# Species can base their impression of themselves on the number of sensory neurons they have and their IUCN level

Aaron Goetz

## Open Research

An excel table was put together to form this data. RStudio was used to get ranks for the different categories of data for pertinence to the article's intended conveyance and interpretation for explanations of validity of using this basis as an effective way of resource management on endangered species.

## Introduction

Humans have the most sensory neurons of any terrestrial species, 18.83B, with more than twice as many as the runner up western gorilla. There are three aquatic species with more than humans and seven more with more than the western gorilla. The killer whale with more than twice as many as humans, long-finned and short-finned pilot whale with a little less than twice humans. With that many sensory neurons it would be assumed that those would be the species with the most emotional disturbance from anthropogenic influence. There is no data on killer whale endangerment, and both long and short finned pilot whales are LC, ranking them 23$^{rd}$ and 24$^{th}$ most disturbed species.

## Methods

Species sensory associated neuron and total neuron quantities from wiki were columnized on an excel. There are 146 species that have their sensory neuron quantities documented on wiki and 110 of those have their total quantities on wiki. A percentage of sensory neurons was then calculated for each of the 110 species that have both. The 146 species were checked on the IUCN for their level. 26 species are without IUCN document so 120 species have both sensory neuron quantities and an IUCN level. For an IUCN level .01 was used for LC, .25 for NT, .5 for VU, .75 for EN and .99 for CR. That percentage multiplied by the quantity of sensory neurons totals a level of IUCN sense for each of the 120 species. Each of the 120 species levels of IUCN sensory use was percentagized comparatively to the species with the most combined sensory neurons and IUCN level. A weighted level of IUCN sense was also calculated for the 110 species that have both sensory and total neuron quantities, only 92 of those with an IUCN level, multiplying the IUCN level and the percentage of sensory neurons to total.

These variables were then put into R as a MLR using $y_i = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \epsilon_{1\text{-}3} \sim$ Normal $(0, \sigma^2)$ to determine the role of each of the columns as variables with the response being the total level of IUCN sense.

y= total.level.of.iucn.sense (sensory associated neurons x iucn level)

sens= sensory.associated.neurons (data on wiki 'List of animals by number of neurons')

tot= total.neurons (data on wiki 'List of animals by number of neurons')

perc= percentage.sens (sens/tot)

iucn= iucn.level (.01 for LC, .25 for NT, .5 for VU, .75 for EN, .99 for CR)

name= name

weightediucn= weighted.level.of.iucn.sense (perc x iucn)

AIC scores were compared for $y_1 \sim \beta sens + \beta perc + \beta iucn$, $y_2 \sim \beta perc + \beta iucn + \beta weightediucn$, $y_3 \sim 1$ (null), $y_4 \sim \beta iucn + \beta sens + \beta weightediucn$, $y_5 \sim \beta weightediucn + \beta tot + \beta iucn$, and $y_6 \sim \beta sens + \beta iucn$.

## Results

The three species with more sensory neurons than humans have not had their total neurons quantified, so humans have the most total neurons of all neural measured species with, 86B total, while the western gorilla has 33.4B and the orangutan 32.6B. Five of the 146 species that have sensory neuron totals are CR with the IUCN an eight are EN. Of the 14 species with the most disturbed ranked, having the most neurons combined with IUCN level, 5 are VU, 6 EN and 3 CR. The species with the most disturbed rank is an EN, the blue whale. After the ninth ranked species the percent of IUCN sense goes less than half of the top ranked species.

| | name | sensory associated neurons | total neurons | percentage sens | iucn level | weighted level of iucn sens | total level of iucn sense | percent of sense |
|---|---|---|---|---|---|---|---|---|
| 2 | Blue whale | 15,000,000,000 | | | 0.75 | | 11250000000 | 1 |
| 3 | Western gorilla | 9,100,000,000 | 33400000000 | 0.27245509 | 0.99 | 0.269730539 | 9009000000 | 0.8008 |
| 4 | Orangutan | 8,300,000,000 | 32600000000 | 0.254601227 | 0.99 | 0.252055215 | 8217000000 | 0.7304 |
| 5 | Fin whale | 15,000,000,000 | | | 0.5 | | 7500000000 | 0.666666667 |
| 6 | Chimpanzee | 7,400,000,000 | 28000000000 | 0.264285714 | 0.75 | 0.198214286 | 5550000000 | 0.493333333 |
| 7 | African elephant | 5,600,000,000 | | | 0.99 | | 5544000000 | 0.4928 |
| 8 | Pygmy chimpanzee or bonobo | 7,250,000,000 | | | 0.75 | | 5437500000 | 0.483333333 |
| 9 | Asian elephant | 6,775,000,000 | 2.57E+11 | 0.026361868 | 0.75 | 0.019771401 | 5081250000 | 0.451666667 |
| 10 | Walrus | 3,929,000,000 | | | 0.5 | | 1964500000 | 0.174622222 |
| 11 | Guenon | 2,500,000,000 | | | 0.75 | | 1875000000 | 0.166666667 |
| 12 | Mandrill | 3,102,000,000 | | | 0.5 | | 1551000000 | 0.137866667 |
| 13 | Hyacinth macaw | 2,944,000,000 | | | 0.5 | | 1472000000 | 0.130844444 |
| 14 | Pigtail Macaque | 2,531,000,000 | | | 0.5 | | 1265500000 | 0.112488889 |
| 15 | Kea | 1,281,000,000 | 2149000000 | 0.596091205 | 0.75 | 0.447068404 | 960750000 | 0.0854 |
| 16 | Horse | 1,200,000,000 | | | 0.75 | | 900000000 | 0.08 |
| 17 | Giraffe | 1,731,000,000 | 10750000000 | 0.161023256 | 0.5 | 0.080511628 | 865500000 | 0.076933333 |
| 18 | Tufted capuchin | 1,140,000,000 | 3691000000 | 0.308859388 | 0.75 | 0.231644541 | 855000000 | 0.076 |
| 19 | Bonnet macaque | 1,660,000,000 | 3780000000 | 0.439153439 | 0.5 | 0.21957672 | 830000000 | 0.073777778 |
| 20 | Grey parrot | 850,000,000 | 1566000000 | 0.542784163 | 0.75 | 0.407088123 | 637500000 | 0.056666667 |
| 21 | Raccoon | 453,000,000 | 2148000000 | 0.210893855 | 0.99 | 0.208784916 | 448470000 | 0.039864 |
| 22 | Crab-eating macaque | 800,960,000 | 3440000000 | 0.232837209 | 0.5 | 0.116418605 | 400480000 | 0.035598222 |
| 23 | Long-finned pilot whale | 37,200,000,000 | | | 0.01 | | 372000000 | 0.033066667 |
| 24 | Short-finned pilot whale | 35,000,000,000 | | | 0.01 | | 350000000 | 0.031111111 |
| 25 | Tarsius | 310,000,000 | | | 0.99 | | 306900000 | 0.02728 |
| 26 | Lion | 545,240,000 | 4667000000 | 0.116828798 | 0.5 | 0.058414399 | 272620000 | 0.024232889 |
| 27 | Risso's dolphin | 18,750,000,000 | | | 0.01 | | 187500000 | 0.016666667 |
| 28 | Goeldi's marmoset | 357,130,000 | 636,000,000 | 0.561525157 | 0.5 | 0.280762579 | 178565000 | 0.015872444 |

Table 1: Top 28 most disturbed species IUCN sense = sensory associated neurons x IUCN level

The results from the AIC scores $y_1$-$y_6$ have $y_4$ (iucn+ sens + weightediucn) with the best covariates, with $y_1$ (sens + perc + iucn) only 45.11795 away. The others are more than 5,000 away. This suggests that combining the iucn and the sens variables are most effective in the 3 variable equations. $y_6$ was added just to test that having the three variables does get a better AIC score than two, even if the two contain the two most pertinent variables, sens + iucn. sens is shown to be the best categorical data contributing to the rankings that measure IUCN and sensory neuron quantities because $y_2$ and $y_5$ are without sens but with iucn and have AIC scores similar to the null, $y_3$, and the two-variable equation, $y_6$. Avoiding combining sens and tot is imperative, because those are already directly used to form the other categories. Implications that $y_4$ has the best AIC score compared to $y_1$ suggests that sens is most pertinent, iucn second, weightediucn third, and perc a close fourth variable category in putting the rankings together of most imperative species to protect, given sensory neurons have been quantified.

$y_i = \beta_0 + \beta_1 + \beta_2 + \beta_3 + \epsilon_{1\text{-}3} \sim$ Normal $(0, \sigma^2)$

$y_4 \sim 11{,}180{,}000 + 17{,}000{,}000_{iucn} + \beta_{sens\ 1\text{-}79} + .000104_{weightediucn} + 6.94x10^{-13}$ $(\sigma^2 = .0000008334^2 = \epsilon y_4)$

95 % Confidence intervals

y intercept = 11,180,000 + 2(.000001664) = 11,180,000.000003328 = upper bound

11,180,000 - 2(.000001664) = 11,179,000.999996672 = lower bound

iucn = 17,000,000 + 2(.00007943) = 17,000,000.00015886 = upper bound

17,000,000 - 2(.00007943) = 16,999,999.99984114 = lower bound

sens = 1-79 estimates + 2(1-79 std. error)

1-79 estimates - 2(1-79 std. error)

weightediucn = .000104 + 2(.0004177) = .0009394 = upper bound

. 000104 - 2(.0004177) = - .0007314 = lower bound

weightediucn is only sort of sure that the slope is going in the right direction. It is only useful to get the confidence interval of that variable, as third ranked, to compare it to fourth ranked perc, because $y_1$ AIC is only 45.11795 away from $y_4$.

Discussion

It is important for us to consider what the species means to them in evaluating what species we should care about, it would be beneficial to base that on what species care about themselves the most. Using resources to protect species just because they are CR on the IUCN doesn't necessarily make the most sense because a species with less sensory neurons is not necessarily understanding as much as one with more neurons.

## Data Accessibility

Dryad dataset
https://datadryad.org/stash/share/cqlVNCyXwwEsU1bhQYryYXUWBQ3Got2FnQoJVvUR0Kc

198

199

200 Reference

201 https://en.wikipedia.org/wiki/List_of_animals_by_number_of_neurons. 10/18/21.