

Predicting Aphasia type from brain damage, measured with structural MRI

Yourganov et al (2015)

ALISHA PHILLIPS

Aims of this presentation

- To critically review this journal article in the field of neuroscience of language
- To consider the faults and what could have been better
- Study comparisons



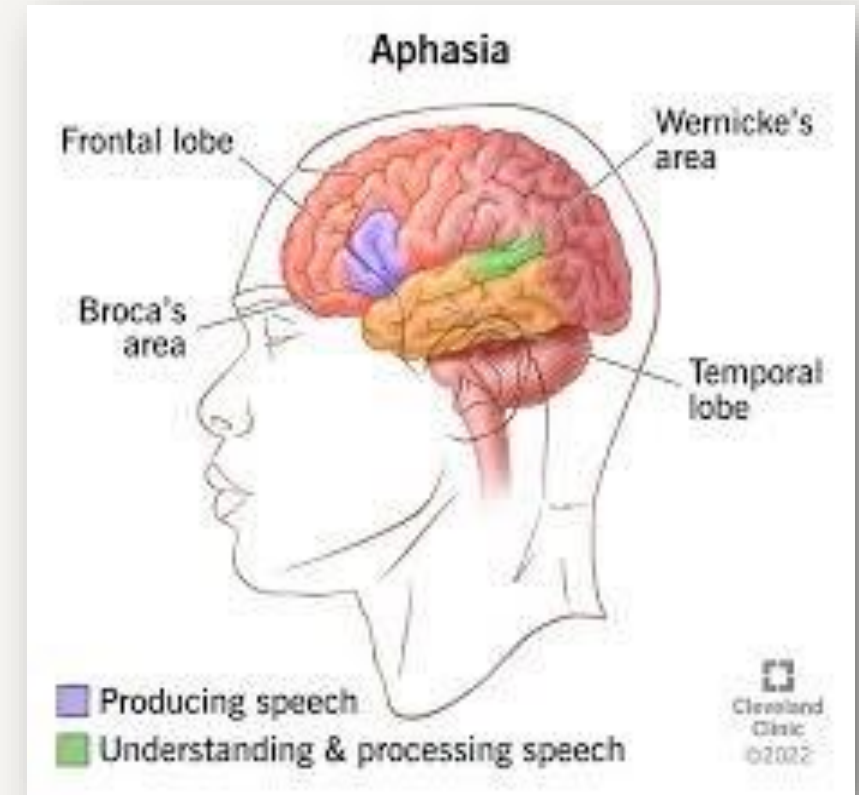
All images in this presentation are derived from google images or the journal results tables.

What is Aphasia?

Impairments in the use of language, in any modality – speech, writing, linguistic signing which can be caused by damage to the brain, eg stroke (Code, 2021)

Different types ;

- Broca's
- Wernicke
- Global
- Conduction
- Anomic

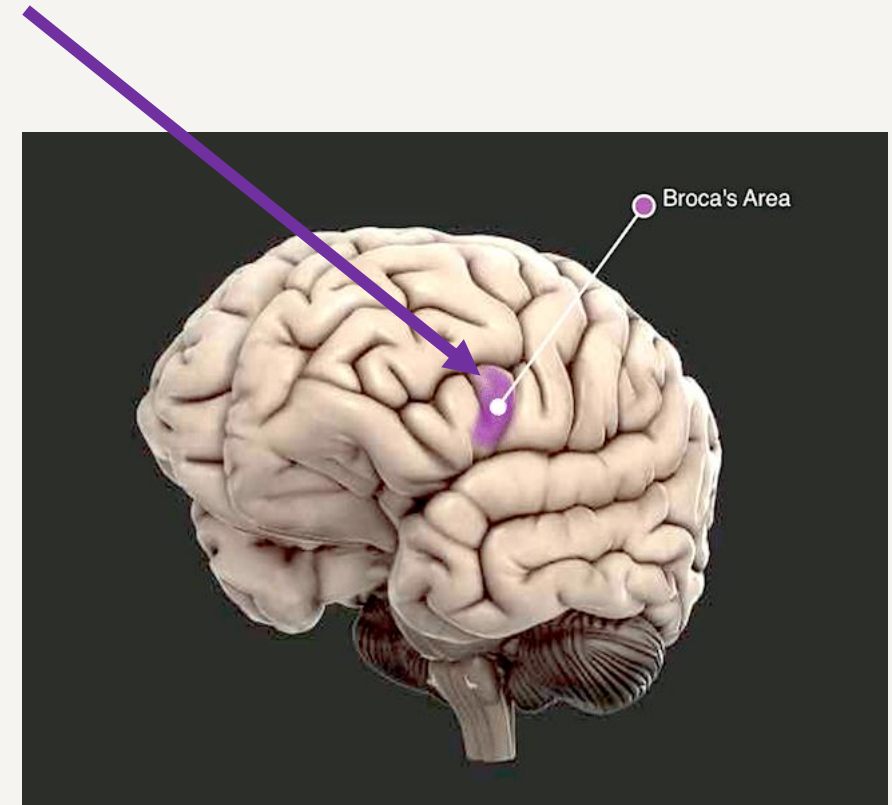


Broca Aphasia

Fridriksson et al (2015)

Broca Aphasia was named after the French scientist 'Paul Broca' in 1861. Broca was the first to associate certain speech deficits with this area of the brain, now recognized as 'Broca's Area'.

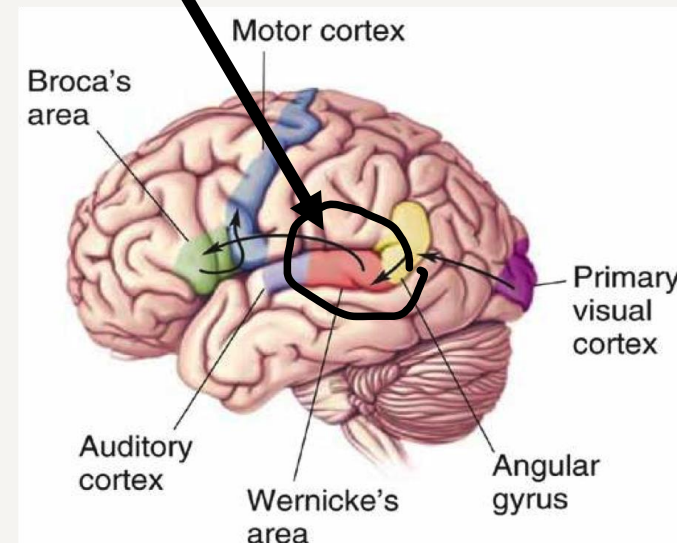
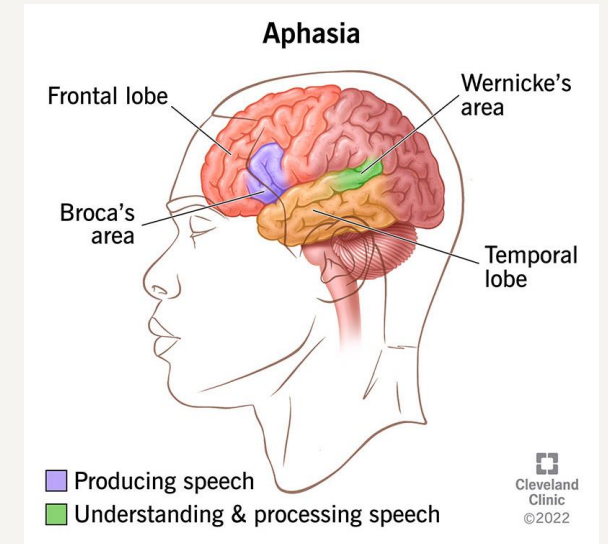
- Responsible for speech production, language structure
- Damage to this area can lead to Impaired speech
- Spared speech (loss of fluency/ loss of word regulation)
- Clumsy formation of sounds and sentences
- Often speaks in short phrases, often leaving small words behind such as 'is' and 'the'
- Often repeats words



Wernicke Aphasia Javed et al (2023)

Wernicke Aphasia is associated with damage to the 'Wernicke area' of the brain. Discovered in 1874 by Carl Wernicke. Although very close to the Broca's area, this is responsible for written and language comprehension.

- Unable to comprehend/express written or spoken language.
- Will most likely have fluent speech, but their words will lack meaning.
- Issues with auditory comprehension of what is being spoken to them. Meaning an individual is unable to understand what is being spoken to them.
- Unaware of these issues

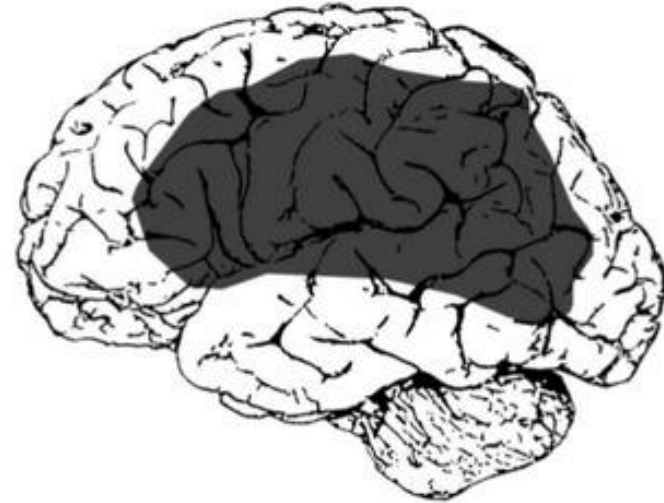


Global Aphasia Li et al (2023)

Global aphasia is the most severe form of post-stroke aphasia and is characterized by severe impairments in all language modalities.

- Injury to the Broca and Wernicke areas, which can arise after massive strokes.
- Damages someones ability to understand others and comprehend language
- Does not affect intelligence – comprehension is damaged

Global Aphasia



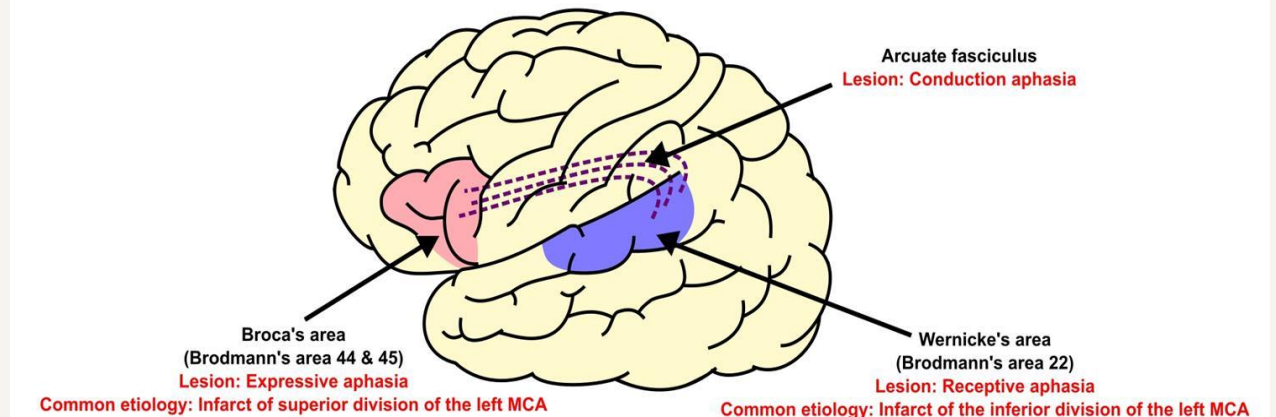
Conduction Aphasia Ardila (2010)

Conduction Aphasia was created by Wernicke which was the first to assume that this type of Aphasia was caused by an issue between two major brain systems responsible for speech.

- Language disturbance
- Spontaneous speech yet sound auditory comprehension
- Poor speech repetition
- Difficulty repeating words
- Substitute with other smaller words



Anatomy of Language



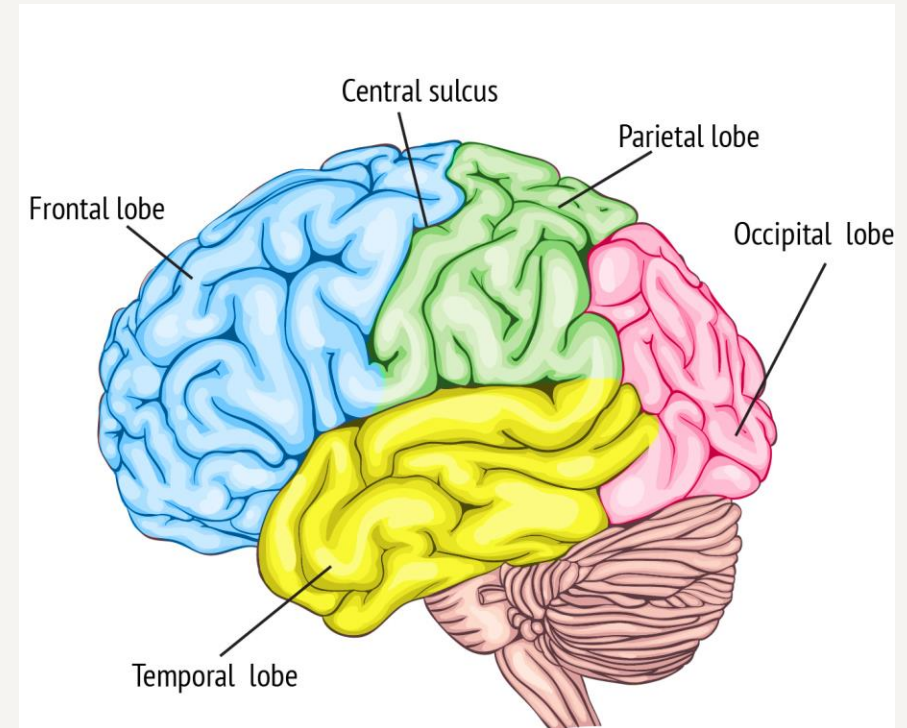
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Moises Dominguez

Anomic Aphasia Harnish (2018)

Mildest form of Aphasia. With mild deficits of word retrieval and relatively spared comprehension in other language domains. Eg auditory comprehension and sentence production.

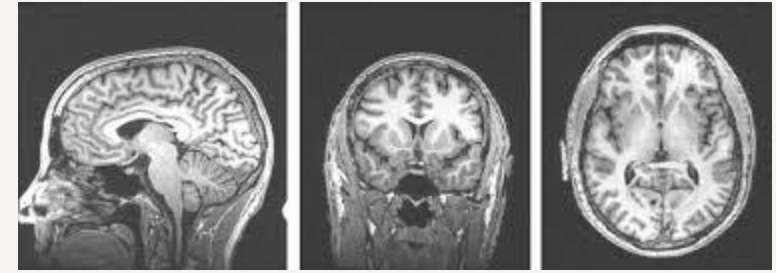
- Caused by damage to language processing areas
- Affecting the left hemisphere and left temporal and parietal lobes (see green and yellow areas)
- Usually still able to understand and repeat phrases, although wording may have mistakes



Using a brain atlas and structural MRI

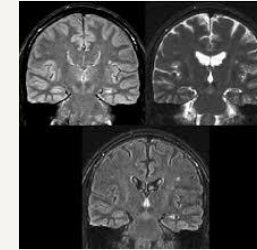
What is structural MRI?

Structural magnetic resonance imaging (SMRI) is a non-invasive technique that produces detailed images of the brain's anatomy. SMRI uses strong magnetic fields in an MRI scanner to create images that detail between gray and white matter (Wattjers, 2011)



What is a brain atlas?

- A 3D model of the brain
- Provides a spatial reference system for neuroscience research.
- A collection of serial sections of a brain, where each structure is assigned coordinates to define its location and volume.
- Brain atlases can include anatomical and genetic features (Nowinski, 2021)

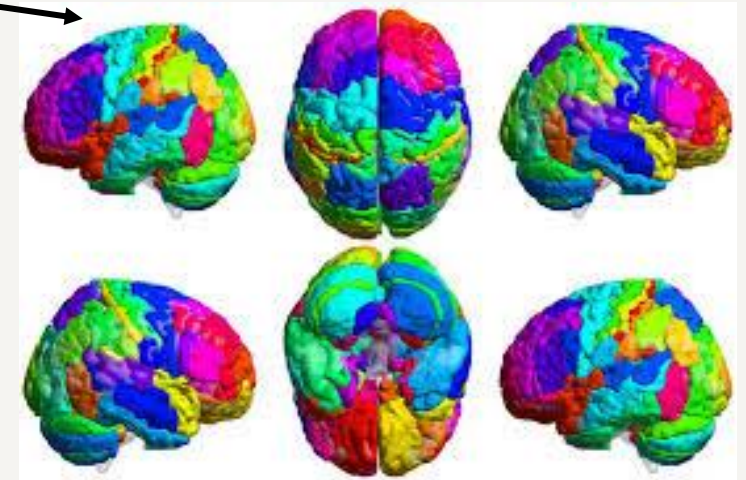


How can these be combined?

- A brain atlas is used in structural MRI to represent a patient's brain as a template
- Helping identify brain structures and locate data/differences.

Weaknesses of using structural MRI

- If there is no obvious pathogenic differences, type can be hard to determine
- Sudden movement can affect results
- Can take a long time



The present study

Aim

To determine whether automated multivariate classification algorithms could accurately predict aphasia type based on the pattern of brain injury

The study – Methodology

Participants

Sample of 98 chronic stroke patients with aphasia - multivariate classifications to distinguish between five aphasia types

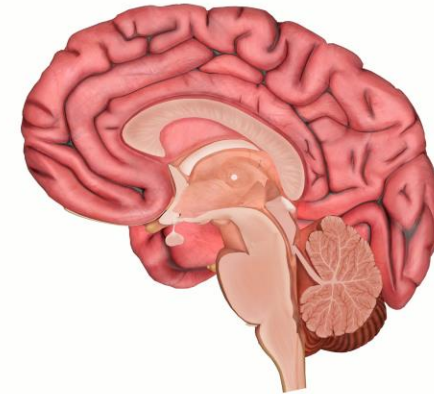
- 1) 35=Anomic, 33=Broca, 7=Wernicke, 13= Conduction, 10=Global
- 2) Mean age was 58 (36 females, 62 males)

Behavioural assessment

- Carried out between May 2007 and October 2014
- Aphasia type could alter
- 6 months post-stroke

Three main approaches

- 1) Careful spatial normalization of lesions
- 2) Segmentation of the lesioned area using a brain atlas
- 3) Multivariate prediction of Aphasia type within a cross-validation framework



The study – Methodology 2

Using a multivariate approach

- Using different variables
- Thought to be the first
- Possibly unreliable

Variables

- An atlas-based approach was used.
- A training and testing process using the Support Vector Machine (SVM) - the classifier
- Aided the prediction of Aphasia type compared to brain damage

Support Vector Machine (SVM)

The SVM was used to group patients separately due to the difference in sample sizes eg 7 with Wernicke and 35 with Anomic.

- Maximum was taken from one group and an equal amount from the other to avoid bias.

Eg 6 with Wernicke and 6 with Anomic (re-sampling procedure).

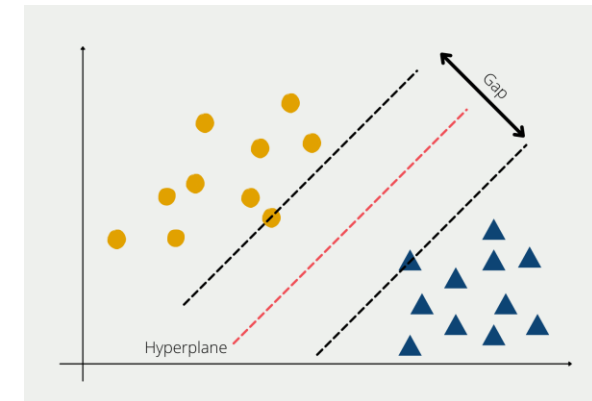
- Used for training and testing

Faults

- Can over complex the study (changing groupings)
- Overfitting the data

Training vs Testing explained

- Predicts the association between patterns of brain damage and aphasia types (Training)
- Assigns the type to previously unseen patients based on their pattern of brain damage (Testing)



Structural MRI and SVM

The SVM works alongside an MRI by supplying more information about the brain regions. This is where the term 'the classifier' comes from.

Faults

- Structural MRI focuses more on the anatomy of the brain rather than the symptoms of the patient
- Could an FMRI be more beneficial
- The use of AI technology?

Using a brain atlas

A spatial reference system that defines the location of brain regions

Fault for the study

- Defined by brain areas not much on voxels which can lead to poor spatial resolution

However

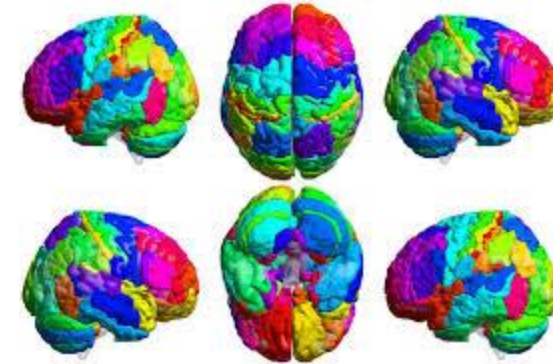
- Efficient if segmenting the brain into areas with Aphasia
- Can then be decoded

Fault

- Can be mis interpreted

Five different atlas' are involved in the segmentation process

- Brodmann, JHU, AAL, CTS and AALCTS



Resampling procedure

- 500 times
- All unique
- One patient from the smaller group was held out, remaining were used for training
- Larger group – the number of training examples was the same for the smaller group and the remaining was used for testing

Then determined significance

Faults

- No graph shown in the journal
- Can change results

Methodology 3

- Once patients were grouped, brain structure differences was determined from each brain atlas
- Re-sampled to avoid bias
- Fluent + Non-Fluent groupings were made

Fluent > Wernicke, Conduction, Anomic

Non-Fluent > Broca, Global

- Data was then inputted to the SVM – the classifier
- Training and testing process
- MRI scans were done to determine changes / significance

Faults

Little explanation about the SMRI process or how the SVM worked with the SMRI

Results of the study – example of structural MRI with the use of brain atlas

Figure 1

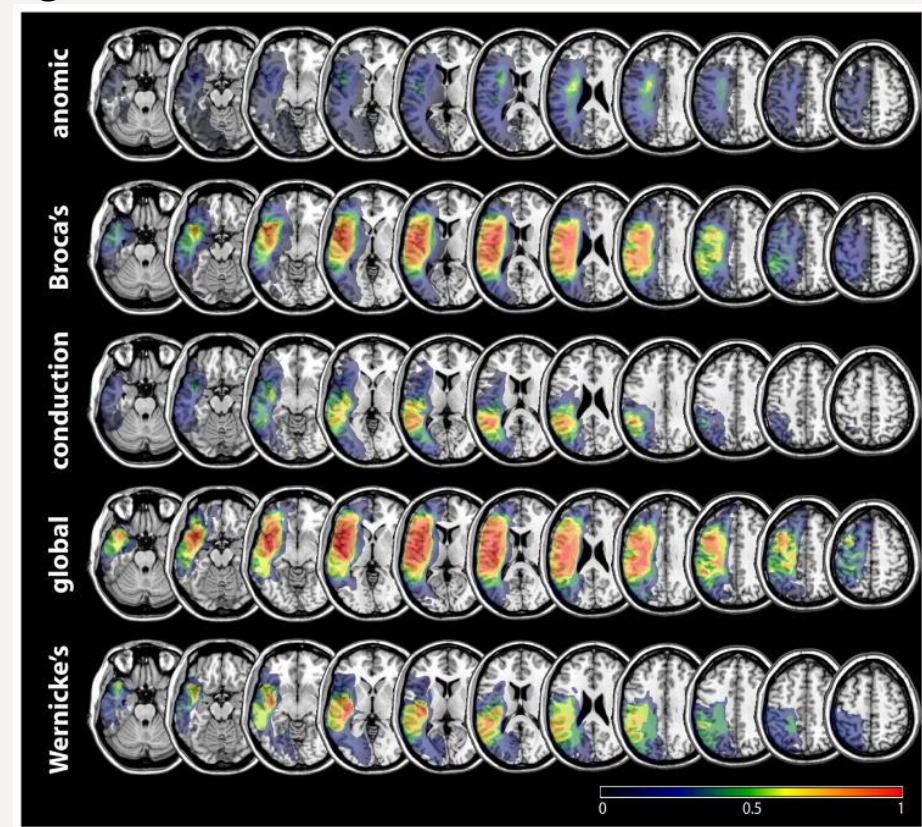
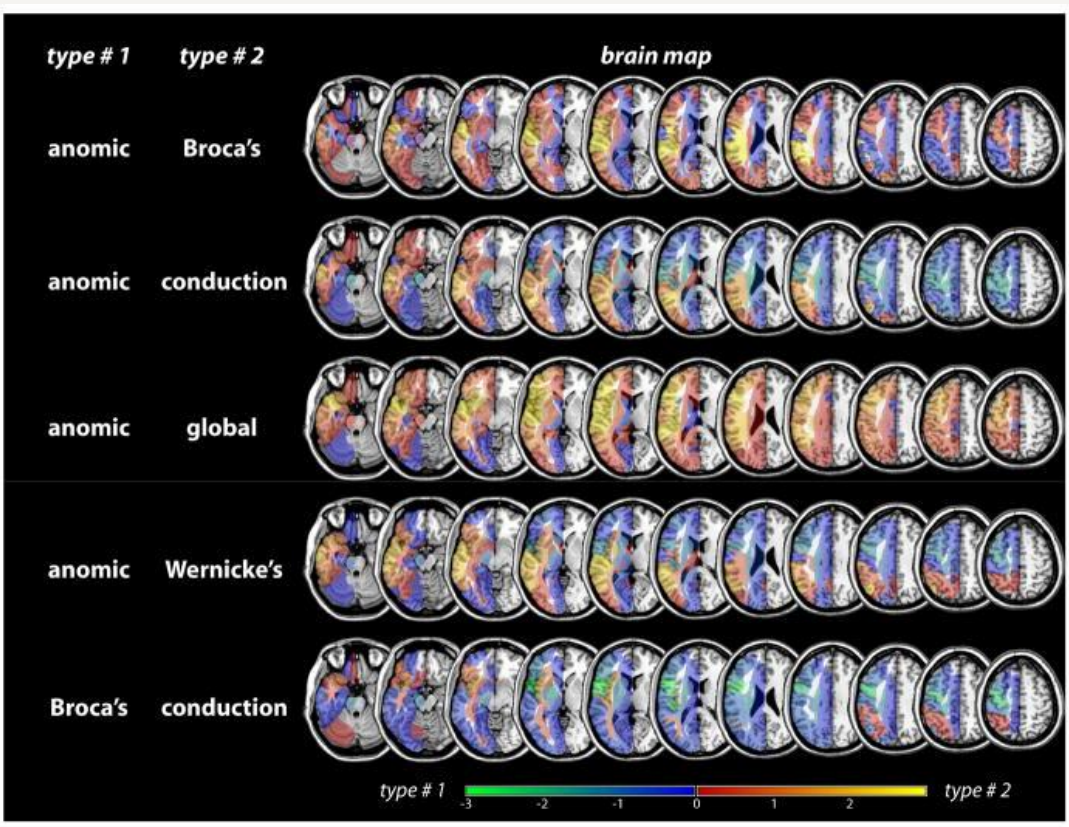


Figure 2

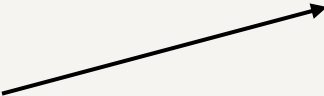


Results

Table 1.
Accuracy of aphasia type prediction (given as ratio of patients with aphasia type predicted correctly) for each pairing of aphasia types. Five different atlases were used to define brain areas; the proportional damage to the brain areas comprised the input to the classifier.

These are all of the percentages of the prediction success

contrast	atlas					chance
	Brodmann	JHU	AAL	CTS	AALCTS	
anomic / Broca's	0.8475**	0.8861**	0.8903**	0.8491**	0.8832**	0.5147
anomic / conduction	0.8247**	0.7989**	0.7805	0.8294**	0.7965*	0.7292
anomic / global	0.9133**	0.9236**	0.9479**	0.8577**	0.9457**	0.7778
anomic / Wernicke's	0.7524	0.7712	0.8128	0.7004	0.7807	0.8333
Broca's / conduction	0.8277**	0.8906**	0.8674**	0.8585**	0.9356**	0.7174
Broca's / global	0.5975	0.5436	0.5818	0.5764	0.5568	0.7674
Broca's / Wernicke's	0.7845	0.7766	0.8532	0.8338	0.8787**	0.825
conduction / global	0.9541**	0.9204**	0.923**	0.8292**	0.9512**	0.5652
conduction / Wernicke's	0.5394	0.5545	0.5031	0.6063	0.5143	0.65
global / Wernicke's	0.9104**	0.9139**	0.9373**	0.7585**	0.9198**	0.5882



Averaged at 81.28% (highest accuracy)

Results - Weaknesses



- Based heavily on predictions, only the prediction of different aphasia types
- Aphasia types can be interlinked / can develop into each other, assessing two processes the same time
- Does not assess symptoms only brain structures/anatomy
- Reliant on brain atlas'
- A range of sample sizes (7 with Wernicke) - sample size was changed once numbers were assessed to avoid bias in the different types of aphasia, by removing the maximum number of participants from one group and an equal amount from another group – this could have influenced different results and affect reliability
- Questionable statements of distinguishing different aphasia types ('could be, in most cases..') later on stating 'no brain areas were seen to be strongly predictive'
- CTS atlas - 81.28% accurate prediction – not 100%
- This is the first multivariate study predicting aphasia through structural MRI to their knowledge, which questions the reliability of this study as they have no previous research to base it on.
- As all patients had Aphasia, how did the investigators know that they wanted to participate if they found speech difficult?



Positives

- It has high prediction percentage of aphasia type, however is not 100% accurate.
- Has sparked a new multivariate path into this type of research
- Has located some structural changes in the brain in different aphasia types – although could be questioned again to its reliability

To improve could be more accurate with less types of Aphasia

- Same group sizes for different types of aphasia
- Made sure to have a participant for training and testing



Conclusion

- Link between pattern of brain damage and results in language deficiencies
- Implications for diagnosis, prognosis and recovery of patients

Future research directions

- Symptoms should be assessed with different assessments before hand
- Newer technology could be more beneficial – give different results
- FMRI could give a different approach
- Avoid predication, as patients will need an accurate diagnosis for support interventions
- Avoid complex sampling

Comparison study - Associations between lesion size, lesion location and aphasia in acute stroke Døli et al (2021).

Aims:

To investigate the relationships between aphasia severity, aphasic symptoms, lesion location and lesion volume in patients with left hemispheric stroke in the acute phase (**within one-week post-stroke**).

- Using a voxel- based lesion-symptom mapping method (VLSM).

Methods & procedures

Findings from diffusion-weighted magnetic resonance imaging (**DWI-MRI**) and patients' scores from the **Norwegian Basic Aphasia Assessment (NBAA)**

- Analysis of descriptive statistics, lesion localization and lesion volume.
- Patients were divided into two groups based on their median scores on the NBAA (one high comprehension group and one low comprehension group)
- The VLSM was used to investigate the associations between the patients' lesions and the results from the NBAA.

Outcomes & Results:

Lesion volume was significantly associated with all subtest from the NBAA. Our initial analysis of the whole group showed that difficulties in naming was associated with lesions within the rolandic operculum. We also found that difficulties in repetition was associated with lesions within the rolandic operculum, and in addition, the superior temporal gyrus. In the group of patients with high comprehension scores lesions within Broca's area, insula, the superior temporal gyrus (STG) and Heschl's gyrus were found to be associated with difficulties with overall aphasia severity,

Retracted: The Progress of Functional Magnetic Resonance Imaging in Patients with Poststroke Aphasia Tang et al (2022)

- Post stroke aphasia
- The progress of Functional Magnetic Resonance Imaging through a literature review of 19 articles
- FMRI provides a sound framework to investigate the pathogenesis and recovery of Aphasia
- Provides a basis for rehabilitation

However,

- Still needs further improvements to fully determine all elements of post-stroke Aphasia
- Although, It may get progressively more popular due to imaging developments

Thankyou for listening

References

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Notes

~~Notes~~ Slide 1

The Journal article I will be critically reviewing today is by Youngson et al (2015)

Slide 2

- The aims of this presentation
- Critically review this Journal
 - Provide a definition of Aphasia types
 - Consider faults / improvements
 - Compare to more up to date

Slide 3

What is Aphasia

According to Code in 2021

- Aphasia is impairments in the use of language in any modality
- Speech, writing, linguistic signing
- often caused by brain trauma or damage.

For the purposes of this presentation language impact is at focus.

There are five different types stated within this study by Youngson which are Broca, Wernicke, global, conduction, Anomic.

Slide 4

Broca ~~Area~~ Area.

- ~~According to Fasherson in 2015~~
- Responsible for Speech production + structure
 - Broca Aphasia causes impaired Speech production
 - Speak in short sentences
 - clumsy formulation
 - Difficulty repeating words

Created/Founded by Paul Broca who linked deficits to localized brain damage in 1861.

Notes

slide 5

Wernicke Aphasia is associated with damage to the Wernicke Area which is responsible for speech comprehension. Discovered by Carl Wernicke in 1874 and is 1 of 2 areas in the Cerebral Cortex that manages speech.

- Damage to this area
- Causes an individual to be unable to comprehend language
- jumbled words
- also unaware of these difficulties

Brain atlases can include anatomical, ~~gen~~ and genetic features

How can these be combined?

A brain atlas is used in structural MRI to represent a patient's brain with a template which aids the prediction of different brain structures different Aphasia weaknesses

- If there are no obvious pathogenic differences, type is hard to determine
- Can take a long time | sudden movement

Using a brain atlas and slide 9
Structural MRI

Structural MRI non-invasive technique that produces detailed images of brain anatomy. ~~SMR~~ uses strong magnetic fields in a scanner to create images that detail between gray and white matter

Brain atlas is a 3D model of the brain that provides a spatial reference system for Neuroscience research

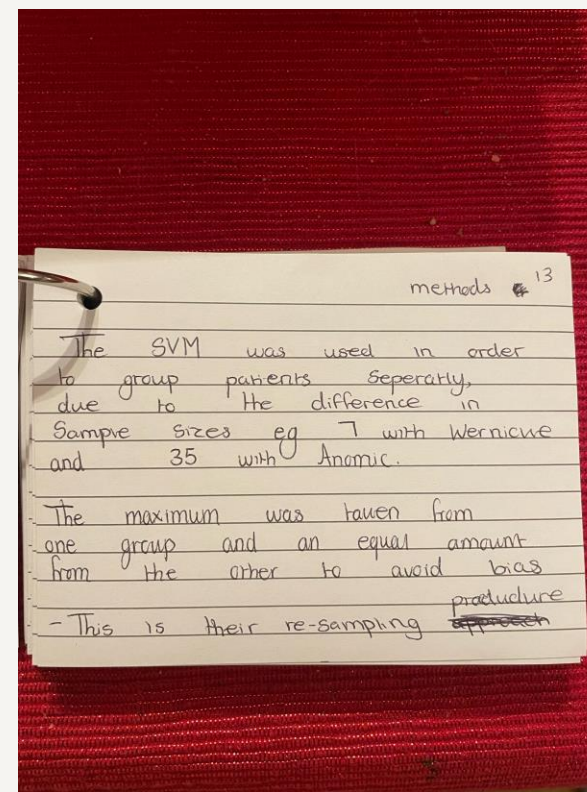
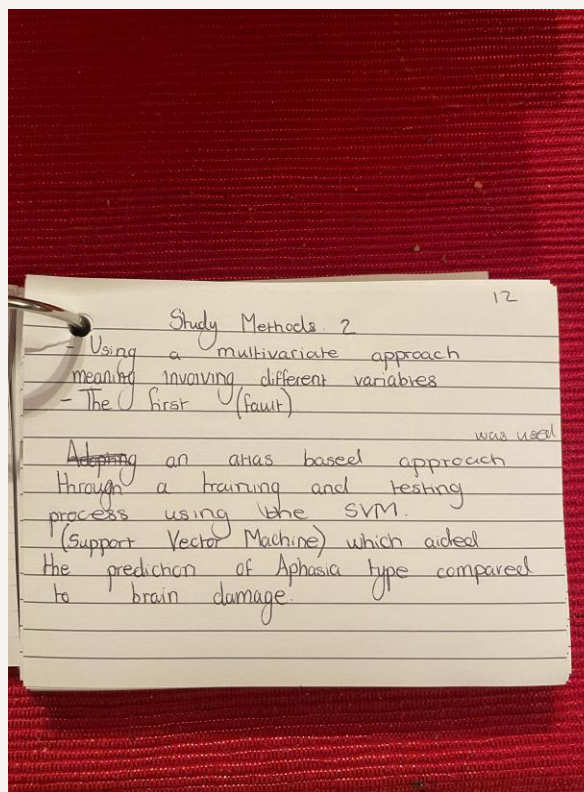
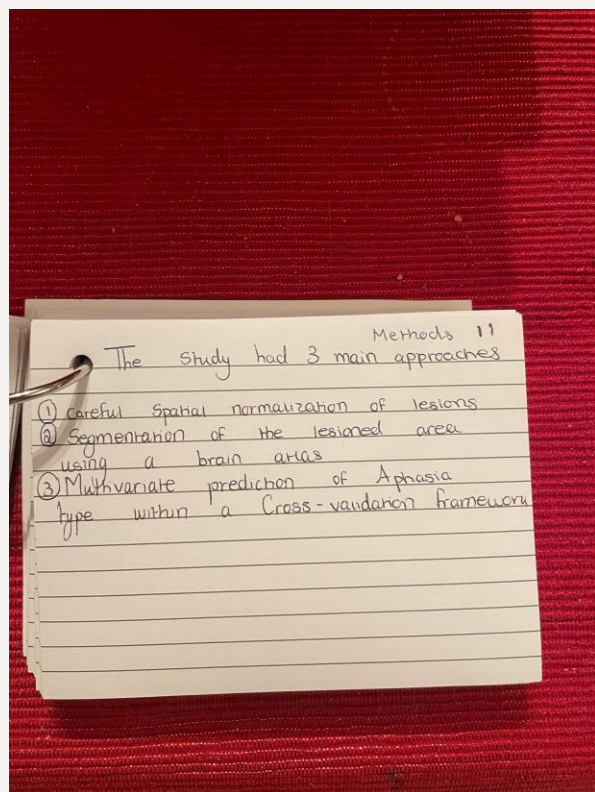
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present study aim
The study is examining whether a multivariate approach can predict Aphasia types.
To determine whether automated multivariate classifications algorithms could accurately predict aphasia type based on the pattern of brain injury

participants slide 11
Originally the study had 139 right-handed patients with Chronic left hemisphere stroke
However only 98 were included
- Others were excluded due to health concerns
35 with Anomic, 33 - Broca, 7 - Wernicke
13 with Conduction, 10 - global
36 females, 62 males

method slide 11
A behavioural assessment was carried out between May 2007 and October 2014
- which leaves a lot of time for those first tested to worsen or change Aphasia type
Recorded 6 months post-stroke.

Notes



Notes

and these were used
for training and testing

- However, this can over complex the study and make the groupings hard to understand
- Over-fitting the data
 - making data sets too small so it will not represent all possible data values.

SVM. methods 13

A big chunk of the method that was used in this study. The SVM estimates the association between patterns of the brain which are damaged and the brain (training) and assigning the type to previously unseen patients based on their pattern of brain damage (testing).

MRI vs other techniques 14

The SVM works alongside an MRI supplying more information. However, Structural MRI focuses more on the anatomy of the brain rather than the patient's symptoms.

- An fMRI could be more beneficial to examine brain activity when using language.
- Although measures all regions of the brain.
- AI technology is now used to assess severity + classifications.

Notes

Methods 8 15
Using a brain atlas

Brain Atlas > A spatial reference system that defines the location of brain regions.

Downside > The study is defined by brain areas rather than voxels which can lead to poor spatial resolution.

However, is efficient if it segments the brain into areas with aphasia so that they can be detected can misinterpret type of aphasia.

The study involved 5 brain areas in the segmentation process to compute damage in different areas: Brodmann, JHU, AAL, CTS and AALCTS.

Due to the time restraints I won't go in depth about the different types but will explain the accuracy ~~where~~ of their use when predicting aphasia types.

Resampling procedure M 16

The resampling was done at least 500 times to ensure ~~an number~~ that all test splits were unique (all different).

- One patient from the smaller group was held out, remaining were used for training.

In the larger group, the number of training examples was the same for the smaller, remaining was used for testing.

Notes

Then determined Significance
to know whether the observed
Classification accuracy is better
than chance

Faults

The Journal does not show a graph
from the SVM but mentions
the hyperplane that separates
the two classes

Re Sampling can change results

Methodology 3 17

once patients were grouped
- brain structure differences were
determined from each brain atlas
- Then re-sampled to avoid bias
- Fluent vs Non Fluent groupings were
made

Fluent - Wernicke, Conduction, Anomic
(Fluent Speech Impaired comprehension)
Non Fluent - Issues with overall speech
Broca, Global
Inputted into SVM

Training + Testing
MRI scan to determine changes/significance

Faults

little expansion about SMRI
process

Notes

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Results 1

For the purposes of this presentation the results that will be discussed are the accuracy of Aphasia type prediction ^(table) and accuracy of ~~explaining~~ one aphasia type from another ~~(presentation)~~ and two examples of the use of structural MRI and brain atlas

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Here are the results of the structural MRI with the use of the brain atlas.

Figure 1 - showcases the overlap of lesions across patients of each aphasia type

Figure 2 - Brain loadings computed from predicting one aphasia type versus another.

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graph explanation

The accuracy was concluded by the use of 5 different brain areas and their explanation of brain regions

The highest accuracy for anomic/broca was by the AAL (0.89%) and higher than chance. Anomic/conduction highest with the highest accuracy was

Notes

There was significant differences in the number of patients with different aphasia types which lead to some accuracies being lower than chance.

- The most accurate was anomic vs Wernicke aphasia at 81.28% regardless of the brain areas used.

This study faced drawbacks with co-ordinating Aphasia types eg. Broca Aphasia is also predictive of global aphasia.

- Based heavily on prediction
- Dealing with two stages of the same process rather than two neurological conditions.
- does not assess symptoms only brain structures

Weaknesses

- Reliant on brain areas
- A range of sample sizes and changes to the sample which could have influenced results and reliability.
- Questionable statements of distinguishing different aphasia types.
 - 'Could be, in most cases...'
 - 'no brain areas were seen to be strongly predictive'

Notes

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- Overall the CTS atlas was 81.28% accurate at the prediction of Aphasia type which is not 100%, does not explain this.
- First Multivariate study predicting Aphasia to their knowledge which further questions the reliability of the study.

All patients had Aphasia/haw did they Consent or explain

Positives 21

- High prediction percentage although not 100%
- Has spawned a possible new path of research
- located some structural changes in the brain in different aphasia types
- To improve could have only set Aphasia types instead of 5
- They did group to avoid bias
- made sure there was a unique number for all groups and training n testing

Conclusion. 22

in

The study showcased that despite diversity in patients there is a link between the pattern of brain damage and results in language behaviours

- Significant implications for diagnosis, prognosis and recovery of the individuals with aphasia if not interpreted correctly.

Notes

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In regards to future research
Symptoms should be taken into
account rather than purely predicting
aphasia type from brain structure

Newer technology like the fMRI
could be more beneficial to gain
more accurate results also to
avoid prediction and complex
Sampling.

23

In Comparison A Study by
Dois et al (2021)
Investigated relationships between aphasia
Severity, Symptoms and location
within the week post-stroke

- Compared to the earlier 6 months gap
- Using a Voxel-based lesion Symptom
mapping method (VLSM) which was also
not included in the earlier study
- Although focusing on acute stroke rather
than chronic stroke.

24

23

A ~~Diffusion~~ DWI-MRI was used
and patients completed a Norwegian
Basic Aphasia Assessment (NBAA)
patients were divided into two groups
based on their median scores
from the NBAA
They studied lesion volume and
placement of lesion
to determine overall aphasia severity.
- Symptoms were taken into account.

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Furthermore Tang et al (2022)
took into account post-stroke
aphasia and the progress of
Functional MRI through a literature
review of 19 articles
and concluded that fMRI provides
a good pathway to investigate the
pathogenesis and recovery of Aphasia
and that it provides a basis
for rehabilitation treatment of the
brain. However still needs improvement
with further imaging developments fMRI
may play a more important role.

Ai Acknowledgments

I acknowledge the use of [Google Scholar] [<https://scholar.google.com/>] on [18th November – 10th December] to [Proofread my work]. I used the prompt(s):

1. Broca Aphasia
2. Wernicke Aphasia
3. Global Aphasia
4. Conduction Aphasia
5. Anomic Aphasia
6. Aphasia

I confirm that I have not presented any AI generated text as my own work. I confirm I have copies of my drafts, notes, and other resources I used before, and after the use of AI tools which I may be asked to provide in evidence.