Functional and structural brain aging and speech perception: new evidence

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I. INTRODUCTION

Speech perception difficulties are common amongst elderlies; yet the underlying neural mechanisms are still poorly understood. New empirical evidence suggests that brain senescence may be an important contributor to these difficulties.

Understanding age-related vulnerabilities of the neural speech system is critical to developing new intervention strategies to maintain communication throughout aging.

Here we investigated the relationship between structural and functional brain senescence and speech perception skills in aging.

II. MATERIAL & METHODS

1. Participants: *see Table 1.*

Table 1. Participants characteristics by age group

	Young adults (N = 11)				Older adults (N = 11)			
	Minimum	Maximum	Mean	Std. Deviation	Minimum	Maximum	Mean	Std. Deviation
Age	21.00	32.00	25.73	3.88	61.00	74.00	68.00	4.56
Education	15.00	21.00	17.45	2.02	11.00	33.00	17.55	5.73
Handedness	18.00	20.00	19.27	.90	19.00	20.00	19.82	.40
MOCA	27.00	30.00	29.18	1.08	26.00	29.00	27.18	1.08
Depression scale	.00	6.00	2.27	2.24	.00	5.00	1.00	1.79

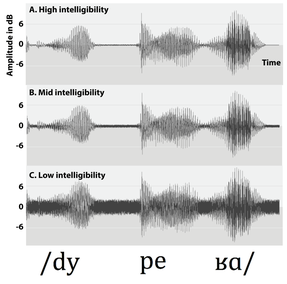
2. Hearing assessment: (1) pure tone audiometry, (2) speech recognition threshold, and (3) distortion product oto-acoustic emissions recording (DPOAEs) **(Fig 4-5)**.

3. Stimuli: 81 meaningless sequences of three French syllables presented through MRI-compatible headphones.

4. Task: participants' task was to repeat the stimuli as quickly as possible.

- Subjects' verbal responses were recorded using a high quality MRI compatible optical microphone.
- Intelligibility of the stimuli was manipulated by adding white noise to the sequences to reach a dB SNR of either 20 (mid) or -5 (low) **(see Fig. 1)**.

Figure 1



5. MRI data acquisition:

o Philips 3.0 Tesla Achieva TX.

o 108 Single-shot EPI BOLD functional images with sparse sampling parallel acquisition technique (40 interleaved slices (3 mm3, no gap); SENSE = 2; TR = 6000 ms; acquisition time = 2140 ms, delay in TR = 3860 ms; TE = 30 ms; FOV = 240 mm 2; 80 x 80 matrix).

o All stimuli were presented during the delay in TR **(see Fig. 2)**.

6. MRI data analyses:

Pre-processing and data analyses were done in AFNI/SUMA. All analyses were controlled for hearing differences using right ear PTA and right ear DP-OEAs as covariates and corrected for multiple comparaisons using a Monte Carlo procedure. Analyses included: 1. Conjunction of all intelligibility levelsfor each subject **(Fig. 7)**; 2. Group-level permutation corrected ANCOVA to examine the effect of age and intelligibility on BOLD (Fig. 8-9); 3. Cortical thickness analyses focusing on the effect of age **(Fig. 10)**; 4. ROI-based mediation analyses to link behavioural, thickness and BOLD data (**Fig. 11**).

Figure 3: *fMRI setup*

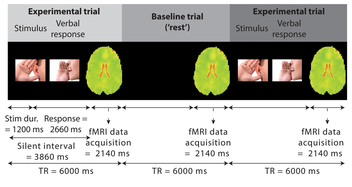
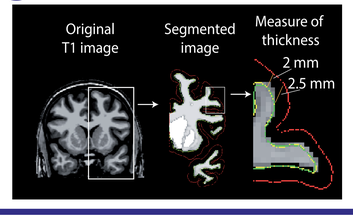


Figure 2: *Cortical thickness*



III. RESULTS & DISCUSSION

- Speech accuracy decreased as a function of intelligibility and age after controlling for hearing differences and sex ($F(2,34) = 4.54$, $p = .018$) **(Fig. 6)**.
- Several cortical regions including the right supramarginal gyrus, posterior right insula, left anterior insula, right medial prefrontal cortex, left precentral gyrus and sulcus were thinner in older adults.
- The core speech network decreases in spatial extent in older adults **(Fig. 7)**. This decline had a beneficial indirect effect on the relationship of age to performance.
- Age-independent intelligibility effects on BOLD signal were found in several motor and premotor areas, including the left ventral premotor cortex and the right SMA **(Fig. 8)**.
- Age-dependent intelligibility effects were also found, mainly in sensorimotor areas, and in left anterior insula **(Fig. 9)**.
- In the left anterior insula we found a detrimental indirect effect on the relationship of age to accuracy through BOLD signal magnitude **(Fig. 10)**. This suggests a role for this region in maintaining speech perception in older ages
- One of the most intriguing finding of this study is the relative dissociation between functional and structural aging. **(Fig. 11)**.

Figure 4: *Audiometry*

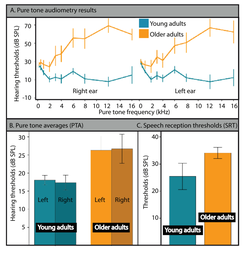


Figure 5: *DPOEAs*

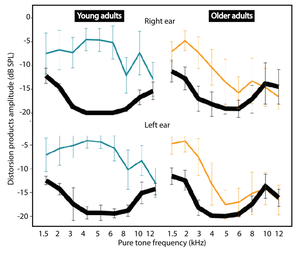


Figure 6: *Repetition accuracy*

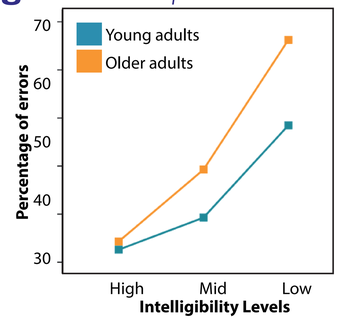


Figure 7: *Conjunction analysis*

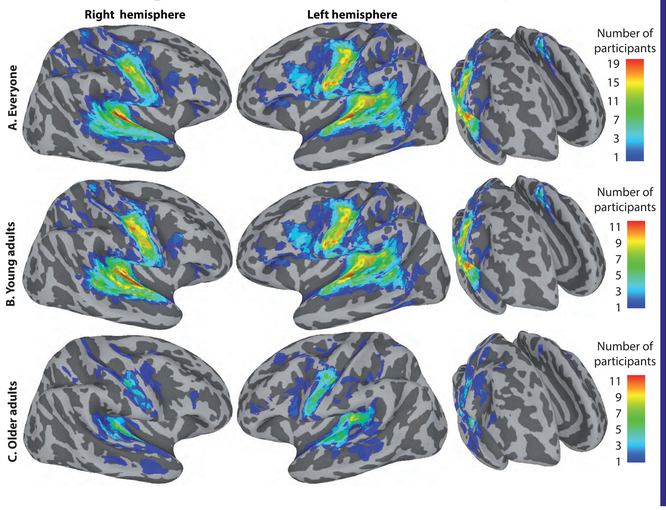


Figure 8: *Intelligibility effects on BOLD*

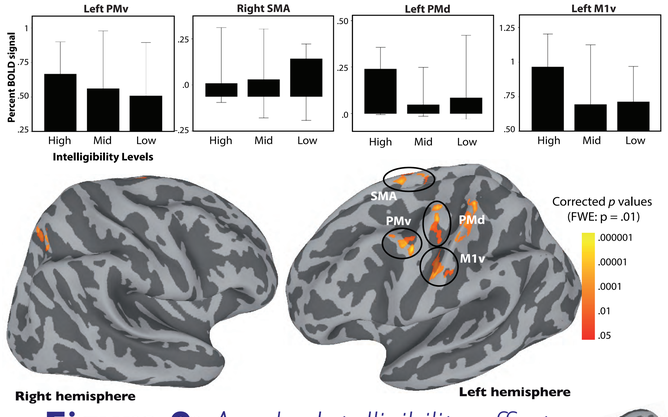


Figure 9: *Age by Intelligibility effects*

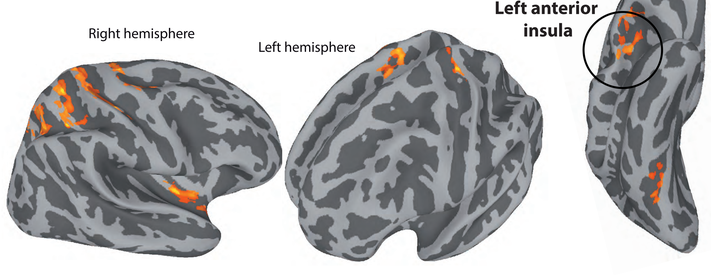
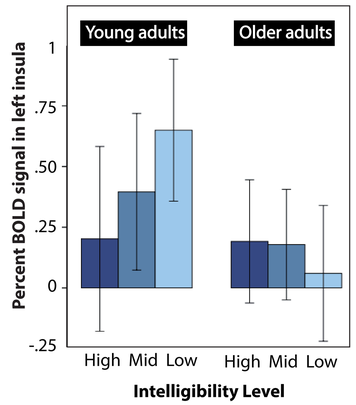


Figure 10: *Left anterior insula*

A. BOLD signal pattern



B. Mediation analysis

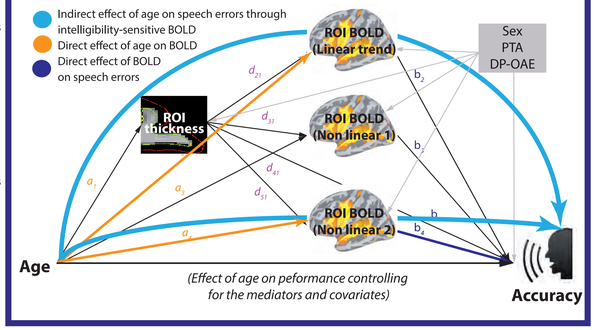
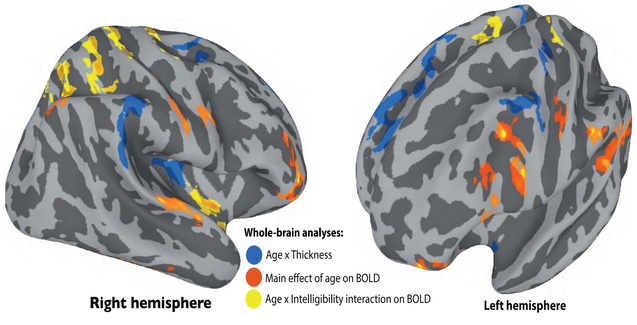


Figure 11: *Comparaison of BOLD and Thickness results*



IV. CONCLUSIONS

In conclusion, we demonstrated important age-related structural and functional neural differences associated with speech perception not accounted for by peripheral hearing loss, which demonstrate the importance of neurobiological factors in the aetiology of age-related speech difficulties.