Brain Processing of Speech in Logopenic Variant Primary Progressive Aphasia

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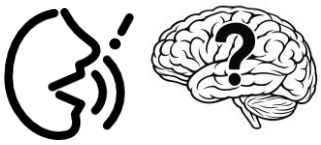
Created by Dana Kongo and Heather Dial

Abstract

Logopenic variant primary progressive aphasia (lvPPA) is a brain disorder that affects the ability to **understand**, **remember**, and **repeat words**

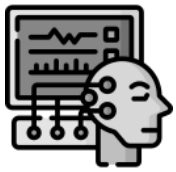
People with lvPPA **may not understand speech sounds** found in everyday words



This affects how **correctly** people with lvPPA **say and repeat words**

Dial et al. (2021) studied how **the brains of people with lvPPA process speech sounds** using **EEG (electroencephalography)**

EEG is a **tool** that **records brain waves. Brain waves** represent the brain's electrical activity



EEGs are often used while people **watch something** or **listen to sounds**

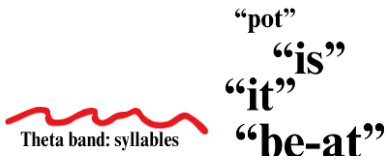
In this study, participants listened to **two stories.**

"Albert loved going to math class. He liked solving problems on the board. His teacher took notice of his excitement and interest in the class. Other students, however, were not so happy about Albert's passion. He was often teased for liking math and answering his teacher's questions. "

The study looked at how well people with lvPPA **understood the two stories**

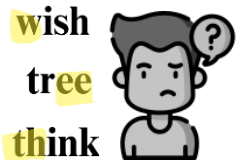
People with lvPPA **struggled to understand the details** of the stories compared to adults without lvPPA

The **EEG** showed that people with **lvPPA** had more brain activity in the **theta band** than adults without lvPPA**. The theta band** processes **syllables** instead of full words and sentences



Introduction

People with **lvPPA** struggle with understanding **speech sounds** called **phonemes**

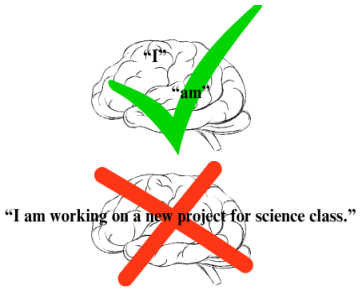


Phonemes are the **most basic elements** of speech

The brains of people with lvPPA may **accidentally hear the wrong phoneme**

People with lvPPA can also have **low phonological working memory**

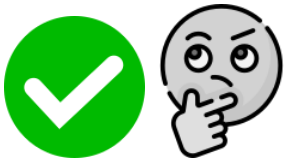
This means that they can **only hold small amounts of sound information** in their memory at a time. They **have a harder time** holding **longer words and sentences** in memory



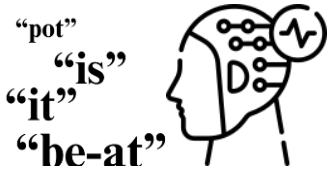
They also have **trouble finding the correct words** for things

"I used a ____ to scoop the yogurt."

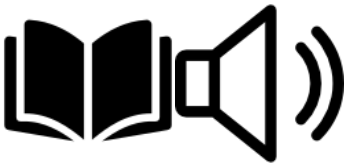
Sometimes they know the word they want to say but **cannot remember it**



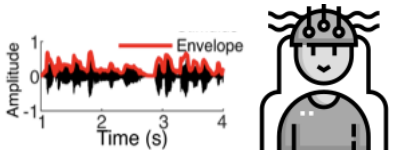
Past studies focused on how the brains of people with lvPPA respond to **shorter speech sounds** and **syllables**



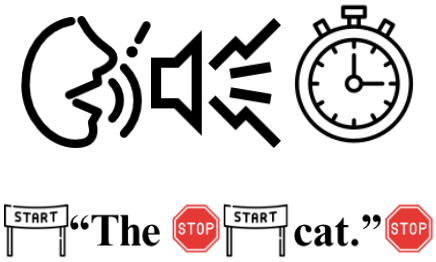
This study is different because **it looks at a whole story** to **understand how the brains of people with lvPPA** process natural speech



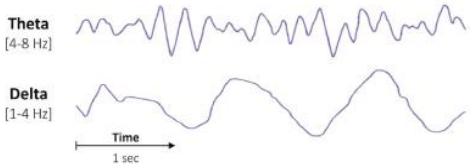
Participants had EEGs done to see how their brains process **speech envelopes.** The researchers call this **cortical tracking of the speech envelope**



Cortical tracking of the speech envelope means the researchers study **how the brain** follows **changes in speech loudness over time.** It also helps mark **where words start and end**

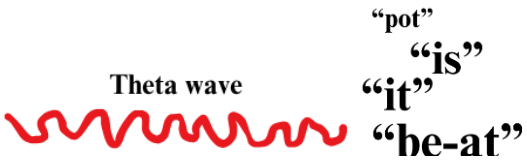


This relies on **delta and theta waves** from the brain's activity

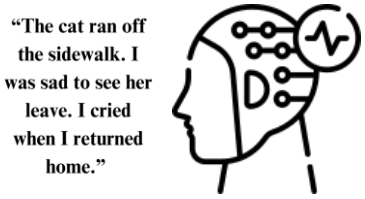


Delta waves track longer speech, like **words, phrases,** and **sentences**

Theta waves track **shorter** speech, like **phonemes** and **syllables**

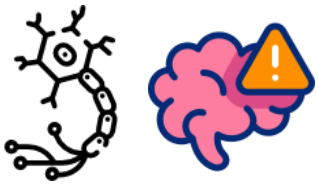


The researchers used **TRF (temporal response function) modeling**, which uses math to explain the brain's response to a stimulus. In this study, the stimulus was the speech envelope.

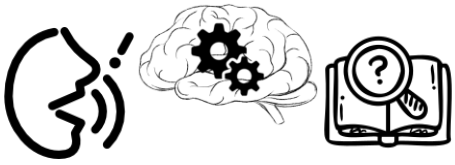


The TRF tells researchers which **aspects of speech** the brain is **processing**

Past studies suggest that problems in lvPPA come from **brain damage** in the **temporoparietal** area of the brain

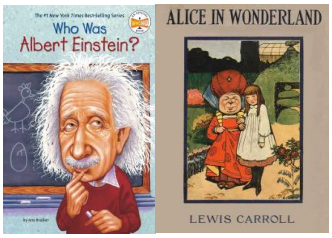


The **temporoparietal** area of the brain **processes speech stimuli** and **helps the brain apply meaning** to speech



The researchers expected that people **with lvPPA** will have **different cortical tracking of the speech envelope** than those **without lvPPA**

Participants listened to **two stories** that use **everyday speech** with full words and sentences

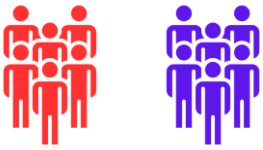


Participants & Methods

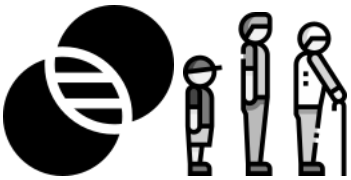
Participants

Dial et al., (2021) **included people without lvPPA** (controls) to better **understand how lvPPA affects the brain**

There were **10** people in the **lvPPA group** and **10** people in the **without-lvPPA group**

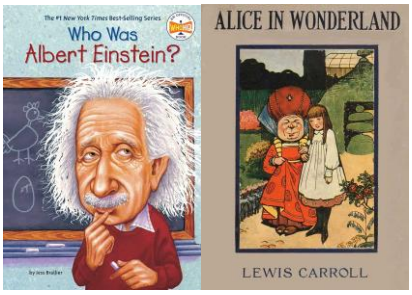


Both participant groups were **similar in age**



Methods

Participants listened **to two stories: *Alice's Adventures in Wonderland*** and ***Who Was Albert Einstein.*** Both stories were 15 minutes long.



Two multiple choice questions about the story were asked after every minute of story

What was Albert Einstein's favorite subject in school?

A. English

B. Woodshop

C. Math

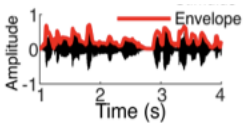
D. Theatre

These questions tested **how well** participants **understood** the stories

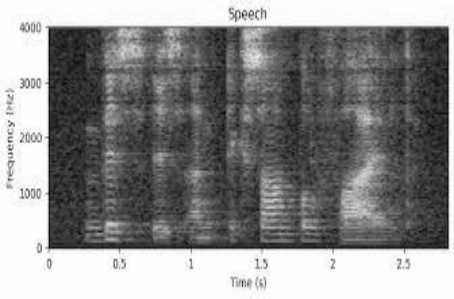
Each participant had their **EEG data** recorded as they listened to both stories

Speech Envelope

A **speech envelope** tells us how **loudness changes over time**. It tells you the **general shape of the sound**, like where it begins and ends.



The **sound** from the two stories in this study was represented using **16 speech envelopes.** One envelope was used for each of **16 frequency bands.** The lower frequency bands are for lower pitches and the higher frequency bands are for higher pitches.

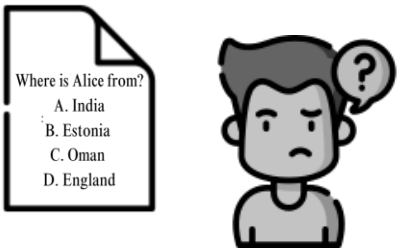


The sound **envelopes** were **edited** to act like our **inner ear.** This is why there were **16 frequency bands.**

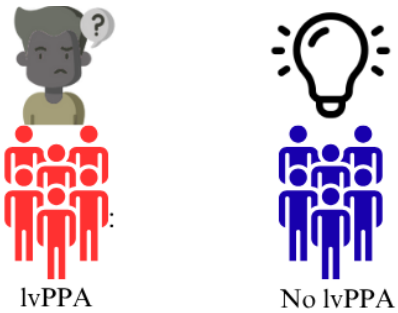
The researchers were interested in where **sound starts or stops quickly** because this tells us when words start and stop. This is important for speech understanding.

Results

Participants with lvPPA had **more trouble answering multiple choice questions.**

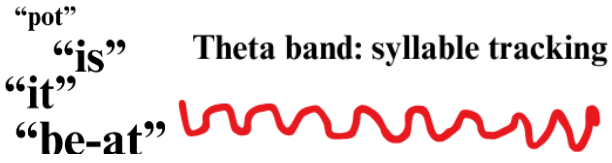


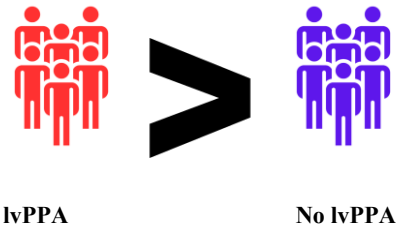
This means participants with lvPPA **had more trouble understanding** the **story details** compared to the non-lvPPA group



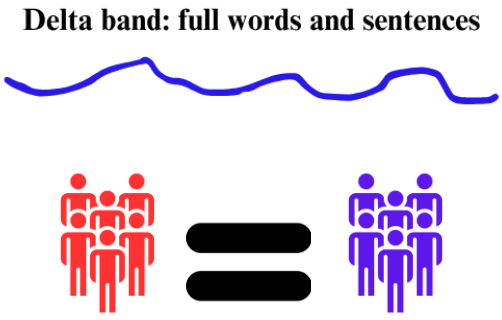
EGG data showed **different cortical tracking of the speech envelope** for **participants with lvPPA** and **participants without lvPPA**

The **lvPPA group** had **larger cortical tracking of the speech envelope** for **theta waves**, meaning that they processed **shorter speech sounds** more than participants without lvPPA



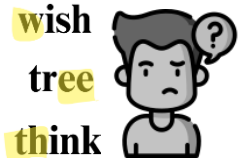


There were **no differences in cortical tracking of the speech envelope** in the **delta band**

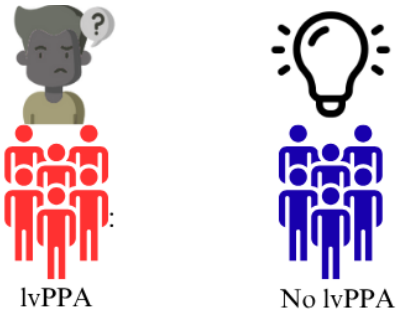


Discussion

People with **lvPPA** struggle with understanding **speech sounds**

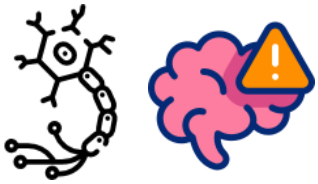


This study by Dial et al. (2021) found that **participants with lvPPA** had **difficulty understanding stories** compared to the non-lvPPA group



They also showed that people with lvPPA have **changes in cortical tracking of the speech envelope** in **theta waves,** which represent **syllables** and **short speech sounds**

The findings make sense based on the brain damage seen in lvPPA. This **brain damage** is in the **temporoparietal region** of the brain: an area responsible for **speech sound processing**



People with lvPPA may be **focused** on these **smaller units of speech** to help their speech comprehension, but this **may not be helpful enough** to totally understand the story.

Cortical tracking findings from this study **may lead to more accurate diagnoses of PPA and its subtypes**