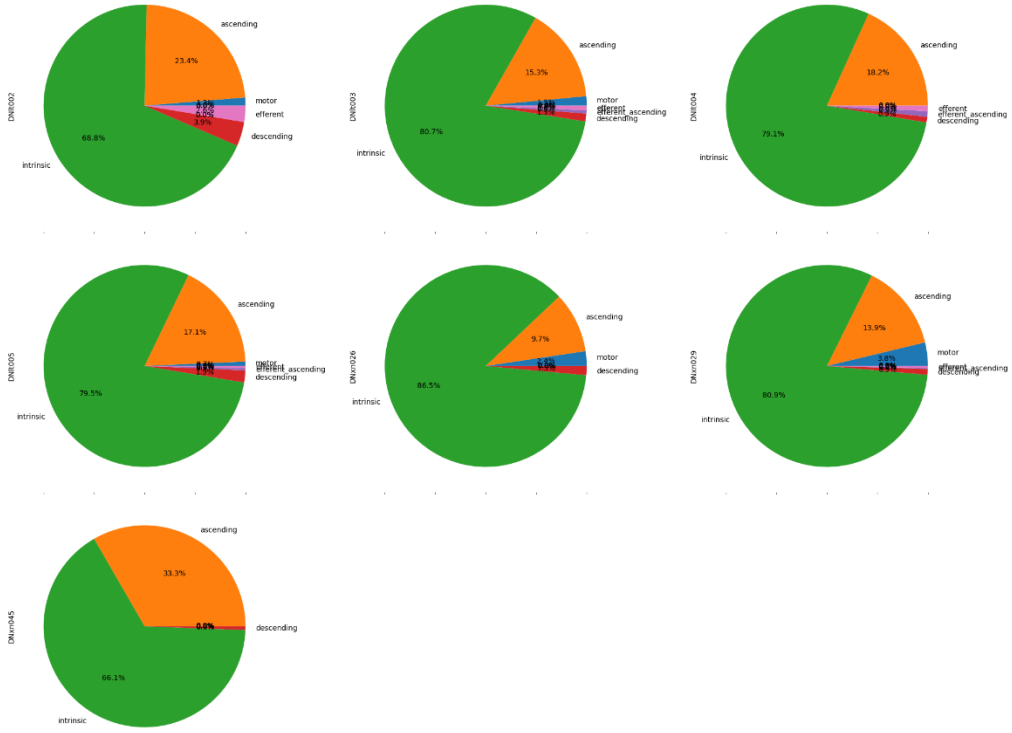


Figure 4.1 Repartition of target neurons class

We can see that except the last one (**DNxn045** (putative role in takeoff), which could explain the difference of repartition), they all seems to have a vaguely similar repartition: majority of intrinsic neurons as target, second most target is ascending, a bit of motor and descending and efferent ascending. For now, this is the class that have the most distinct repartition.

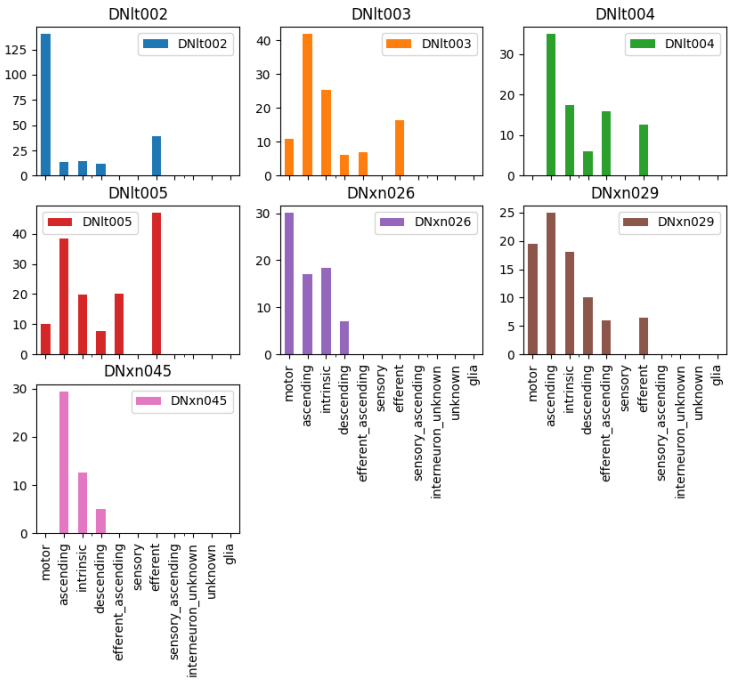


Figure 4.2 Number of synapses per target class (normalized by number of neurons targeted)

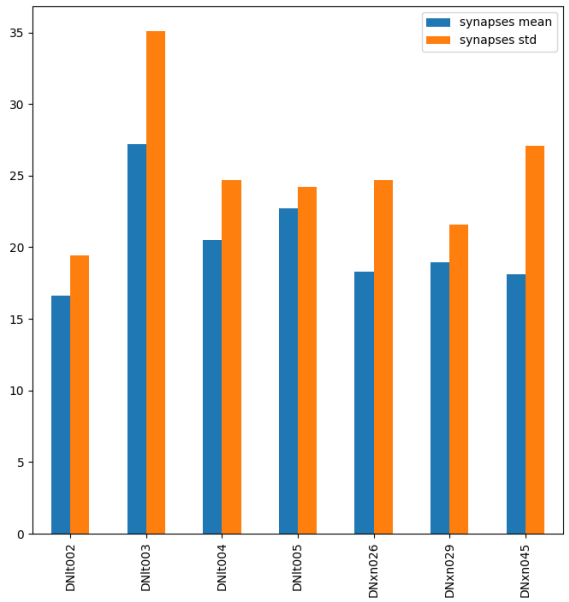


Figure 4.3 average number of synapses and std per neuron

Fig 4.2: Despite having similar repartition their ratio doesn't look similar at all.

Fig 4.3: The second neuron seems to be an outlier, but the rest have all have a similar average of ~20 synapses on average.

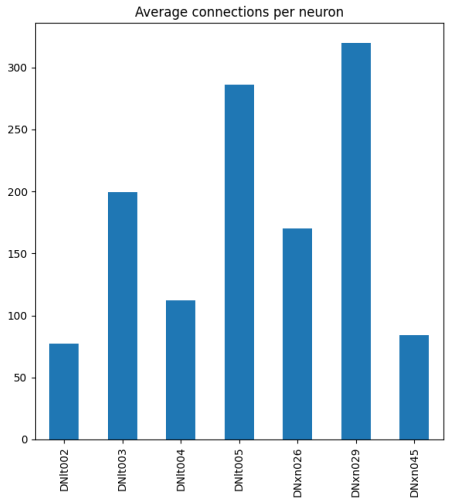


Figure 4.3 average number of synapses and std per neuron

<u>Conclusion:</u> Still no global pattern but the repartition of the target class was really similar except for one, but it is supposedly responsible for takeoff and we are not sure.

5. Conclusion

First, I want to precise why I didn't do more type with the same phenotype, it is because there were too little neurons type for me to try to find a pattern. Even if some part didn't display many different neurons type it was enough to try to find a pattern.

To conclude there is not “*global*” pattern that would allow to tell what is the phenotype of a particular neuron type just by looking at its statistics. Not all neurons type of the same phenotype has the same statistics.
This could be explained as even if the phenotype is the “*same*”, walking forward, turning and walking backward is different from one another, but is classified as walking. In this direction it could be then expected than not all neurons that are responsible for a walking phenotype are similar as they don’t make so similar movement. And that could explain why the similarity are between type of neurons with the same specific phenotype (e.g. backward walking and not just walking).
To continue on this, we noticed similar pattern for walking and flying phenotypes (similar target distribution and same average number of connections for type with the same specific phenotypes), and similar target distribution for takeoff (not really average number of connection), but no pattern for anterior movement. One answer could be that walking and flight movement are more specific (target respectively legs and wings), and anterior movement is more diverse (e.g. leg rubbing and anterior reaching). And takeoff could be similar for all types because it is much more specific than just walking or flying.
It's then probable that the more specific you are on a certain phenotype, the more similar the neurons type will behave.

We can also notice other things: neurons type for walking and takeoff don’t target much motor neurons in comparison to anterior and flight movement. One explanation could be that takeoff and walking both require leg movement specifically. And since the leg is composed of many parts it seems hard to directly connects the descending neurons to all the motor neurons in all part of the leg. And maybe easier/more efficient to target intrinsic neurons that can then “*broadcast*” information.

In addition to that it would have been interesting to look if neuron with the same phenotypes target the same neurons (not just neuron class but more precisely individual neurons). But I haven’t had the time to do this.