Cortical thickness, speech impairments, and cognitive abilities in speakers with amyotrophic lateral sclerosis

Jeannine Bradsby[1], Sanjay Kalra[2], Avyarthana Dey[2], Liziane Bouvier[1,3]
[1]Laboratory for Impaired Production of Speech, McGill University; [2]Neuroimaging Research Unit, University of Alberta, [3]Centre de Recherche Interdisciplinaire en Réadaptation du Montréal métropolitain (CRIR & IURDPM)

BACKGROUND & AIM

What is ALS [1]
- Neurodegenerative disease affecting motor neurons
  - central and peripherous nervous systems
- 80% of patients develop bulbar dysfunction
  - motor speech, swallowing, salivation
- 50% of patients show evidence of cognitive and/or behavioral decline during the disease course

Brain imaging in ALS [2,3]
- Cortical thinning and reduced gray matter density of motor, extramotor, and frontotemporal regions
- Bulbar motor dysfunction linked to white matter abnormalities

Speech and cognitive impairments in ALS [4,5]
- Reduced speaking rate and articulation rate
- Impaired language and executive function
- Cognitive impairment contributes to neurodegeneration affecting performance on speech and pause measures

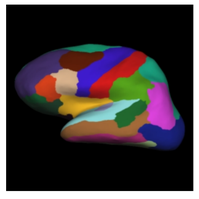
OBJECTIVE

To examine the effects of cognition on the relationship between speech and pause analysis (SPA) measures and cortical thickness (CT) in patients with ALS.

METHOD

Participants
- 204 participants recruited from CALSNIC [6]
  - 11 bulbar onset, 104 spinal onset, 5 mixed
  - 84 age and sex matched healthy speakers
- 2.8 to 259.7 months post-onset (M=42.56,D=46.03)

Imaging
- CT measurements corrected for site, age, sex, and years educated
- Desikan-Killiany Free Surfer atlas used for ROIs [7]



Speech assessment [8]
- Bamboo Passage Reading
- Acoustic analyses –> SPA measures

Cognitive assessment [9]
- ECAS: total score, ALS specific, verbal fluency, executive function

Statistical analyses
- Simple linear regression and mediation analyses using PROCESS in SPSS [10]

RESULTS

Table 1. Linear regressions and mediation analyses for patients with ALS (left) and healthy controls (right).

Analysis	Measure	LH cmf	LH paro	LH prec	LH rmf	LH sufr	LH sute	RH cmf	RH prec	RH rmf	RH sufr	RH sute
Linear regression - SPA												
	Speaking Rate	✗	✗	✓	✗	✗	✓	✓	✗	✗	✗	✓
	Articulation Rate	✗	✗	✓	✗	✗	✓	✓	✓	✗	✗	✓
	% Pause	✓	✗	✗	✓	✗	✓	✓	✗	✗	✓	✓
	CV Phrase	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Linear regression - ECAS												
	ECAS Verbal Fluency	✓	✗	✗	✓	✓	✗	✓	✗	✓	✓	✗
	ECAS ALS Specific	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
	ECAS Executive Function	✗	✓	✗	✗	✗	✗	✗	✗	✗	✗	✗
	ECAS Total	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
Mediation - ECAS Verbal Fluency												
Direct effect	Speaking Rate	✗			✗	✗		✓		✗	✗	
	Articulation Rate	✗			✗	✗		✓		✗	✗	
	% Pause	✗			✗	✗		✓		✗	✗	
	CV Phrase	✗			✗	✗		✗		✗	✗	
Indirect effect	Speaking Rate	✗			✗	✗		✗		✗	✗	
	Articulation Rate	✗			✗	✗		✗		✗	✗	
	% Pause	✗			✗	✓		✗		✗	✗	
	CV Phrase	✗			✗	✗		✗		✗	✗	
Total effect	Speaking Rate	✗			✗	✗		✓		✗	✗	
	Articulation Rate	✗			✗	✗		✓		✗	✗	
	% Pause	✗			✗	✗		✓		✗	✗	
	CV Phrase	✗			✗	✗		✗		✗	✗	
Mediation - ECAS Executive functions												
Direct effect	Speaking Rate		✗									
	Articulation Rate		✗									
	% Pause		✗									
	CV Phrase		✗									
Indirect effect	Speaking Rate		✗									
	Articulation Rate		✗									
	% Pause		✗									
	CV Phrase		✗									
Total effect	Speaking Rate		✗									
	Articulation Rate		✗									
	% Pause		✗									
	CV Phrase		✗									

Analysis	Measure	LH prec
Linear regression - SPA		
	Speaking Rate	✗
	Articulation Rate	✗
	% Pause	✗
	CV Phrase	✗
Linear regression - ECAS		
	ECAS Verbal Fluency	✗
	ECAS ALS Specific	✓
	ECAS Executive Function	✗
	ECAS Total	✗
Mediation - ECAS ALS Specific		
Direct effect	Speaking Rate	✗
	Articulation Rate	✗
	% Pause	✗
	CV Phrase	✗
Indirect effect	Speaking Rate	✗
	Articulation Rate	✓
	% Pause	✗
	CV Phrase	✗
Total effect	Speaking Rate	✗
	Articulation Rate	✗
	% Pause	✗
	CV Phrase	✗

Note. LH, left hemisphere; RH, right hemisphere; cmf, caudal middle frontal gyrus; paro, pars opercularis; prec, precentral gyrus; rmf, rostral middle frontal gyrus; sufr, superior frontal gyrus; sute, superior temporal gyrus. SPA, Speech and Pause Analysis; ECAS, Edinburgh Cognitive and Behavioural ALS Screen; CV, coefficient of variation; ✓, significant; ✗, not significant.

CONCLUSION

Mediation analyses show:
- Significant direct and total effect in patients of RH caudal middle frontal gyrus on SPA measures with no mediation;
- Significant indirect effects, indicating mediation:
  - by cognition (ECAS VFT) on the relationship between % pause and LH superior frontal gyrus in patients;
  - by cognition (ECAS ALS specific) on relationships between articulation rate and LH precentral gyrus in healthy controls;
- Lack of significant total effect and significant indirect effect together could be related to reduced statistical power.

Regions known to be associated with language (e.g. pars opercularis and pars triangularis) not significant, might indicate:
- Relationships skewed by the neurodegeneration that occurs during ALS;
- Cognitive changes are so widespread as to minimize the importance of degeneration in a single area.

Results suggest that:
- Patterns of neurodegeneration, rather than focal neurodegeneration, are responsible for changes in speech;
- Deficits in pausing measures reflect underlying cognitive impairment in areas not directly effecting performance on SPA measures;
- The RH caudal middle frontal gyrus could be an important region to consider when examining speech related changes in conjunction with neuroimaging in the absence of cognitive data.

References

Acknowledgements

We would like to thank the participants and their families for their collaboration.

Created with BioRender Poster Builder