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# Visualisations in Affective Neuroscience

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# Abstract

Affective neuroscience is an interdisciplinary field involving neuroscience and psychology where research involving data analysis are paving the way for new findings.

This paper tells about the various types of visualizations in the field of affective neuroscience based on the nature of information. Neuroanatomy is of importance in this field and based on that the two broad categories identified are spatial and nonspatial visualizations.

# Introduction

## Affective Sciences

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 then 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 (i.e. questionnaires) 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 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.

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.

In this paper visualisations in affective neuroscience are classified into two categories - Spatial and Non-Spatial Visualisations.

# Spatial Visualisations

Spatial visualizations give information about the spatial orientation or organization of different parts in space and give information about the position or the relationship between location of different components and distance between them.

### Volumetric - Anatomical Visualisations

Data is processed and mapped in 3D space based on anatomy. Visualisations like 3D brain atlases enable comparison between different states of the brain like the effect of various disorders, drugs or any other condition by comparing the activation in brain regions. They are based on anatomy.

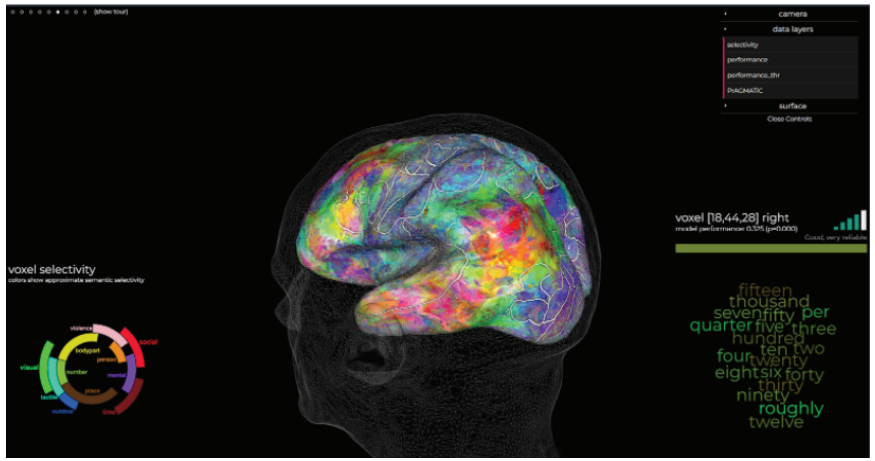

Fig 1 : Semantic Maps,  gallantlab.org/huth2016/

In Fig 1, multiple fMRI scan images of brain activation data of effect of certain words is analyzed and mapped onto regions of the brain in 3D.

Similarly, connectomes can also be visualised in this manner. Connectomes show different neural connections in the brain.

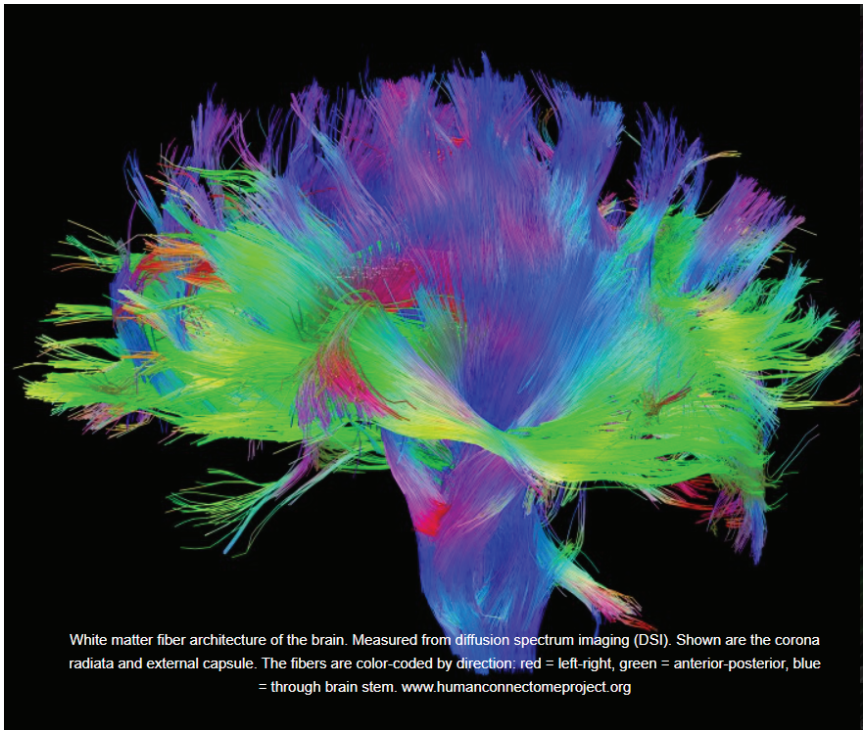


Fig 2 : The Human Connectome Project, youtu.be/aLxR9vOhVaw

In Fig 2, direction is colour coded on white matter fibres architecture.

## Volumetric - Functional Visualisations

Similar to volumetric-anatomical visualisations, these also have data mapped in 3D space but the difference being that the anatomical information is absent and the functional relevance is highlighted.

Figure 3 shows how certain parts in the brain are connected to one another in 3D space. It shows the distance between each along with the location with respect to other parts

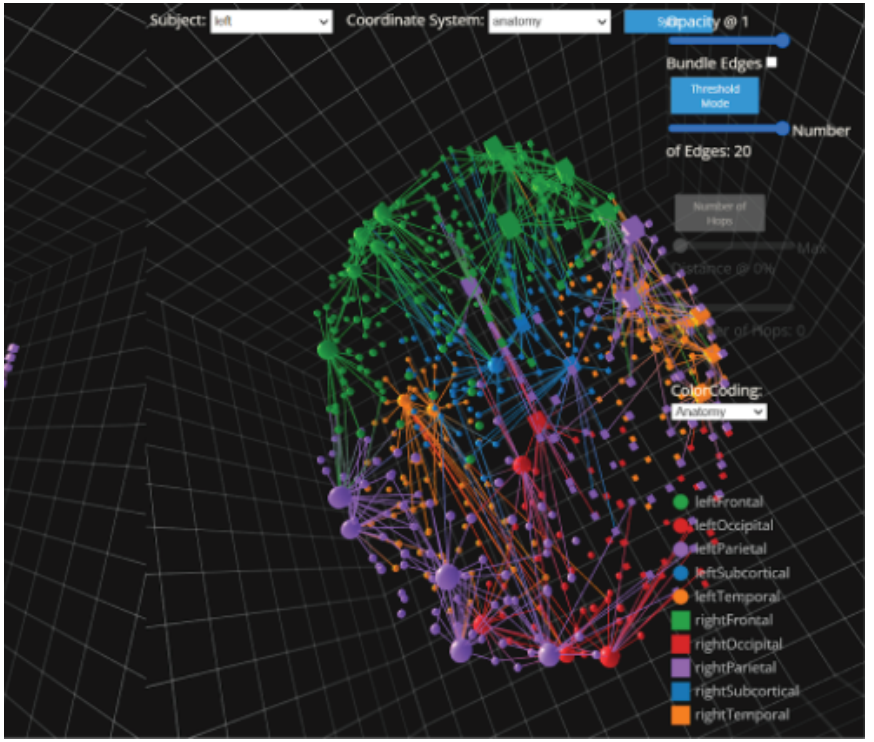


Fig 3 : NeuroCave

## Planar - Anatomical Visualisations

In this,  data is presented or mapped in a 2D space based on anatomy. The following example in fig 4 shows a mapping of various emotions onto the regions of the human body where the sensations are felt.

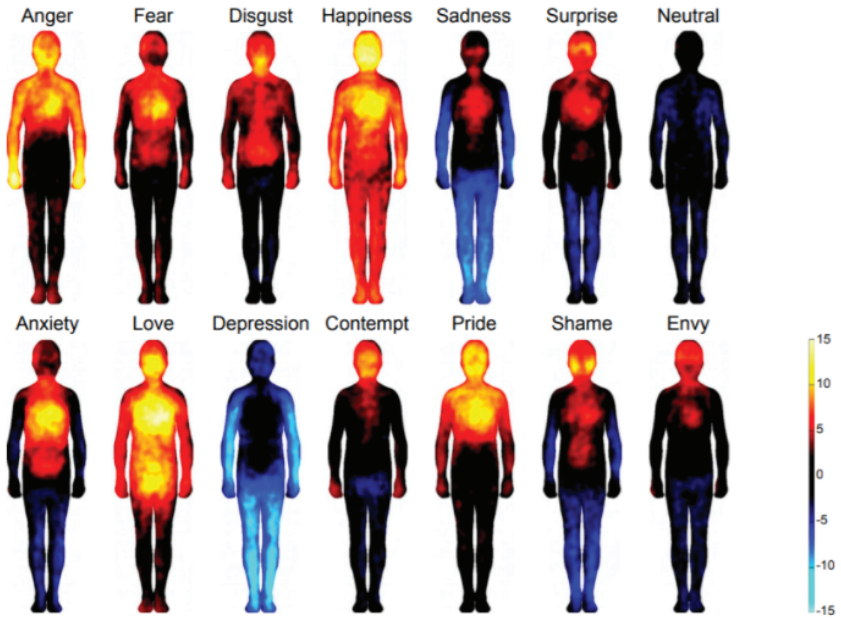


Fig 4: Bodily maps of emotions, doi.org/10.1073/pnas.1321664111

Scientific illustrations can also be considered a part of this.


Fig 5 :  Self Reflected, www.fi.edu/selfreflected

The above diagram 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

### Planar - Functional Visualisations

These pay importance to the functional relevance of the connections  in space rather than the anatomical relevance. The relative distance between any two points is represented in 2D space.

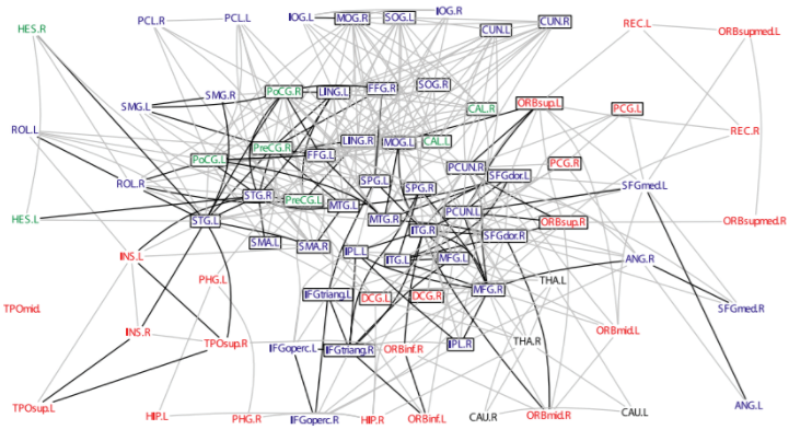


Fig 6: Topological map of asmall-world human brain functional network created by thresholding thescale 4 wavelet correlation matrix representing functional connectivity in the frequency interval 0.03– 0.06 Hz, doi.org/10.1523/JNEUROSCI.3874-05.2006

# Non Spatial Visualisations

These visualizations don't have a spatial element in them. They include diagrams like chord diagrams, matrix diagrams etc which don't provide spatial information and are generally used to present results and findings to an audience by providing reasoning based in data.

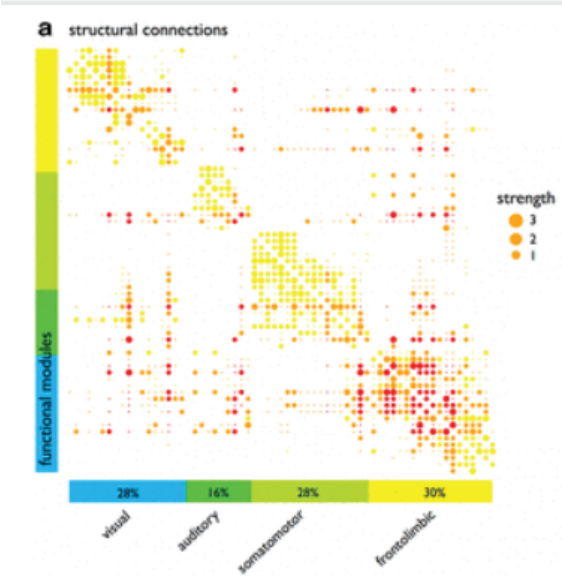


Fig 7: Connectivity matrix of the cat connectome, doi.org/10.1523/JNEUROSCI.1448-13.2013

Figure 7 shows corticocortical connections in the cat brain in the form of a binary matrix diagram which shows the strength of the connections encoded in size of dots. It uses data from 65 regions in one hemisphere of the brain.

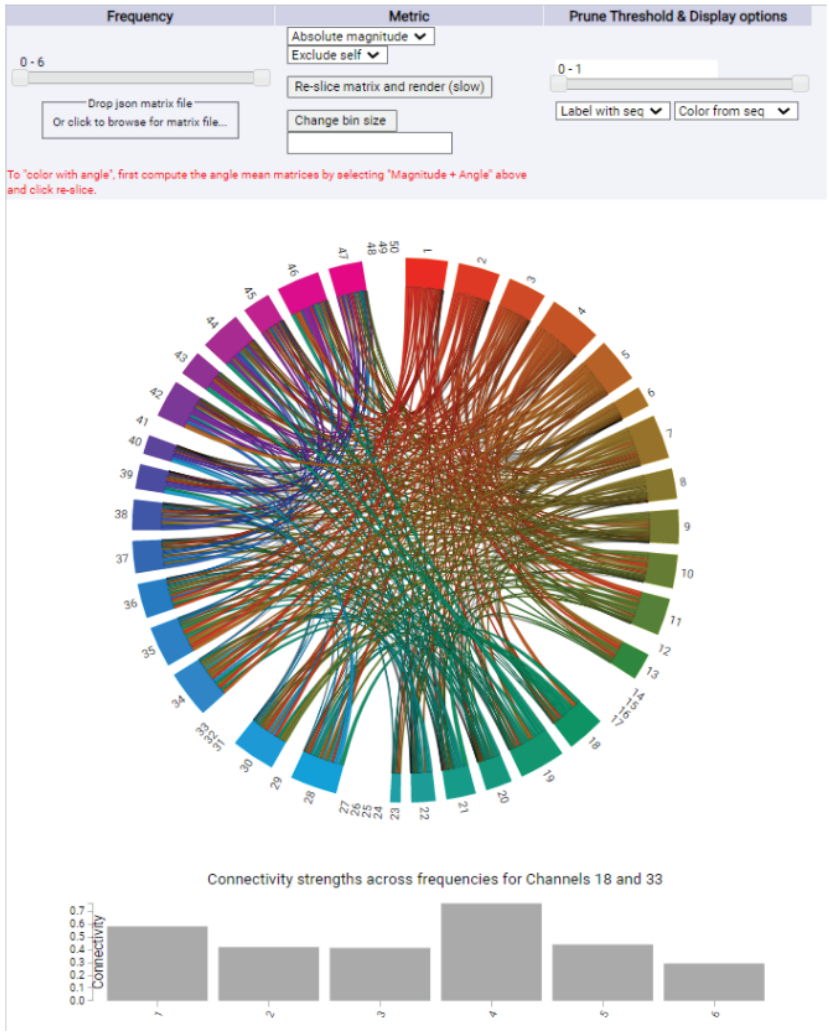


Fig 8 : Neural Connectivity, davidjuliancaldwell.github.io/Affinity/main.html

The above example shows a visualisation of human connectome that doesn't have the spatial data encoded in it.

The following example shows a series of scatter plots which indicate the valence and arousal mappings of four individuals and gives information about the intensity of emotions. The genres of clips are colour code.

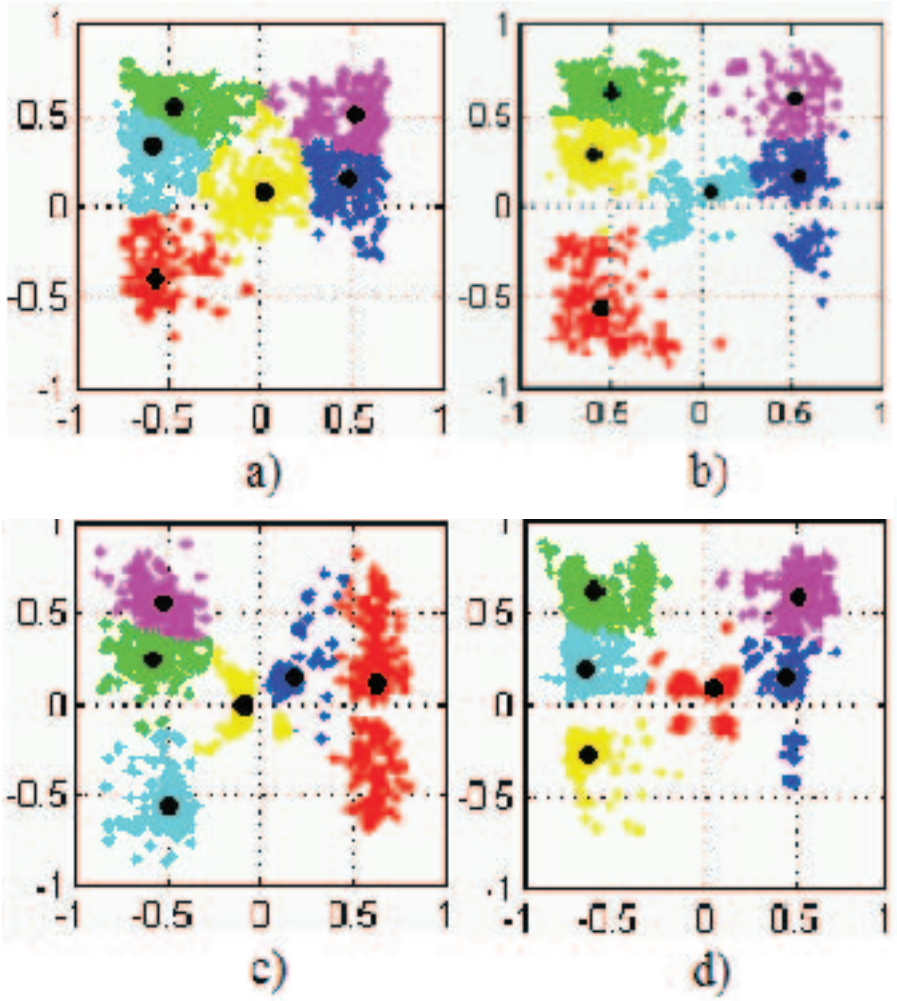


Fig 9: 4 partitioning results of V-A plane based on FCM.

# Conclusion

This paper attempts to classify visualisations in affective neuroscience. The two broad categories identified were spatial and non spatial visualisations as neuroanatomy plays an important role and a lot of visualisations are based on that.

The two categories of visualisations are presented with examples. Spatial visualisations were further categorised into four subcategories based on the representation and nature of information. However, no distinct sub categories were identified in the nonspatial visualisation category.

# References


Semantic Maps **gallantlab.org/huth2016/**

The Human Connectome Project, **youtu.be/aLxR9vOhVaw**

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Figure 2, Bodily maps of emotions, Lauri Nummenmaa, Enrico Glerean, Riitta Hari, Jari K. Hietanen **doi.org/10.1073/pnas.1321664111**

Self Reflected, www.fi.edu/selfreflected

Figure 4, A Resilient, Low-Frequency, Small-World Human Brain Functional Network with Highly Connected Association Cortical Hubs Sophie Achard, Raymond Salvador, Brandon Whitcher, John Suckling, Ed Bullmore, Journal of Neuroscience 4 January 2006, 26 (1) 63-72; **doi.org/10.1523/JNEUROSCI.3874-05.2006**

Figure 5, Rich Club Organization and Intermodule Communication in the Cat Connectome, Marcel A. de Reus and Martijn P. van den Heuvel, Journal of Neuroscience 7 August 2013, 33 (32) 12929-12939; **doi.org/10.1523/JNEUROSCI.1448-13.2013**

Fig 8 : Neural Connectivity, **davidjuliancaldwell.github.io/Affinity/main.html**

Figure 2, An improved valence-arousal emotion space for video affective content representation and recognition, Kai Sun, Junqing Yu, Yue Huang and Xiaoqiang Hu