The role of statistical learning in speech processing of dogs as evidenced by awake fMRI

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Introduction

Human infants are tuned to spoken language from birth and use **computational strategies** to detect the statistical and prosodic patterns in a language input[1].

In contrast there is a limit to language capacity in non-human species, which is especially apparent in vocabulary acquisition[2]. Although, there is behavioural evidence for statistical learning in some mammals[3,4], the neural basis of this ability is not known in non-human species.

Dogs live in the **same language environment** as humans, they attend to spoken words and process them similarly to humans, as evidenced from neuroimaging studies[5,6]. Consequently, the aim of the present study is to investigate if a **neural attunement to statistical regularities** in language can be observed in dogs, similarly to humans [7-10].

Methods

Stimuli: Two sets of 12 syllables forming two conditions – equal frequency, different transitional probabilities (TP, the conditional probability of one syllable following the other):

Word: **daropi**golatu**pabikutibudo**golatu**daropitibudo**

TP 1 0,3 1 1

Random: **pefimunovukabafugivikogabanokagifimukope**

TP 0,09 0,09 0,09 …

Subjects: 18 fMRI trained family dogs (8 males, mean age 5,5 yrs)

Acquisition details: Sparse sampling, 8 channel coil, 32 transverse slices, acquisition matrix 80 × 58; TR=7700 ms, including 1700 ms acquisition and 6000 ms silent gap; TE=12 ms; flip angle=90°

Data preprocessing SPM12 (realignment, manual coregistration, normalization to an in-house template, smoothing 4mm FWHM)

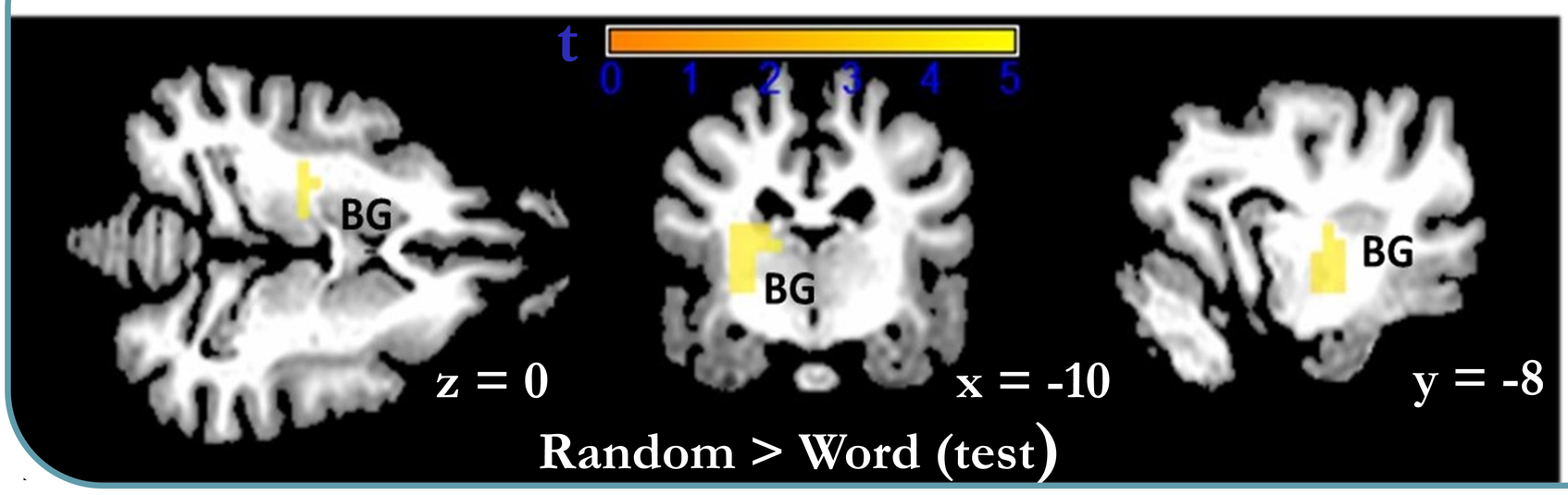
Procedure: 3 sessions following each other immediately

Baseline fMRI	Exposition	Test fMRI
3 blocks per condition	10 blocks per condition	3 blocks per condition
5 blocks of silence	no silence	5 blocks of silence
~5 mins	2 x 8 mins	~5 mins

Comparisons:

1. Pre vs post exposition
2. Word vs Random condition

Results



No difference between the word and random condition in the **baseline** fMRI measurement.

Stronger response for the random than for the word condition in the **test** fMRI measurement in the **left basal ganglia**.

Activity rendered on a template dog brain. Cluster size threshold: $p_{FWE}<.05$

Conclusions

- Similarly to rats [4] and cotton top tamarins[3], dogs can quickly (~20 mins exposure) learn and extract statistical regularities found in a linguistic input
- However, in dogs this ability is mediated by the basal nuclei, which are known to support sequence learning in humans[11] and other animals[12]
- This mechanism is different from that found in humans, where statistical language learning predominantly involves language processing areas (superior temporal gyrus, inferior frontal gyrus and ventral premotor cortex) [7-10]

References

1. Saffran et al., 1996
2. Savage-Rumbaugh et al., 1980
3. Toro et al., 2005
4. Hauser et al., 2001
5. Andics et al., 2014
6. Boros et al., 2020
7. McNealy et al., 2008
8. McNealy et al., 2010
9. Cunillera et al., 2009
10. Karuza et al., 2013
11. Jin & Costa, 2015
12. Winocur & Eskes, 1998

Acknowledgements

Funded by the Hungarian Academy of Sciences Lendület grant no LP2017 - 13/2017 awarded to Attila Andics