The robustness of repetition-based rule learning in infants: a meta-analysis of fNIRS language studies

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INTRODUCTION

- Infants can learn simple repetition-based structures in the form of AAB and ABB patterns (Marcus 1999, Gervain et al 2008, 2012)
- Rule-based learning has a pivotal role in language acquisition
- The neural foundations of this mechanism have been long investigated with functional near-infrared spectroscopy (fNIRS), but to date, a quantitative analysis of its effect size is missing
- There are several possible sources of variability, including individual characteristics (sex, age)

WORK OBJECTIVES

1. Evaluate effect size of repetition-effect measured by NIRS
2. Quantify its variability across studies, brain regions, age groups
3. Explore sex differences as potential source of variability

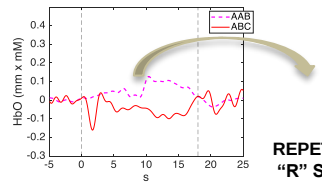
METHODS: DATA

Eight fNIRS studies on repetition-based learning (published and unpublished) conducted between 2008 and 2018 in three different labs

ID	Lab	#trials/cond	Age group	Device	Fs (Hz)	M	F
1	Paris	14	Newborns	NIRx	10	9	15
2	Paris	3	6 months	NIRx	15.62	10	8
3	Paris	12	Newborns	NIRx	15.62	12	12
4	Trieste	7	Newborns	Hitachi	10	8	3
5	Paris	7	6 months	NIRx	15.62	5	8
6	Paris	7	6 months	NIRx	15.62	8	7
7	Vancouver	14	Newborns	Hitachi	10	13	9
8	Trieste	14	Newborns	Hitachi	10	10	12
Total						**75**	**74**

Stimuli: Auditory adjacent repetition sequences (either initial or final, AAB/ABB) vs random control sequences (ABC)
Optodes arrangement: Frontal, temporal ROIs (bilateral)

METHODS: ANALYSIS



REPETITION "R" SCORE

= difference AAB – ABC in the mean value of the signal

META-ANALYTIC EFFECT SIZE

$$d = \frac{AVG\ (Individual\ R\ scores)}{STD(Individual\ R\ scores)}$$

Meta-analytic approach
(to estimate robustness and variability across studies)
R package: *metafor*

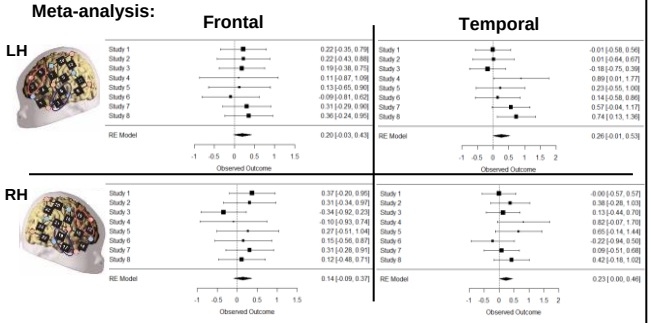
INDIVIDUAL EFFECT SIZE

$$d = \frac{Individual\ R\ score}{Pooled\ STD(R, N\ trials)}$$

Mixed-effects model
(to explore the impact of individual characteristics on variability)
R package: *lmer*

RESULTS

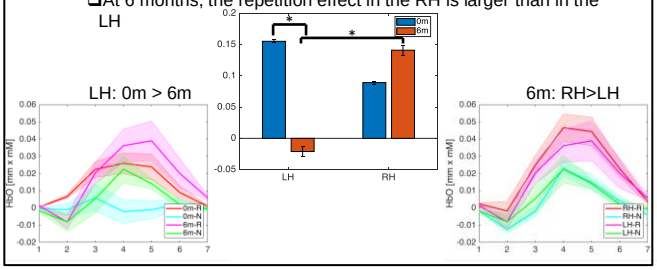
Meta-analysis:



Individual level analysis:

- No significant effect of sex
- Significant **Age X Hemisphere** interaction ($F(1, 366)= 5.81$, $p<0.05$)

  - In the LH, newborns show larger effect than 6-month-olds
  - At 6 months, the repetition effect in the RH is larger than in the LH



CONCLUSIONS

- Repetition-effect in infants as measured by NIRS is robust and replicable (d_z= 0.26 [-0.01 0.53] in the left temporal area)
- Consistently with expectations, in the left hemisphere newborns show larger effect than six-months-olds
- Rule-learning shows no sex differences: differences in language skills often reported are likely to be associated to other differences
- Variability can likely be ascribed to several factors, both related to the experimental settings (lab practices, different hardware, experience of the experimenter) and to physiology (variability of infant hemodynamic responses) , to be further explored.

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