IDC School of Design
अभिकल्प विद्यालय

# Science Visualisation: Emotion and Affective Disorders

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# Approval

The BDes Design Project - 2 titled “Science Visualisation: Emotion and Affective Disorders” by Prita Raut is approved, in partial fulfilment of the Bachelor in Design Degree at IDC School of Design, Indian Institute of Technology Bombay.

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| Project Guide | Chairperson |
| Internal Examiner | External Examiner |

# Declaration

I declare that this written document represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and provided reference to the original sources.

I also declare that I have adhered to all the principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea or data or fact or source in my submission.

I understand that any violation of the above will call for disciplinary action by the institute and can also evoke penal action from the sources which have not been properly cited or from whom proper permission has not been taken when needed.

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# Acknowledgements

I would like to thank my project guide Prof Venkatesh Rajamanickam for providing guidance and support throughout the course of the project.

I also thank Prof Vivek Kant and Prof Swati Pal for their valuable feedback at each stage.

# Contents

# Abstract

Affective neuroscience is an interdisciplinary field involving neuroscience and psychology. This project aims to design a data visualization to simplify and present some of the research findings in the field of affective neuroscience related to similarities in animals and humans, behavior and basis in neuroanatomy and affective disorders in an attempt to explain the scientific reasoning behind them to the general audience through a web based interactive infographic.

# Introduction

## Affective Neuroscience

Affective science is an interdisciplinary field that involves neuroscience, psychology, behavioral sciences, biology etc. that scientifically study various aspects of human and non-human emotions or the affective systems including emotion processing, emotion regulation, mood disorders, etc.

Studying this helps in understanding our brain connectivity and interdependencies which is relevant for producing biologically based treatments for psychiatric and affective disorders.

## Data Visualisation

Data visualization involves using graphical methods for representing data which helps in identifying trends and patterns which can bring forward new findings by means of analysis of data.

Data visualization can also be used as a means to present certain information to an audience. Information visualization is used for explaining a concept or idea. Information is carefully selected and visually presented in order to communicate the intended insight in an easy to understand way.

The process of data visualization involves acquiring an appropriate dataset, setting the purpose, cleaning, processing and structuring the data to derive insights or information and designing the visuals to convey the information in a relevant manner for proper comprehension without misinterpretation.

The complexity or level of simplification of data depends on the intent and audience of the visualization. For researchers, if data is oversimplified, they might lose out on some important understanding whereas in case of explaining the concept to the general audience complexity might create hindrances for comprehension or the level of detail might not be required for that audience and purpose.

## Data Visualisation in Affective Neuroscience

Emotion is a subjective phenomenon. Each field has its own methods of studying it. In psychology, the use of self-reporting by questionnaires, interviews has been widely adopted by researchers. However the reliability of this method is poor as it is often entirely subjective to how the individual is feeling at the time.

In neuroscience neuronal activity is recorded using fMRI and EEG. Along with that physiological measures of facial expressions, skin conductance, muscle tension and hormone secretion are also used depending on the nature of the study.

Data visualization is widely used in affective neuroscience to come up with new findings by means of analysis and synthesis of large amounts of data. Data is collected based on various hypotheses according to previous research or already available data is acquired and relevant comparisons are made. Information visualisation is also widely used to explain concepts like anatomical correlations.

## Different types of Visualisations in Affective Neuroscience

Visualizations can be classified on the basis of a number of parameters like purpose, audience, data transformation and form, etc. Data visualizations can be exploratory, explanatory or both.

Visualisations in affective science involve a wide range from illustrations to complex network diagrams. Following are some of the examples.

### 1. Anatomy based Visualisations and Illustrations

These visualisations are focused on brain anatomy and give different information about the parts of the brain. The main objective is understanding neurobiology

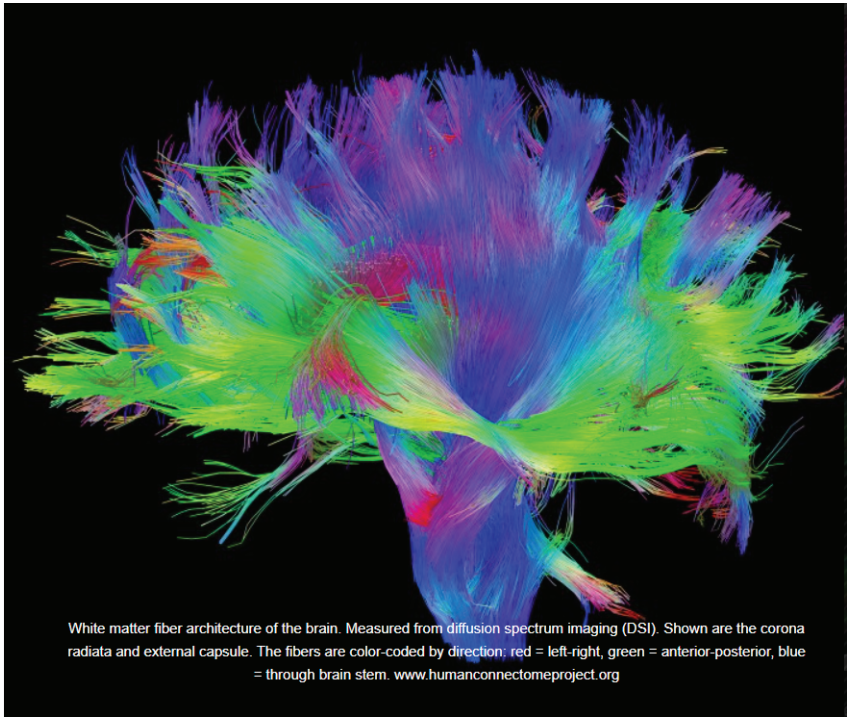



Fig 1 : The Human Connectome Project, youtu.be/aLxR9vOhVaw

Fig 1 shows a visualisation of connectome of white matter fibres architecture where direction is colour coded.


Fig 2 : Self Reflected, www.fi.edu/selfreflected

The above illustration was created by neuroscientists and artists Greg Dunn and Brian Edwards which depicts a slice of the human brain with more than 5,00,000 individual neurons.

Certain parts are tweaked and are designed in a way to give the audience a sense of what the brain would look like without overwhelming them by depicting the actual number of neurons present.

## 2. Data Visualisations

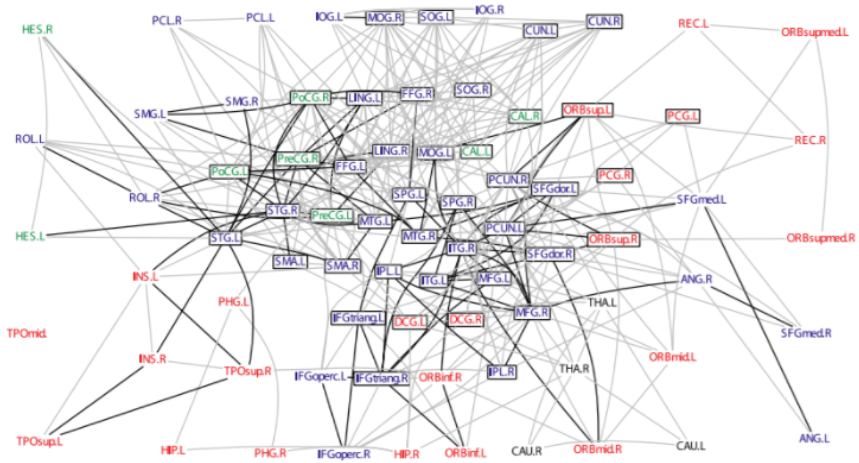



Fig 3: Topological map of a small-world human brain functional network created by thresholding thescale 4 wavelet correlation matrix representing functional connectivity in the frequency interval 0.03– 0.06 Hz, doi.org/10.1523/JNEUROSCI.3874-05.2006

The above example shows a visualisation of one of the networks in the brain. The relative distance between any two points and their relations is represented in 2D space.

In this the focus is on the functional relevance of the brain connections rather than the anatomical relevance. It is an abstracted form and anatomical information is filtered out.

Fig 4 : Neural Connectivity, davidjuliancald-well.github.io/Affinity/-main.html

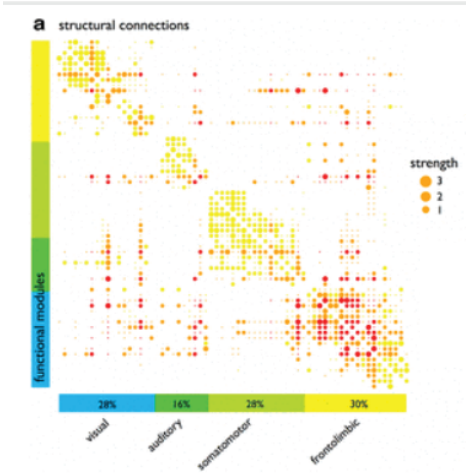



Fig 5: Connectivity matrix of the cat connectome, doi.org/10.1523/JNEU-ROSCI.1448-13.2013

Fig 4 and 5 are examples of data visualisations of a human and cat connectome respectively. These are even more focused towards functional aspects as compared to the previous example as spatial information is filtered out and visualisation only communicates functional relations of different regions.

In this project I will be focusing on explaining research findings rather than giving anatomically relevant information.

# Objective

The objective of this information and data visualisation project is to make research in the field of affective sciences accessible to the general public by simplifying and presenting it in a light and easy to understand manner.

Apart from the basic level information, the other information is mostly available in the form of research papers which involves a lot of jargon used by experts in the scientific community which is difficult for the common people to understand.

The final outcome is a web-based interactive infographic based on the science of emotion and affective disorders which involves not just conceptual data but also provides insights and reasoning based on quantitative data which the audience can see and interact with by themselves.

When some people were asked about what they think are causes of affective or mood disorders like depression, the most common answer was stressful life situations. However, there are other other factors like genes and substance abuse that can contribute to this. To make people aware of this and other similar things is also a secondary aim of the project.

# Scope

- To present already known facts and insights, explanations of and how's and does not involve exploring the data to come up with new findings through the available data in manner which makes it easy to comprehend

- Focusing on communicating reasoning rather than anatomical information. Not focused on explaining biology of emotion and anatomical visualisations.

- Does not allow the audience to have full control on the entire dataset but only enough to get the insight

# Target Audience

The infographic is meant for anyone who is interested in the fields of psychology and neuroscience but doesn't have expert level knowledge in the field. There is no specific age group requirement however there are some prerequisites in terms of prior knowledge.

**Level of Literacy**
Audience must have primary level education and should understand English language. Having basic knowledge of brain parts and nervous system, reflex action, etc is good but not necessary to understand the infographic. The audience should know how to use a computer and browse websites to be able to interact.

**Level of domain expertise**
The visualisation is meant for the general audience who may have little to no knowledge of the field, so audience is expected to be novice in the domain.

**Level of interest in the field**
The audience may have moderate interest in the field. the infographic starts with basic information and explains each idea to spark curiosity in novice audience which do not know much about the field and is not inclined towards exploratory visualisations.

# Background Study

In the initial part of the project I started off with a very broad scope i.e affective neuroscience. I went through biology textbooks for class 10 and psychology textbooks for class 11th and 12th to understand what is included in the curriculum at these levels.

Relevant parts of the book Affective Neuroscience: Foundations of human and  animal emotions by Jaak Panksepp was read which tells about primal emotions, instincts and motivations which is the evolutionary perspective. One part of it also has information on neurodynamics.

Along with that recent research papers were read to get a better understanding of the field for both human and non-human systems and know about the latest research. Cross species studies which attempt to find similarities and differences between animals and human behavior were also looked at.

Some papers in psychology based on affective disorders and personality involving statistical studies were also looked at.

Some of the excerpts from research referred are as follows:

**Affective Neuroscience : the Foundations of Animal and Human Emotions**

“The use of carefully chosen animal models in exploring the underlying brain processes is essential for making substantive progress. Even with recent advances in functional brain imaging and clinical psychopharmacology, the human brain cannot be ethically studied in sufficient detail to allow the level of analysis needed to understand how emotional systems actually operate.”

“Since we cannot directly measure the internal experiences of others, whether animal or human, the study of emotional states must be indirect and based on empirically guided theoretical inferences. Because of such difficulties, there are presently no direct metrics by which we can unambiguously quantify changes in emotional states in any living creature. All objective bodily measures, from facial expressions to autonomic changes, are only vague approximations of the underlying neural dynamics.”

**Comparative expression of hedonic impact: affective reactions to taste by human infants and other primates**

ttps://doi.org/10.1016/S0149-7634(00)00051-8

”The taste of sucrose elicited homologous positive hedonic patterns of facial affective reactions from humans and other primates, whereas quinine elicited homologous aversive or negative affective patterns. The degree of similarity between

human and other primate affective reaction patterns appeared to be strongly indicative of their phylogenetic relatedness. These results show that both positive/negative valence and intensity of affective reaction may be quantitatively assessed in human and non-human primates, and indicate that taste-elicited affective reaction patterns of human infants are related systematically to those of other primate species."

**Significant Neuroanatomical Variation Among Domestic Dog Breeds**

"Neuroanatomical variation is plainly visible across breeds. This variation is distributed nonrandomly across the brain. A whole-brain, data-driven independent components analysis established that specific regional subnetworks covary significantly with each other. Variation in these networks is not simply the result of variation in total brain size, total body size, or skull shape. Furthermore, the anatomy of these networks correlates significantly with different behavioral specialization(s) such as sight hunting, scent hunting, guarding, and companionship. Importantly, a phylogenetic analysis revealed that most change has occurred in the terminal branches of the dog phylogenetic tree, indicating strong, recent selection in individual breeds. Together, these results establish that brain anatomy varies significantly in dogs, likely due to human-applied selection for behavior."

**Overview of the Genetics of Major Depressive Disorder**

doi: 10.1007/s11920-010-0150-6

"Major depressive disorder (MDD) is a common psychiatric illness with high levels of morbidity and mortality. It is estimated that 10% to 15% of the general population will experience clinical depression during their lifetime [1], and 5% of men and 9% of women will experience a depressive disorder in a given year, according to the World Health Organization [2]. Genetic factors play important roles in the development of MDD, as indicated by family, twin, and adoption studies. Twin studies suggest a heritability of 40% to 50%, and family studies indicate a twofold to threefold increase in lifetime risk of developing MDD among first-degree relatives. This degree of familial aggregation, coupled with the high heritability from twin studies, generated optimism that molecular genetic techniques would reveal genes of substantial influence on MDD risk. Unfortunately, gene localization and identification has been a slow, labor-intensive process. Genetic investigators have encountered similar frustrations with other common complex traits"

**Psychiatric disorders in the biological and adoptive families of adopted individuals with affective disorders**

DOI: 10.1001/archpsyc.1986.01800100013003

"Analysis of the data showed an eightfold increase in unipolar depression among the biological relatives of the index cases and a 15-fold increase in suicide among the biological relatives

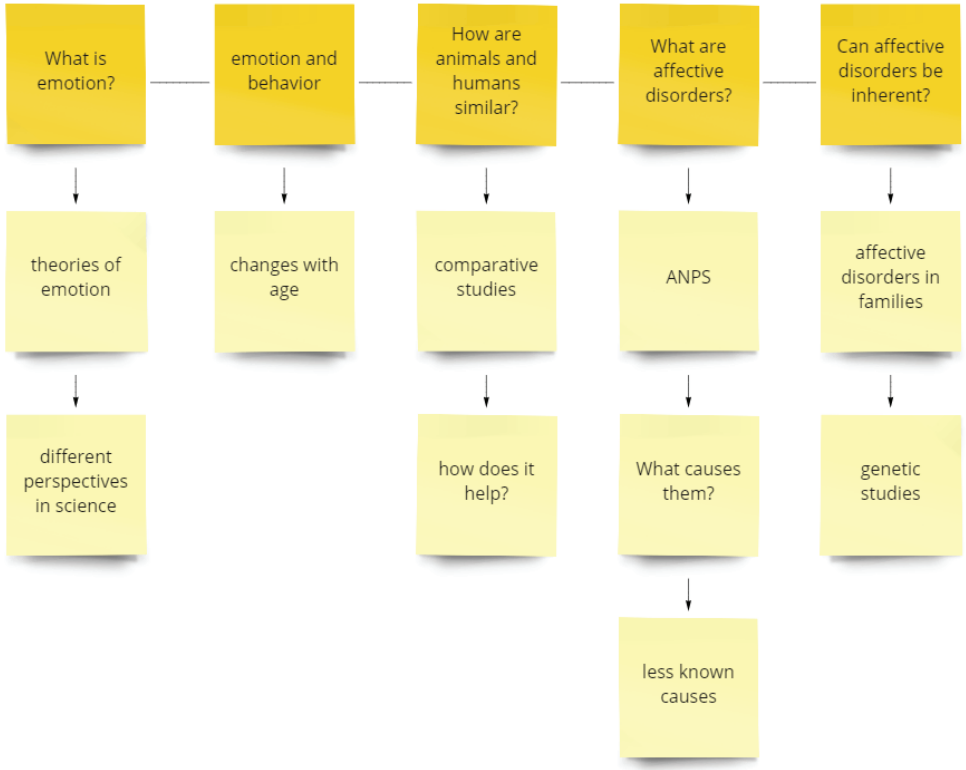
of the index cases. These data demonstrate a significant genetic contribution to unipolar depression and suicide. They fail to disclose a significant contribution of family-associated transmission in the genesis of the mood disorders."

The topics that I read about could be categorized into broad groups which gave me ideas about narrowing down the scope of my project further.

**Project Directions**

# Content

Based on the subtopics that emerged from the background study and secondary research, I narrowed down the scope of my project topic to creating an infographic based on a series of research papers revolving around basic affective systems, correlation of animals and humans, behavior and affective disorders.



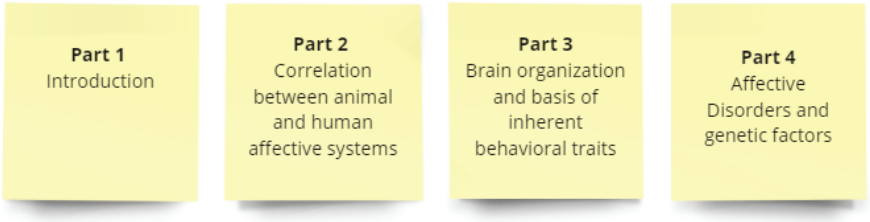

I wrote down some questions to guide myself to select the content and accordingly create the structure of the narrative

# Infographic Structure

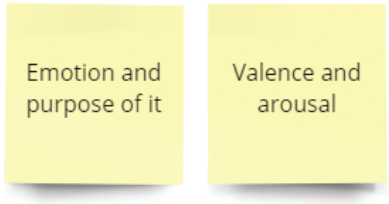
The final outcome is a web based infographic which will have a combination of information design and data visualization. It follows a linear structure. The content is conceptual as well as data driven.

The infographic is divided into four parts which are further divided into smaller chunks of information so that the target audience which is new to this field can understand the moderately complex information in a stepwise manner.

The following are the contents of each part:



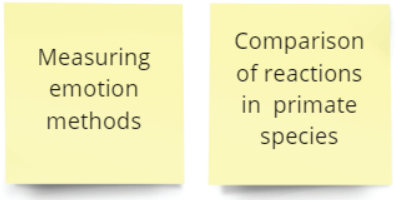

## Part 1 : Introduction




The infographic will begin with the introduction part which will prepare the audience for the topic and anyone who doesn't have prior knowledge will get the necessary background information at this stage about what emotions are, what is their purpose and what is the use of studying emotion scientifically.

This will be followed by  the concept of valence and arousal. This information is taken from the NCERT psychology textbook for class 11 and the book Affective Neuroscience : Foundation of animal and human emotions. This will be a conceptual part and visualization type will be idea illustration.

## Part 2 : Similarities in Animal and Human Affective Systems

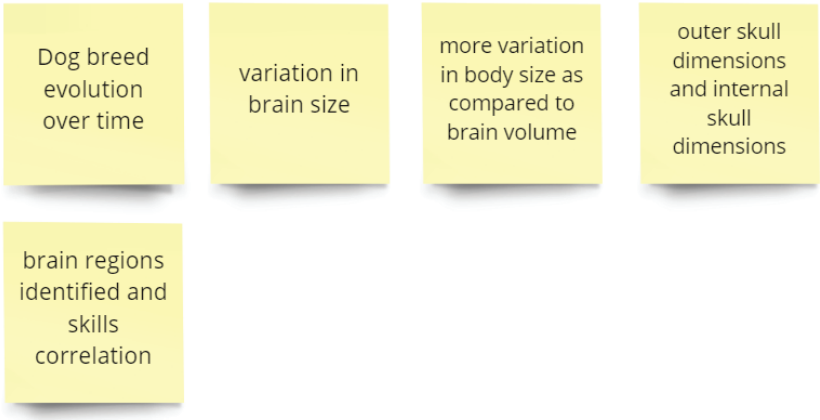



The second part will be about the similarities between affective systems of humans and non-human animals. In this the insight will be that the affective systems and animals and which have varied levels of brain development do have similarities in basic level affective systems.

This will tell that the primary level systems work in similar ways. It will have basic information about why measuring feelings directly is not possible and the different ways used to measure emotion.

This is followed by a comparative perspective between emotional responses of animals and humans. The data for this will be of the research analysing affective reactions of human infants and newborns of other primates like chimpanzees, orangutans, etc which don't have much experience in the world and so have comparatively less acquired(learned) information, in response to gustatory stimulus. The visualizations in this part would be idea illustration and visual confirmation

## Part 3 : Inherent Behavior and brain organisation

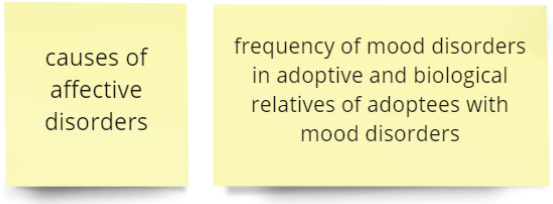



The third section will be about inherent behavioral qualities and its basis in brain organisation which studies where natural skills do have an effect in the actual structure of the brain.

Different breeds of dogs which have been intentionally bred by man to have varying specializations in behavior like some dogs are specialised in hunting while some are exclusively house dogs and provide companionship are compared in this study. Various comparisons are made between the body mass, brain volume, head shape, etc

Animal study is extensively used in neuroscience as it greatly helps in understanding basic level brain structures even in humans because of common primary level systems.

## Part 4 : Affective Disorder




The final part is about affective disorders which talks about how some people can have an inherent tendency to develop certain affective disorders based on history of affective disorders in their family. It tells what affective disorders are, the possible causes and then investigates the role of genes in passing down of affective disorders in the family.

For this the research where a comparison was done between the frequency of affective disorders in the biological and adoptive relatives of adult adoptees having affective disorder and those not having affective disorder. It attempts to investigate the role of environmental versus biological factors i.e. genes in occurence of affective disorder in an individual

# Datasets

The data used is based on research in the fields of psychology and neuroscience.

1. Basics of emotion
   **Data -** Purpose of emotion in animals and role in survival and evolution
   **Source -** Affective Neuroscience : Foundation of Animal and Human Emotion, Book by Jaak Panksepp

2. Valence and Arousal
   **Data -** What is valence and arousal
   **Source -** NCERT textbook

2. Similarities between humans and animals
   **Data -** Comparison of affective reactions in response to gustatory stimuli in infants of different primate species
   **Source -** www.sciencedirect.com/science/article/pii/S0149763400000518

3. Inherent Behavioral traits and Brain Organisation
   **Data -** Neuroanatomical data of dog breeds of different behavioral traits
   **Source -** https://www.jneurosci.org/con

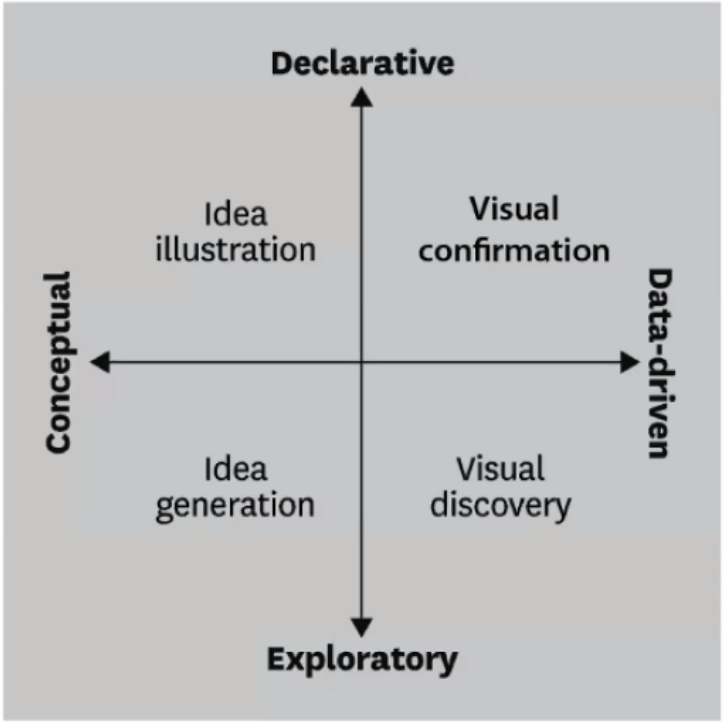
4. Affective Disorders
   **Data -** Comparison of frequency of affective disorders in biological and adoptive relatives of adult adoprees with and without affective disorders
   **Source -** pubmed.ncbi.nlm.nih.gov/3753159/

# Visualisation Type

**Data type - Conceptual + Quantitative**
The content includes concepts and supporting quantitative data

**Visualisation type - Idea Illustration + Visual Confirmation**
The aim of the infographic is to explain certain concepts or facts. Visualisations are desiged accordingly which will highlight the information to be communicated. The visualisations are not inclined towards exploration of data but highlighting what is already known.

The infographic is supported by simple interactions which enable easier and better comparisons.




Scott Berinato, HBR, June 2016

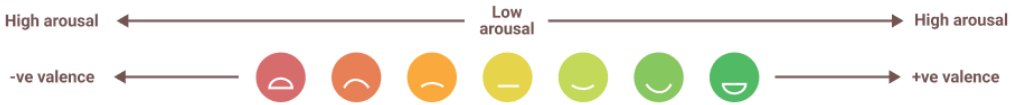
# Ideation

The research papers or content in each part is further broken down into smaller chunks of information in order to make it easy to follow. Each concept is supported by relevant data visualisation or idea illustration.

## Valence and Arousal / Ideation 1


For representing positive and negative valence, red-orange-yellow-green gradient scale is used small to large size of text represents and high or low arousal

## Valence and Arousal / Ideation 2



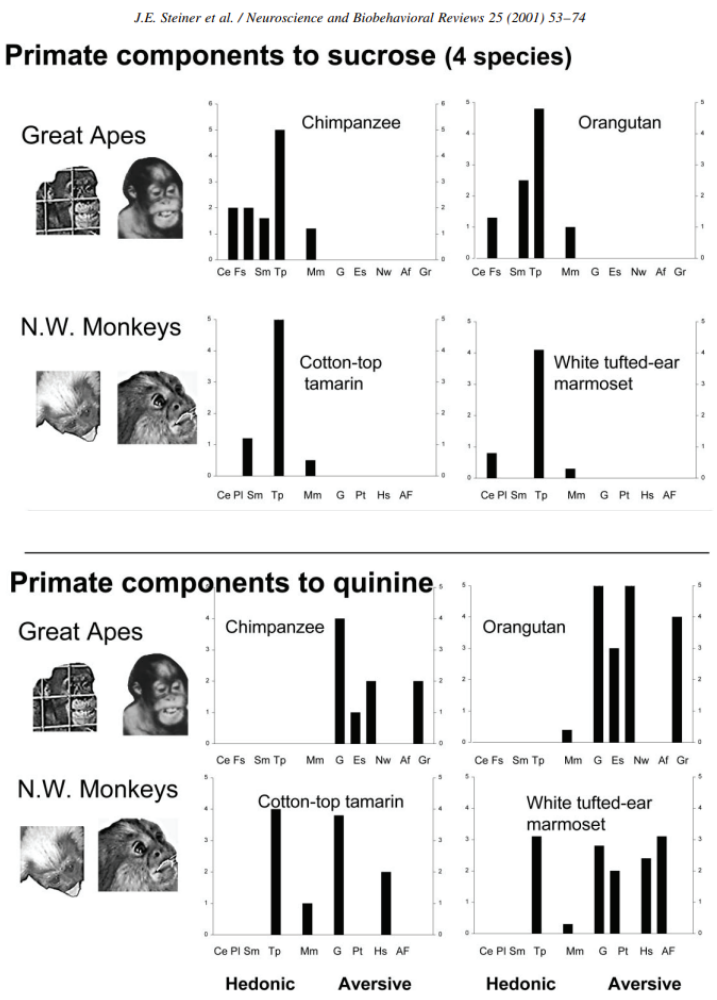

In this idea, the colour scale of red-orange-yellow-green which is associated with scale of negative to positive is used to represent positive and negative valence whereas the increasing smile and frown represents arousal. On hovering over the circles, audience can see which emotions are associated with each.

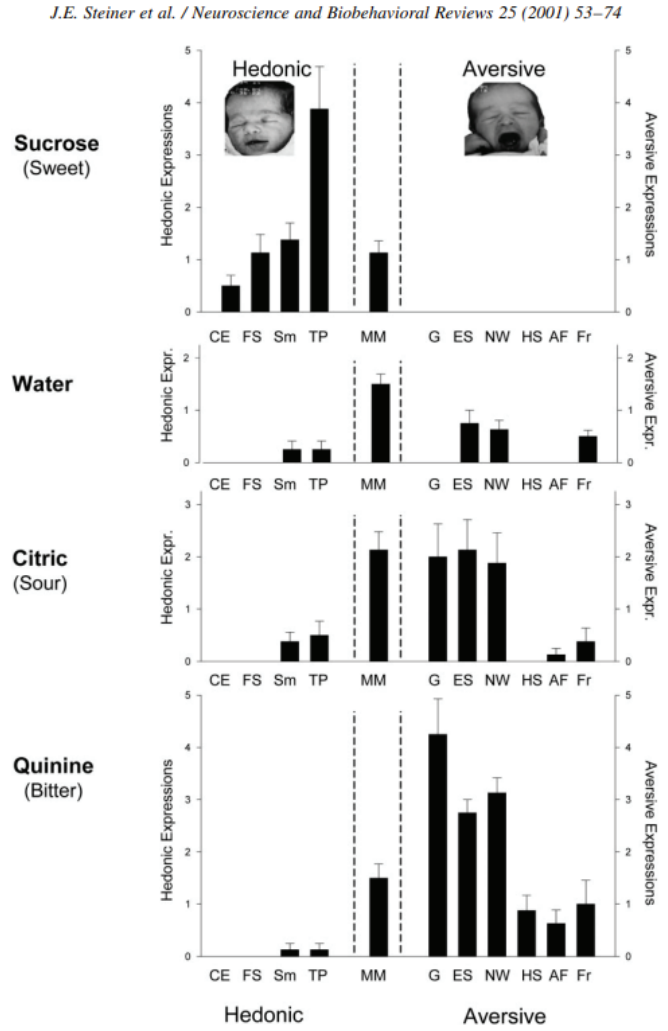
This was selected because it explains the concept through the visual as well as informs the category of different emotions as opposed to ideation 1 which informs the audience about the valence and arousal associated with different emotions but only explains the concept through text and not visually.

# Comparison of affective reactions in response to gustatory stimuli in different primates

In the original visualisation, reactions are grouped according to the primate species. However, here the purpose is to compare the different reactions between species so this type of grouping is not helpful.

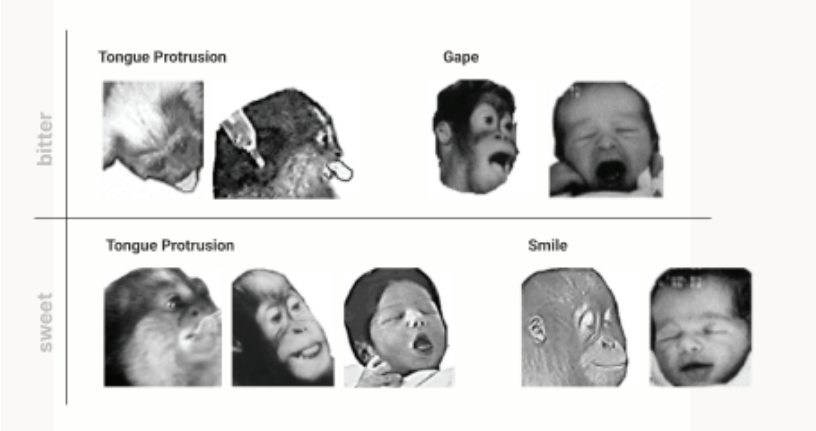
So even though data is represented visually, it doesn't allow for easy comparison between species.

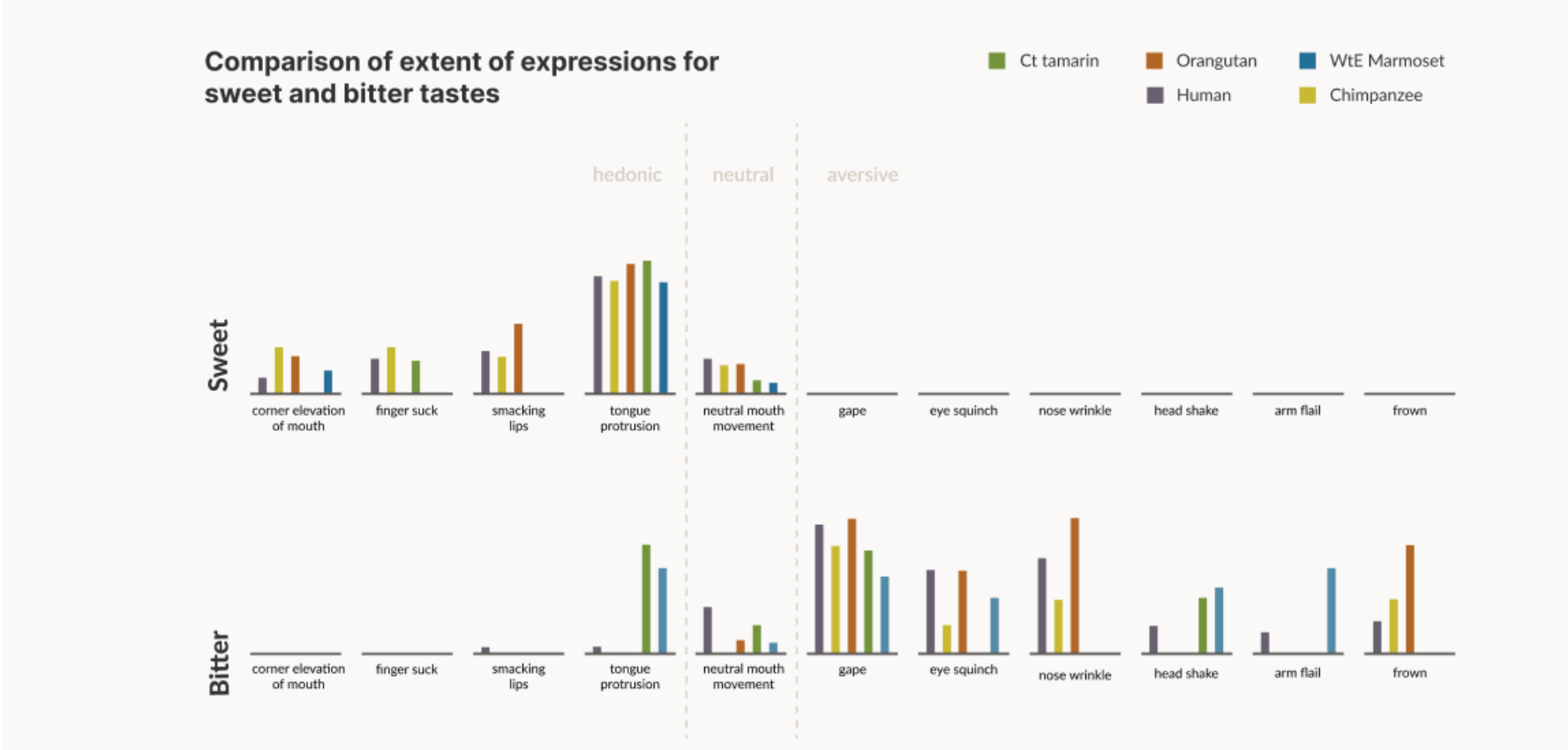


In the redesigned visualisation, sweet and bitter stimuli are divided by space, and placed next to each other for easier comparison of reactions for both the stimuli. Instead of grouping all reactions of one species together, reaction levels of different species for a particular reaction are grouped together.

Hovering over the individual species highlights all reactions specific to that species

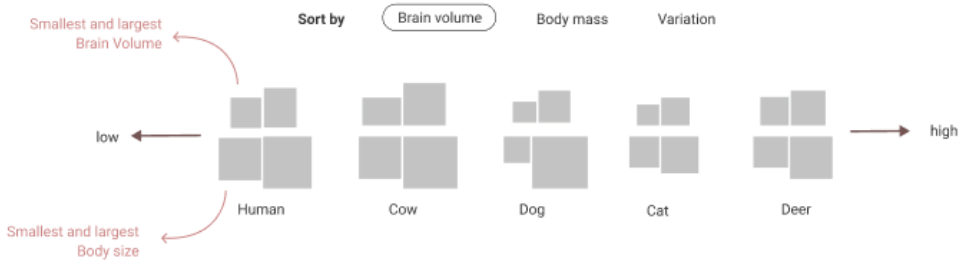


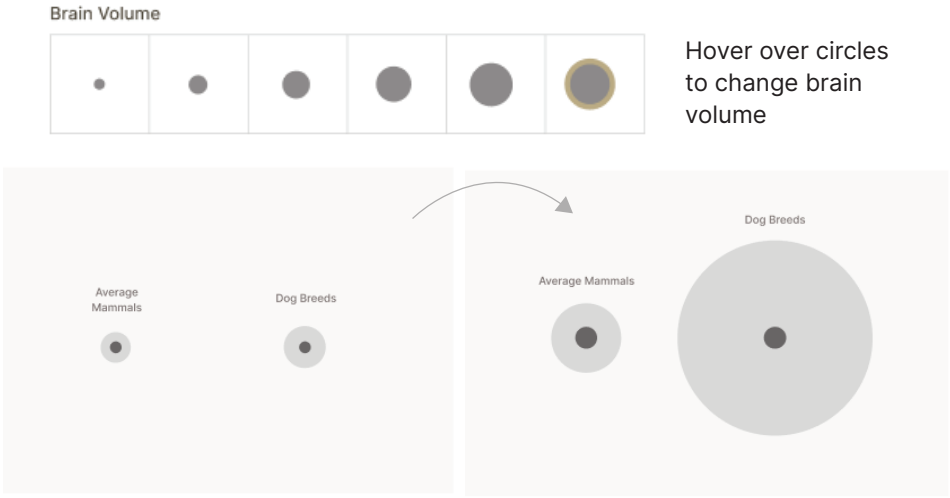
## Variation in Body Mass relative to variation in brain volume / Ideation 1

Variation in brain volume and variation in body size has to be compared in this visualisation. In this the top two squares represent smallest and largest brain volume of the given species and the bottom two squares represent smallest and largest body mass for the given species to compare the variation between them and speculate the relation between both the variations whether they are proportionate or not. Species can be sorted according to increasing body mass, volume and variation.

The problem with this is that visually the variation in dogs as compared to other mammals is not clearly evident in this type of a visualisation and it relies on the sorting options to inform which is the species with high variation.

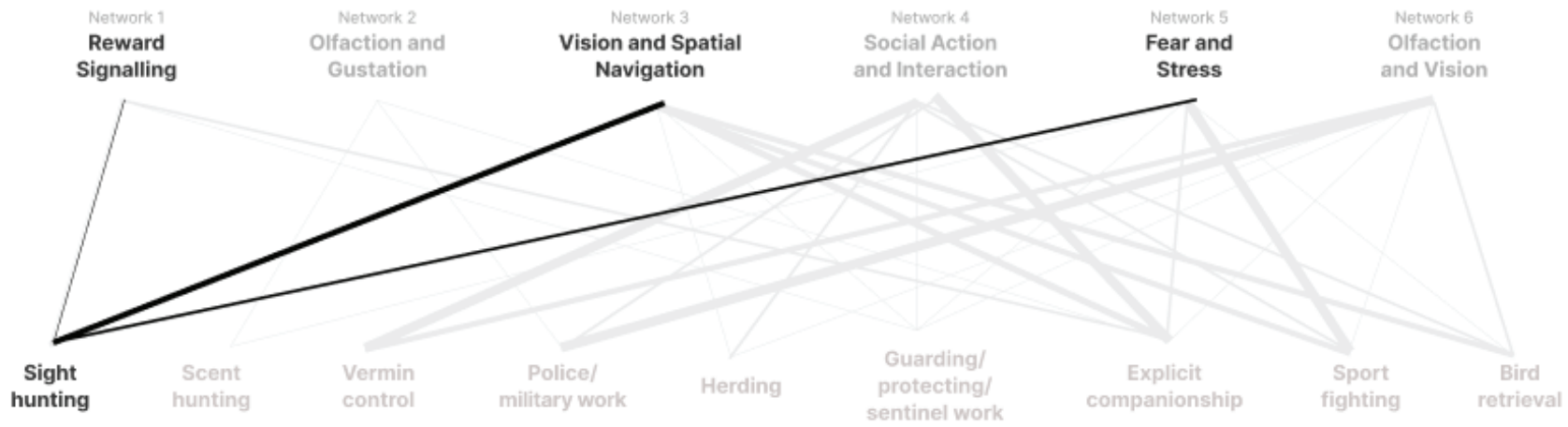



## Variation in Body Mass relative to variation in brain volume / Ideation 2




In this the group of circles on the right show scaling in body mass and brain volume of dog breeds and the one of left show average scaling in body mass and brain volume of mammals. The purpose of this visualisation is to show how there is more variation in body mass of dogs than the brain volume as compared to other mammals. By hovering over the different brain volumes, one can see how the body mass scales differently for both groups.

## Correlation of networks and specialised skills of dog breeds



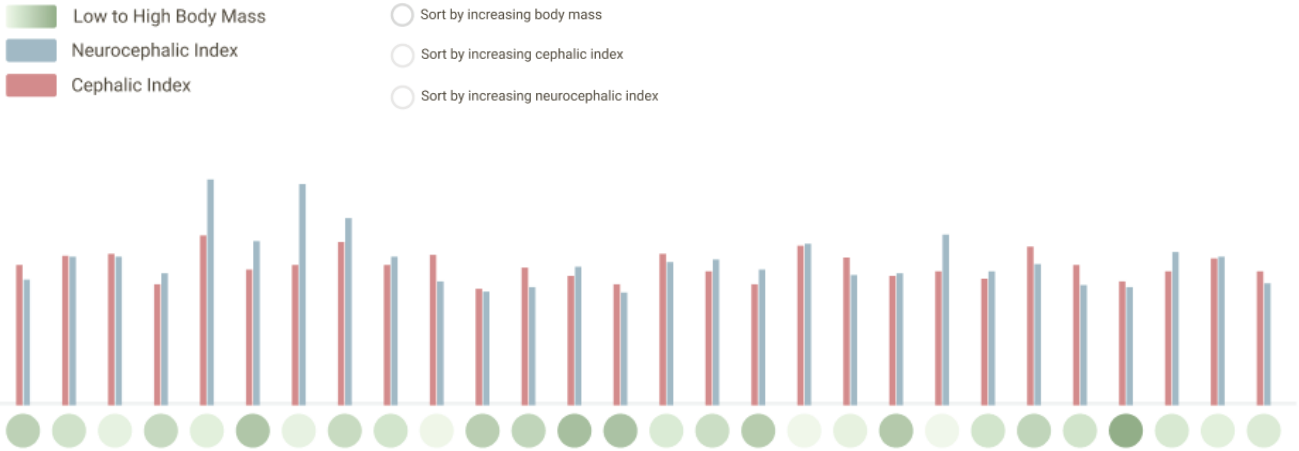

In this, correlations between different networks in the brain and skills of different dog breeds is shown. Hovering on a skill will show the networks it is associated with and vice versa.

The strength of the correlation is represented by thickness of line connecting it.

## Comparison of  Neurocephalic Index, Cephalic Index,and Body Mass

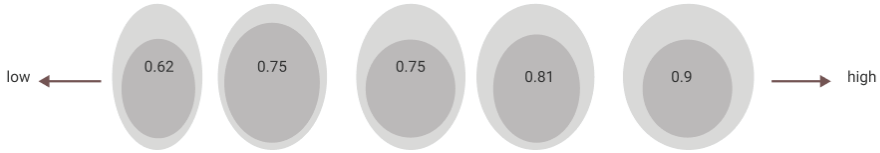
### Ideation 1

In this bar diagram is used to compare cephalic index and neurocephalic index. The intended pattern is visible here. Low to high body mass is represented using light to dark colour gradient scale. Data can be sorted according to increasing body mass, cephalic index or neurocephalic index.




## Comparison of Neurocephalic Index, Cephalic Index and Body Mass

### Ideation 2

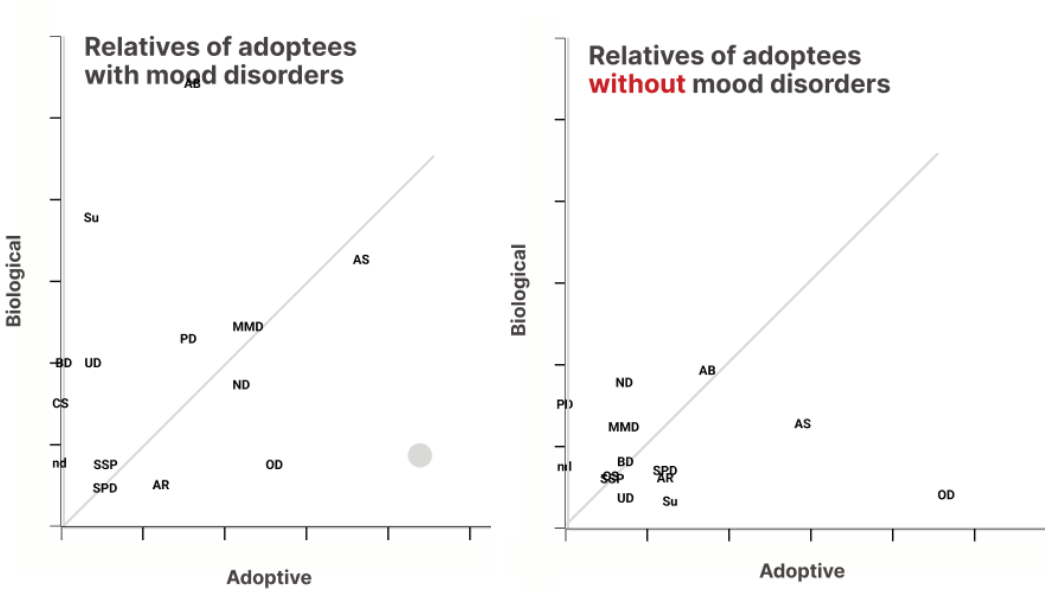


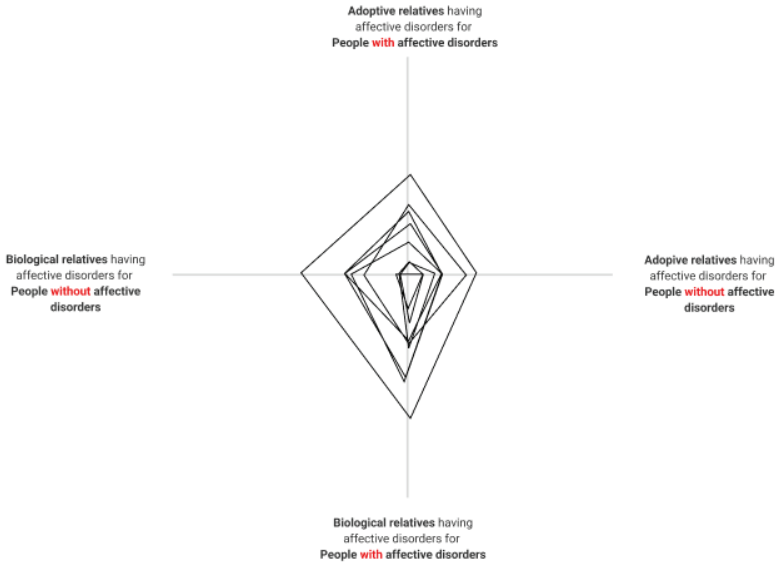

In this cephalic index is represented by the outer circle and neurocephalic index is represented by the inner circle. In this visualisation cephalic index and neurocephalic index has to be compared. This visualisation explains the indices but doesn't help in establishing the findings of the research.

## More biological relatives with affective disorder

The different disorders identified in both the sets of relatives for both adoptees with disorders and adoptees without disorders are plotted here with x-axis representing number of adoptive relatives and y-axis representing biological relatives.

It is seen that for adoptees having affective disorders, the distribution is scattered vertically and comparatively towards lhs of the graph which shows more number of biological relatives having affective disorders, whereas in the second diagram the disorders are scattered more horizontally which shows less number of biological relatives having affective disorder in the adoptees not having mood disorder.




The four lines represent the four kinds of relatives in the study. The intent behind using radar chart in this was to show the more number of biological relatives but in this type of visualisation it is not significantly evident.

# Evaluation

Evaluation was performed with 4 target users online individually over zoom calls. The participants were in the range of 22-26 years of age and belonged to metro cities. 3 out of 4 participants hadmoderate interest in affective sciences and 2 out of 4 participants had studied some affecrive science at some point in their life earlier.

Since the objective of this project was to simplify the research for making it accessible and easy to understand for the general public, I evaluated :
1) whether the participants understand the reasoning behind the insights
2) the effort required to understand

Information about the participant demographics, interest level in the field and their prior knowledge was obtained. To test the prior knowledge of the participants, they were asked to classify statements related to the subject matter as true or false.

After this the participants were asked to go through all the research papers and the corresponding part of the infographic, one at a time, after which they had to answer a set of questions related to them to test how much they understood it, the difficulty they faced and how the infographic compared to the original research papers. They could refer to the paper and infographic while giving answers. Participants were also asked to rate the effort needed to understand the content on a likert scale for each research paper and corresponding part of the infographic

Due to limitations of time and availability, expert evaluation was not performed.

## Results:

**Comparative perspective of affective reaction:** Participants were able to understand the final insights in the research paper. However the data visualization which is used to support the reasoning in the research paper is not helpful. Participants also mentioned the images of facial expressions was good. This was missing in the final infographic which can be added in the main data visualisation instead of keeping it separate. Participants found the corresponding part for this in the research paper simple and straightforward which highlighted the important parts of the research and cut down some information. Some participants mentioned that there could be some provision to have a simplified version and more complex version in the same infographic.

**Inherent behavioral traits:**
The research paper for this part was the most difficult for the participants to understand. The final insight in this one too was understood. However, participants mentioned it having a lot of jargon and scientific knowledge in the reasoning part which was not understood by the participants .
The corresponding part in the final infographic was understood by the participants. Some participants mentioned that instead of having the explanations after the data visualisations, it is better to have them before the visualisation so that people know what they are trying to see instead of randomly interacting with the data visualisations. Participants interacted with the data visualisation, went ahead in the infographic read the text which explained it and went back to the data visualisation. The current format in the infographic makes it a bit exploratory instead of declarative.

**Causes of affective disorders:**
The third research paper was easy to understand. It was statistical. However participants mentioned that visual comparison of the numbers for all the different types of disorders in the final infographic helped in better understanding of the final results.

For all the three research papers, the final insight was understood by the participants through the conclusion section of the research paper. However the part which was difficult to understand in the research papers was the reasoning behind the final insight.

The participant who had studied affective science before had knowledge of 2 out of 3 research papers included. So the infographic is relevant to more novice audience.

# Final Visualisation Link

Please visit the following link to view the final infographic prototype:
*file may take some time to load

**https://homepages.iitb.ac.in/~18u130024/**

# Conclusion

The final visualisation provides novice audience a starting point to get interested in the field of affective neuroscience and psychology.

Considerable amount of time was spent understanding the subject matter before attempting to simplify it. The infographic touches on different ideas and concepts which can imbibe curiosity in novice audience to explore more later on. Due to limitations of time and skills a coded outcome was not produced.

Preliminary evaluation performed with 4 participants from the target audience showed that some aspects of the research papers have been simplified to suit the novice audience.

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