



Emerging word segmentation skills in atypical development

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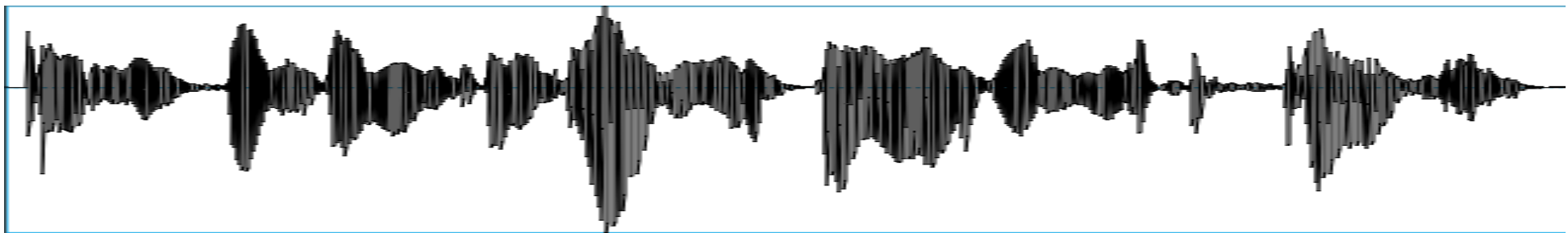
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Introduction

The word segmentation problem: when and how infants begin to segment word-like forms from the continuous speech stream?

édifícilencontraruma palavranesta frase



CHALLENGE!

It is difficult to find a word in this utterance



Typically developing (TD) infants

- Early word segmentation plays a crucial role in language acquisition (i.e., word learning – Newman et al., 2006; Singh et al., 2012; Kidd et al., 2018; Hoareau et al., 2019)
- Segmentation abilities in TD infants have been shown to **vary across languages** (e.g., Jusczyk & Aslin, 1995; Jusczyk et al., 1999; Seidl & Johnson, 2006; Hohle & Weissenborn, 2003, 2005; Bosch et al., 2013; Nazzi et al., 2006; Nazzi et al., 2014; Nishibayashi et al., 2015; Berdasco-Muñoz et al., 2018)
- Segmentation abilities are **modulated by prosodic structure**: Words at prosodic edges, namely utterance-final position, are segmented earlier than in utterance-medial position (e.g., Johnson et al., 2014; Butler & Frota, 2018)



Atypical development I

Familiarized with words; Tested with passages

- Only a few studies on segmentation abilities in atypical development: Development of this ability is **seriously delayed**, but the **learning path** is **similar** to TD (Nazzy, Paterson & Karmiloff-Smith, 2003; Mason-Apps et al., 2011; Mason-Apps et al., 2018)

Clinical Group	Language	Bisyllabic		Age/CDI
		Trochaic (7.5m)	Iambic (10.5m)	
Williams Syndrome (19)	English	33 m/19 m	Failed	No/No
Down Syndrome (9)	English	18-20 m/- - -	Failed	-/No
Down Syndrome (11)	English	18-20m/9-11m	Failed	No later outcomes



Atypical development II

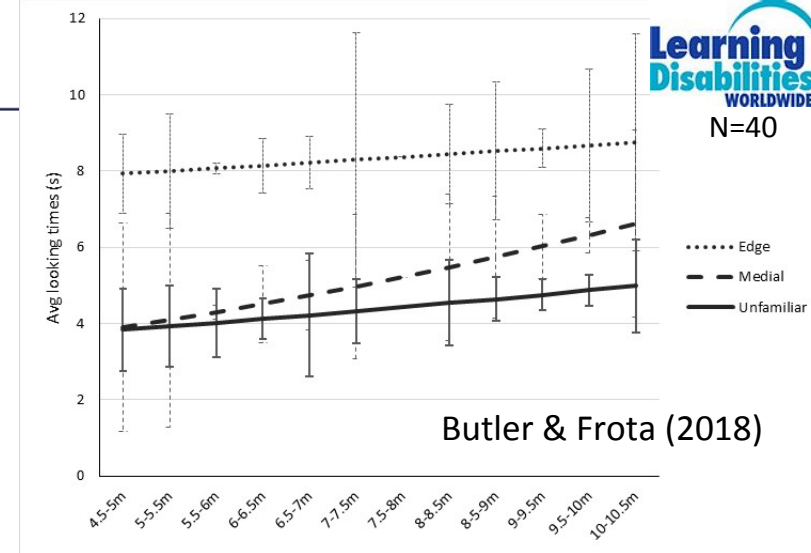
Familiarized with passages; Tested with words

- Two studies on segmentation abilities in infants at risk for language impairments – preterm infants: **Mixed findings** (Bosch, 2011; Berdasco-Muñoz et al., 2018)

Group	Language	Succeeded	Failed	Full-term
8-month olds (maturational)	Spanish Catalan	–	CVC, CCVC	Do it
6-month-old (post-natal)	French	CV	–	Do it



Current study



- Early segmentation abilities in European Portuguese (EP)-learning infants with **Down Syndrome (DS)** and **at-risk for language impairment (AR)**
 - Premature birth and familial risk for autism or language disorder
- Goals
 - Examine **whether prosody facilitated word segmentation**, as previously shown for TD infants (Butler & Frota, 2018)
 - Early segmentation for prosodic-edge only (earliest evidence for segmentation in the literature)
 - Segmentation at utterance-medial position still developing by 10 months
 - As lexical acquisition seems to be delayed in DS and AR (Sansavini et al., 2011), we further asked **whether prosody modulated the relation between segmentation abilities and lexical knowledge**



Atypical development



- If similar mechanisms and/or trajectories guide word segmentation, a similar pattern of results is expected, albeit possibly delayed.



Method

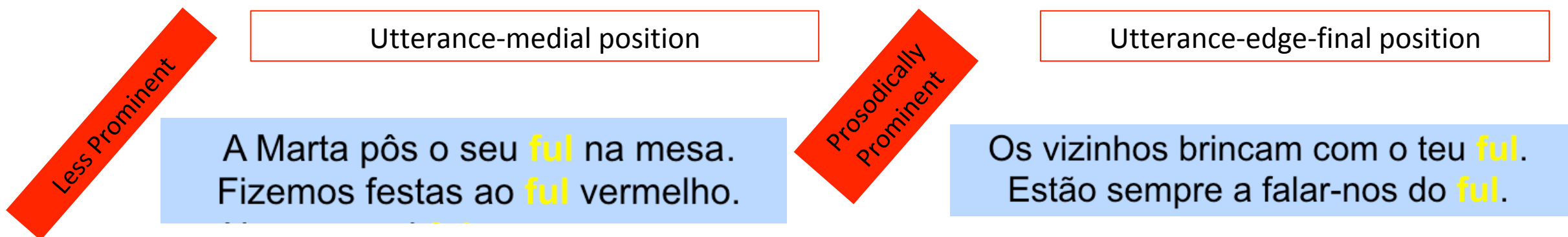
Participants

- **DS:** 25 infants and toddlers (12 girls, mean age 16 months and 12 days, range 7 to 23 months)
- **AR:** 21 infants and toddlers (10 girls, mean age 15 months and 17 days, range 6 to 26 months)
 - preterm birth < 37 weeks (9), familial risk for autism or language disorder (9), and other factors like low Apgar score and reanimation at birth (3)
- Monolingual homes; Normal hearing; Normal or corrected-to-normal vision; No history of seizures/other medical or neurological conditions



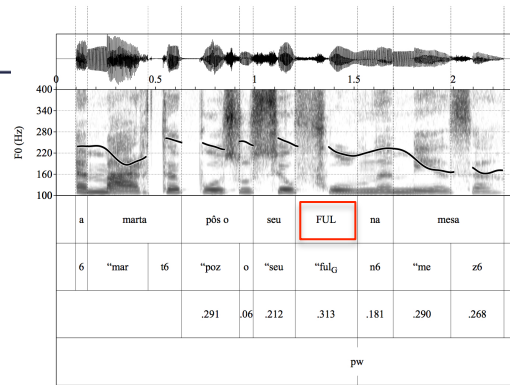
Stimuli

- 4 monosyllabic pseudo words (CVC/CVG)
 - Ful, Queu, Pis, Sau
- 2 passages constructed for each word, one for **medial** and one for **edge** prosodic conditions; 4 word-lists from different spoken exemplars

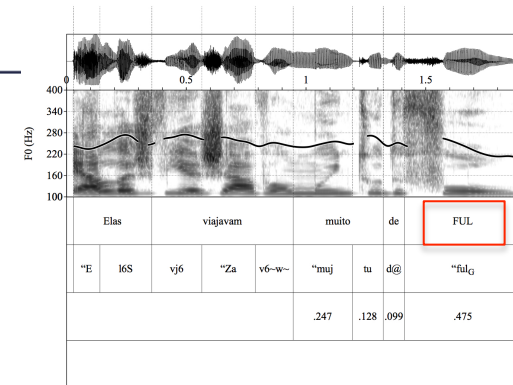


http://labfon.lettras.ulisboa.pt/babylab/infant_word_segmentation/word_segmentation_supporting_materials.htm





Stimuli



	Medial		End		
	Mean	SD	Mean	SD	
Sentence Length (ms)	2000.63	143.36	1952.88	154.91	1.11, $p = .27$
Syllable Duration Before Boundary (ms)	308.79	52.49	494.50	53.60	12.13, $p < .001$
Syllable Duration After Boundary (ms)	203.46	67.98	-	-	-
Pitch Range (Hz)	-24.52	32.32	-59.58	21.83	4.4, $p < .001$
Tonal Event	-		L%		-

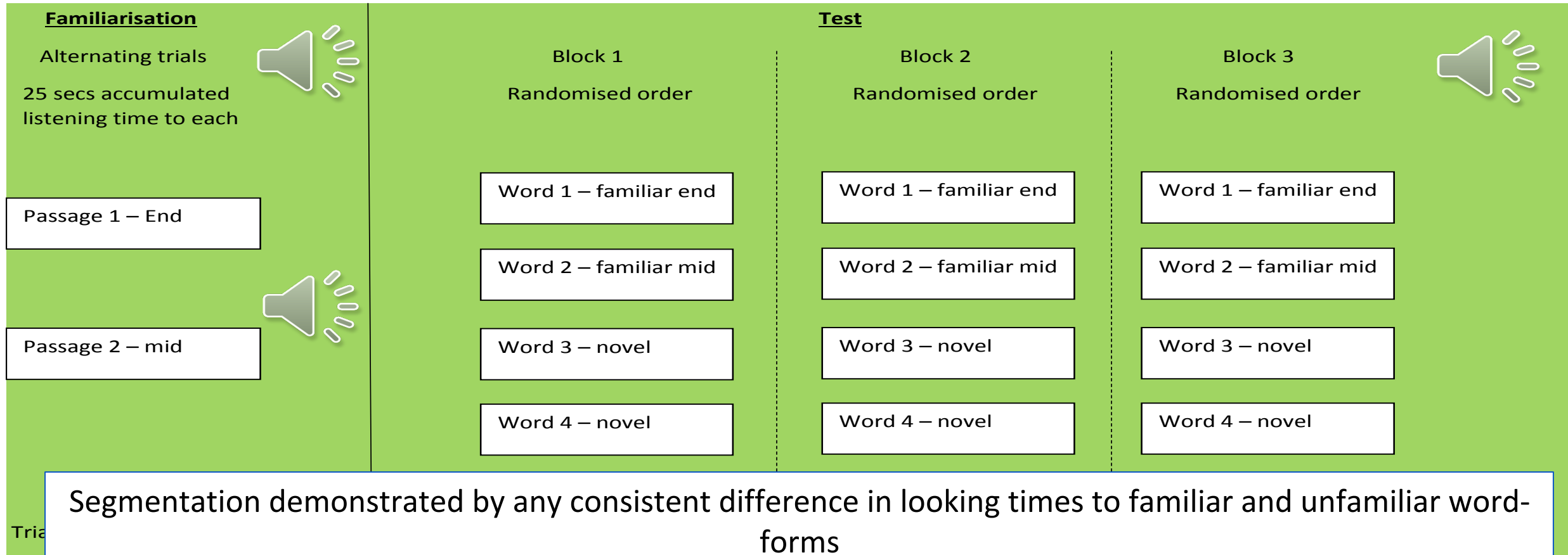
Butler & Frota, 2018



Procedure

Familiarized with passages; Tested with words

Modified version of the visual habituation paradigm (Altvater-Mackensen & Mani, 2013)





Lisbon Baby Lab



Measuring concurrent language abilities

EP version of the MacArthur Bates Communicative Development Inventory (CDI) short forms

<http://labfon.letras.ulisboa.pt/babylab/pt/CDI/>

CLUL | FLUL | FCT
Fundação para a Ciência e a Tecnologia

CDI para o Português Europeu – Forma reduzida: Nível I
Adaptação autorizada do MacArthur-Bates CDI. Copyright 2013, ISBN 978-989-97373-9-8
http://www.flul.pt/babylab/letras/ulisboa/pt/CDI_Portugues_Europeu.html

Nome da criança _____ Sexo F ☐ M ☐
Data de nascimento ____/____/____ Data de hoje ____/____/____

Instruções

Para palavras que a criança compreende mas ainda não diz, assinala a primeira coluna (Compreende). Para palavras que a criança compreende mas também diz, assinala a segunda coluna (Compreende e diz). Se a criança usa uma forma diferente de dizer a palavra, assinala-a na mesma (ex: 'nana' para banana). No caso de palavras que podem ter uma forma masculina e feminina, ou singular e plural (ex: bonito, bonito, bonitos, bonitas), responda considerando qualquer uma das formas. Inclua ainda as formas com -inho/a (ex: bonitinho, bonitinha, bonitinhos, bonitinhas). Considere também as várias formas do mesmo verbo (ex: dar, dá, deu).

	Compreende	Compreende e diz		Compreende	Compreende e diz		Compreende	Compreende e diz
ai	<input type="radio"/>	<input type="radio"/>	biberão	<input type="radio"/>	<input type="radio"/>	cal/calir	<input type="radio"/>	<input type="radio"/>
ão (sem do animal)	<input type="radio"/>	<input type="radio"/>	colher	<input type="radio"/>	<input type="radio"/>	canta/cantar	<input type="radio"/>	<input type="radio"/>
brum-brum	<input type="radio"/>	<input type="radio"/>	copo	<input type="radio"/>	<input type="radio"/>	dá/dar	<input type="radio"/>	<input type="radio"/>
piu-piu (sem do animal)	<input type="radio"/>	<input type="radio"/>	escova	<input type="radio"/>	<input type="radio"/>	espera/esperar	<input type="radio"/>	<input type="radio"/>
cão	<input type="radio"/>	<input type="radio"/>	garfo	<input type="radio"/>	<input type="radio"/>	gosta/gostar	<input type="radio"/>	<input type="radio"/>
galinha	<input type="radio"/>	<input type="radio"/>	luz	<input type="radio"/>	<input type="radio"/>	para/parar	<input type="radio"/>	<input type="radio"/>
gato	<input type="radio"/>	<input type="radio"/>	manta	<input type="radio"/>	<input type="radio"/>	puxa/puxar	<input type="radio"/>	<input type="radio"/>
leão	<input type="radio"/>	<input type="radio"/>	cadeira	<input type="radio"/>	<input type="radio"/>	rir/rir	<input type="radio"/>	<input type="radio"/>
pato	<input type="radio"/>	<input type="radio"/>	came	<input type="radio"/>	<input type="radio"/>	salta/saltar	<input type="radio"/>	<input type="radio"/>
rato	<input type="radio"/>	<input type="radio"/>	cozinha	<input type="radio"/>	<input type="radio"/>	tira/tirar	<input type="radio"/>	<input type="radio"/>
carro	<input type="radio"/>	<input type="radio"/>	mesa	<input type="radio"/>	<input type="radio"/>	toma/tomar	<input type="radio"/>	<input type="radio"/>
triciclo	<input type="radio"/>	<input type="radio"/>	televisão	<input type="radio"/>	<input type="radio"/>	atua	<input type="radio"/>	<input type="radio"/>
bola	<input type="radio"/>	<input type="radio"/>	água	<input type="radio"/>	<input type="radio"/>	bom	<input type="radio"/>	<input type="radio"/>
boneco	<input type="radio"/>	<input type="radio"/>	árvore	<input type="radio"/>	<input type="radio"/>	bonito	<input type="radio"/>	<input type="radio"/>
livro	<input type="radio"/>	<input type="radio"/>	casa	<input type="radio"/>	<input type="radio"/>	depressa	<input type="radio"/>	<input type="radio"/>
banana	<input type="radio"/>	<input type="radio"/>	chuva	<input type="radio"/>	<input type="radio"/>	falo	<input type="radio"/>	<input type="radio"/>
bolo	<input type="radio"/>	<input type="radio"/>	flor	<input type="radio"/>	<input type="radio"/>	grande	<input type="radio"/>	<input type="radio"/>
leite	<input type="radio"/>	<input type="radio"/>	lua	<input type="radio"/>	<input type="radio"/>	já está	<input type="radio"/>	<input type="radio"/>
pão	<input type="radio"/>	<input type="radio"/>	pedra	<input type="radio"/>	<input type="radio"/>	mau/má	<input type="radio"/>	<input type="radio"/>
papa	<input type="radio"/>	<input type="radio"/>	rua	<input type="radio"/>	<input type="radio"/>	hoje	<input type="radio"/>	<input type="radio"/>
sopa	<input type="radio"/>	<input type="radio"/>	avó/vovó	<input type="radio"/>	<input type="radio"/>	noite	<input type="radio"/>	<input type="radio"/>
chapéu	<input type="radio"/>	<input type="radio"/>	bebê	<input type="radio"/>	<input type="radio"/>	este	<input type="radio"/>	<input type="radio"/>
fralda	<input type="radio"/>	<input type="radio"/>	mãe/mamã	<input type="radio"/>	<input type="radio"/>	meu/minha	<input type="radio"/>	<input type="radio"/>
meia(s)	<input type="radio"/>	<input type="radio"/>	menina	<input type="radio"/>	<input type="radio"/>	mim	<input type="radio"/>	<input type="radio"/>
sapato(s)	<input type="radio"/>	<input type="radio"/>	banho	<input type="radio"/>	<input type="radio"/>	onde	<input type="radio"/>	<input type="radio"/>
cabeça	<input type="radio"/>	<input type="radio"/>	chichi	<input type="radio"/>	<input type="radio"/>	quem	<input type="radio"/>	<input type="radio"/>
cabelo	<input type="radio"/>	<input type="radio"/>	colo	<input type="radio"/>	<input type="radio"/>	ali	<input type="radio"/>	<input type="radio"/>
dentes	<input type="radio"/>	<input type="radio"/>	cucu	<input type="radio"/>	<input type="radio"/>	fora	<input type="radio"/>	<input type="radio"/>
olho(s)	<input type="radio"/>	<input type="radio"/>	não	<input type="radio"/>	<input type="radio"/>	alguém	<input type="radio"/>	<input type="radio"/>
pé	<input type="radio"/>	<input type="radio"/>	olá	<input type="radio"/>	<input type="radio"/>	mais	<input type="radio"/>	<input type="radio"/>

(Frota et al. 2016)



Results - DS

- ✓ No clear evidence for segmentation
Familiar vs. Unfamiliar: $t(24)=1.9$, $p=.065$, Cohen's $d= .38$
- ✓ Overall, the DS group is **not segmenting**: no effect of the prosodic conditions
 $F(2,48)=0.8$, $p=.45$, $\eta^2=.03$

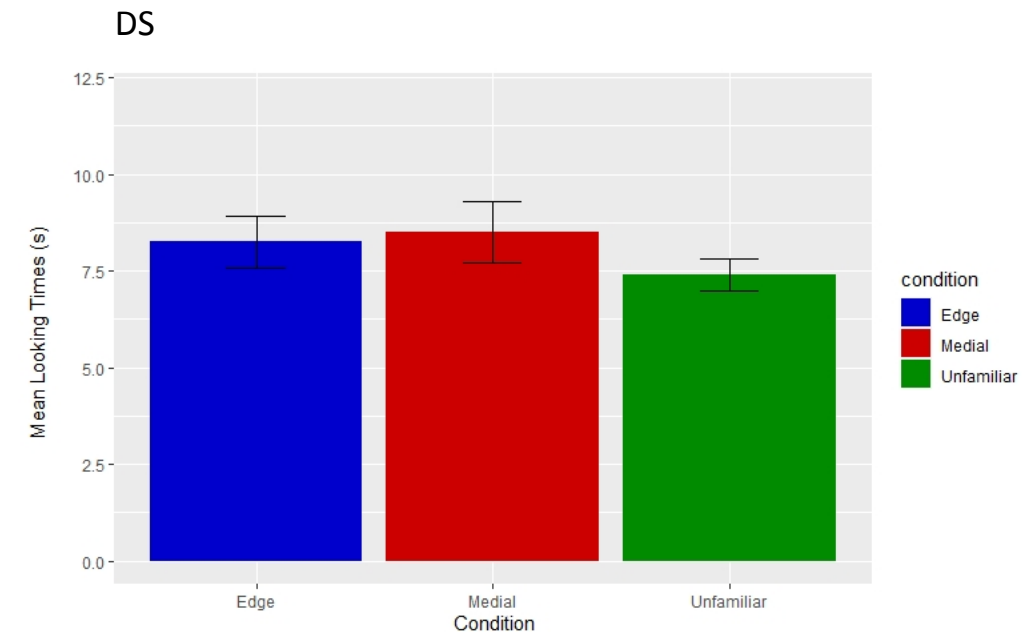


Fig. 1. DS Mean looking times (s) to edge, medial and unfamiliar.



Results - DS

✓ No age effect.

- ✓ Two age groups (CDI age range): younger (below 18 mos, mean 12 mos) older (above 18 mos, mean 20 mos)

RM ANOVA: No effect of prosodic condition, no effect of age group ($F(1,23)=0.7, p=.39, \eta^2=.02$) and no interaction ($F(2,46)=0.7, p=.46, \eta^2=.01$).

However, **medial** > unfamiliar in younger, but **edge** > unfamiliar in older. Only **edge** vs. unfamiliar in older approached significance ($p=.08$)

- ✓ Age as a continuous variable:
 $\text{lm}(\text{LT} \sim \text{condition} + \text{Age in Months})$
Condition, $F(2,71) < 1$; Age, $F(1,71) < 1$

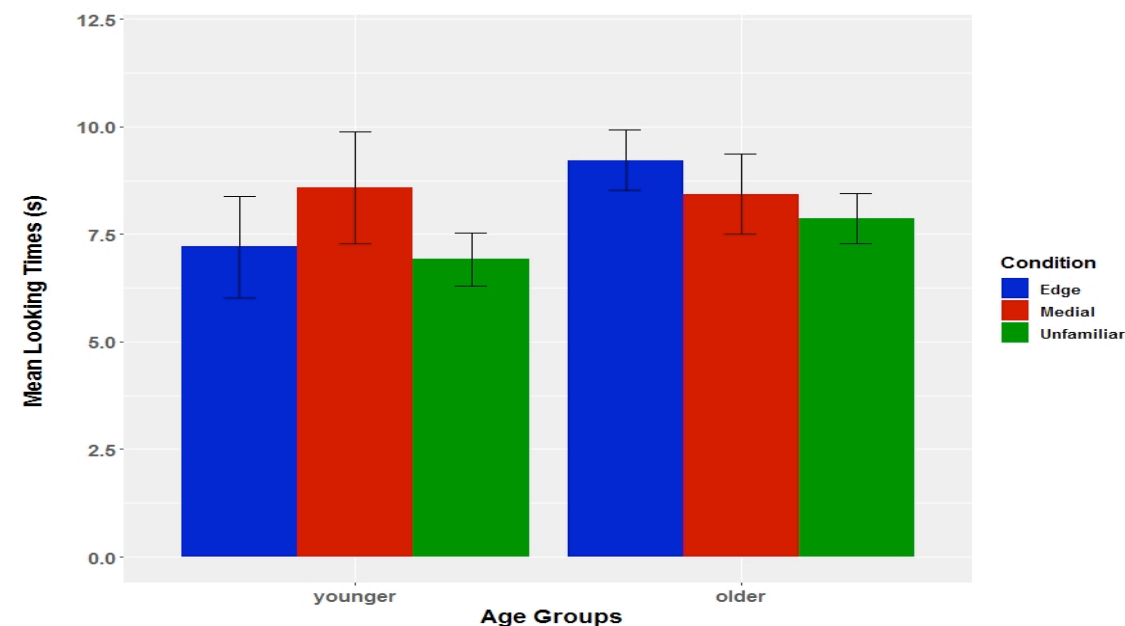


Fig. 2. DS Mean looking times (s) to edge, medial and unfamiliar by age.



DS: Concurrent language skills

- ✓ Segmentation abilities correlated with the CDI expressive vocabulary score

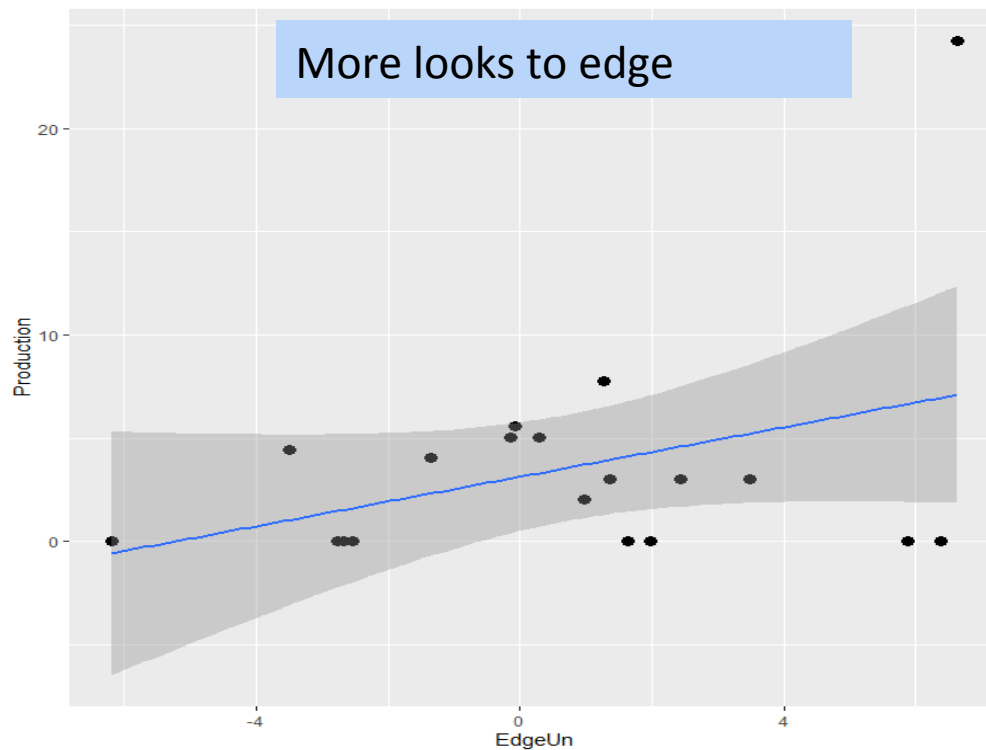


Fig. 3. Correlation between looks to edge minus unfamiliar and the CDI vocabulary score (Pearson's $r = .34$, $p = .05$).



Results - AR

✓ Evidence for segmentation

Familiar vs. Unfamiliar: $t(20)=2.9$, $p=.008$, Cohen's $d= .66$

✓ Evidence for segmentation in edge position!

RM ANOVA: condition, $F(2,40)=9.64$, $p<.001$, $\eta^2=.32$;

Post hoc, edge/unfamiliar $p=.008$, edge/medial $p=.03$,
medial/unfamiliar $p=.99$

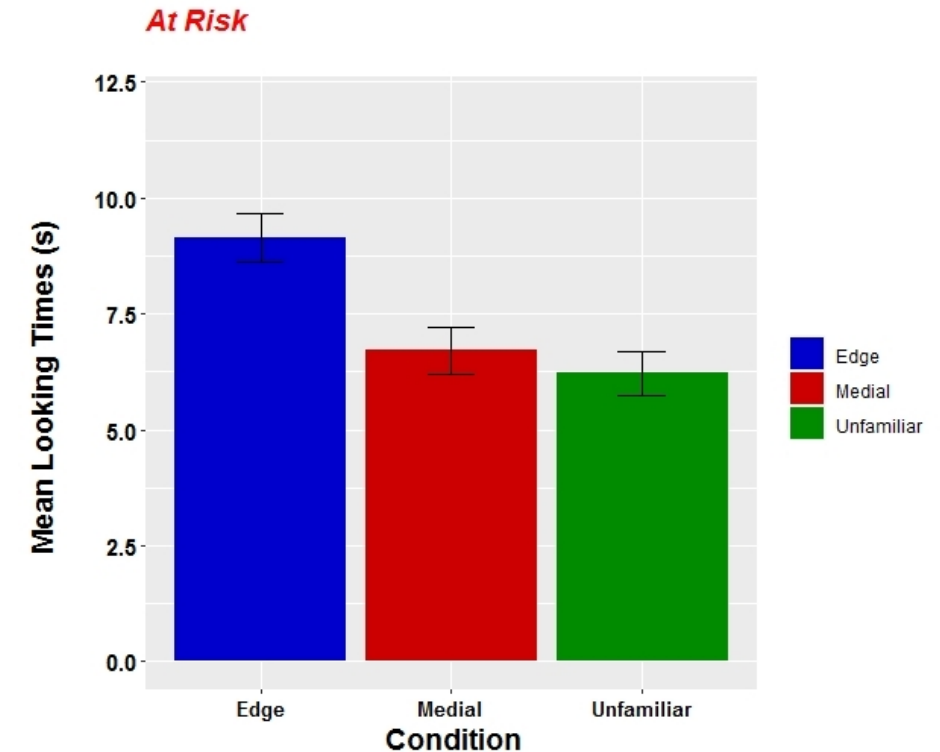


Fig. 4 AR Mean looking times (s) to edge, medial and unfamiliar.



Results - AR

- ✓ No age effect.
 - ✓ Two age groups (CDI age range): younger (below 18 mos, mean 11 mos) older (above 18 mos, mean 21 mos)
 - ✓ Age as a continuous variable:
 $\text{lm}(\text{LT} \sim \text{condition} + \text{Age in Months})$
 Condition, $F(2,59)=5.53, p=0.006$; Age, $F(1,59) < 1$

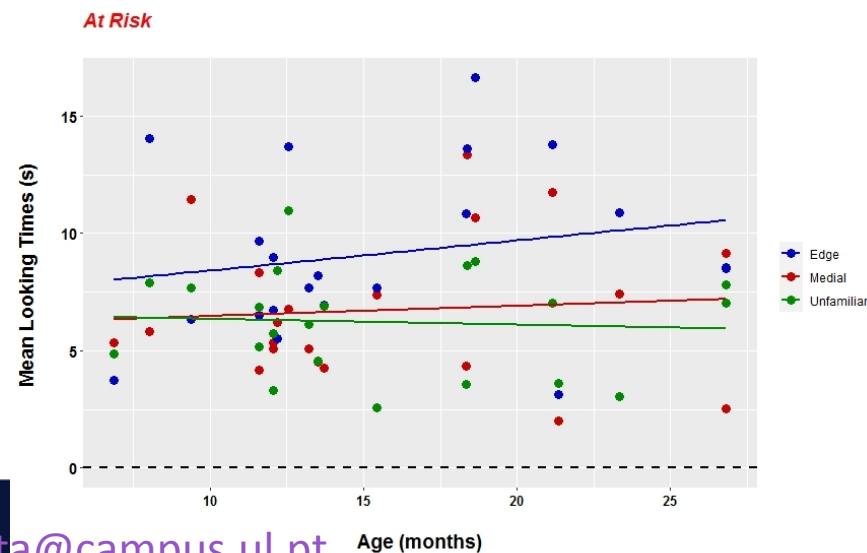


Fig. 3.

RM ANOVA: Main effect of prosodic condition, but no effect of age group ($F(1,19)=1.69, p=.2, \eta^2=.08$) or interaction ($F(2,38)=1.74, p=.18, \eta^2=.08$). Same pattern of results across age groups.

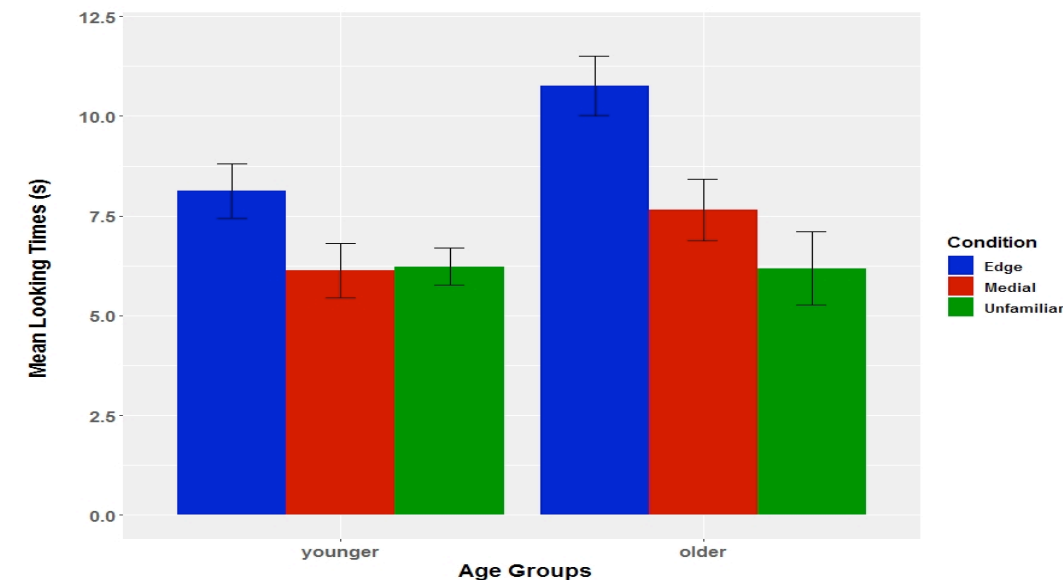


Fig. 5. AR Mean looking times (s) to edge, medial and unfamiliar by age group.



AR: Concurrent language skills

- ✓ Segmentation abilities correlated with receptive vocabulary (CDI)

More looks to edge

Better receptive vocabulary

More looks to medial

Lower receptive vocabulary

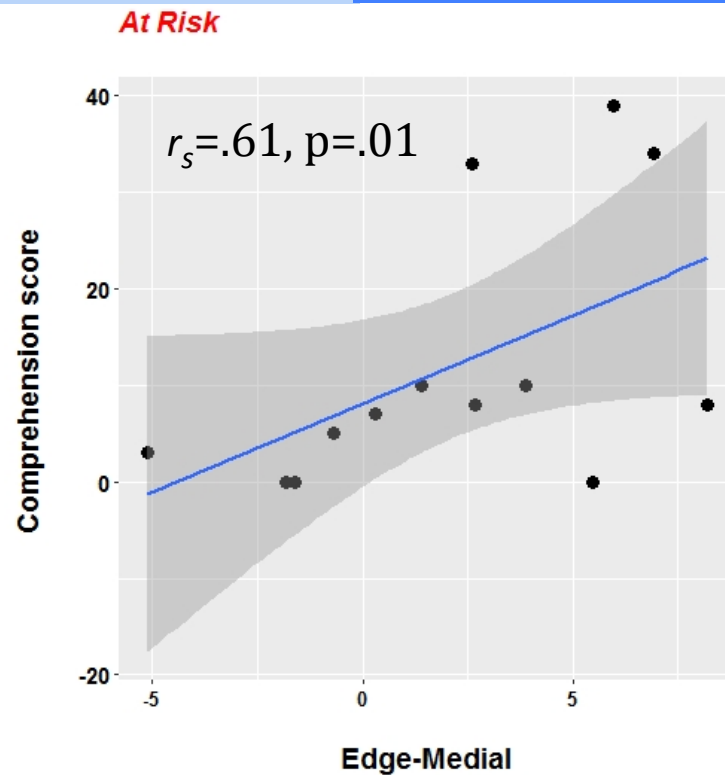


Fig. 4.

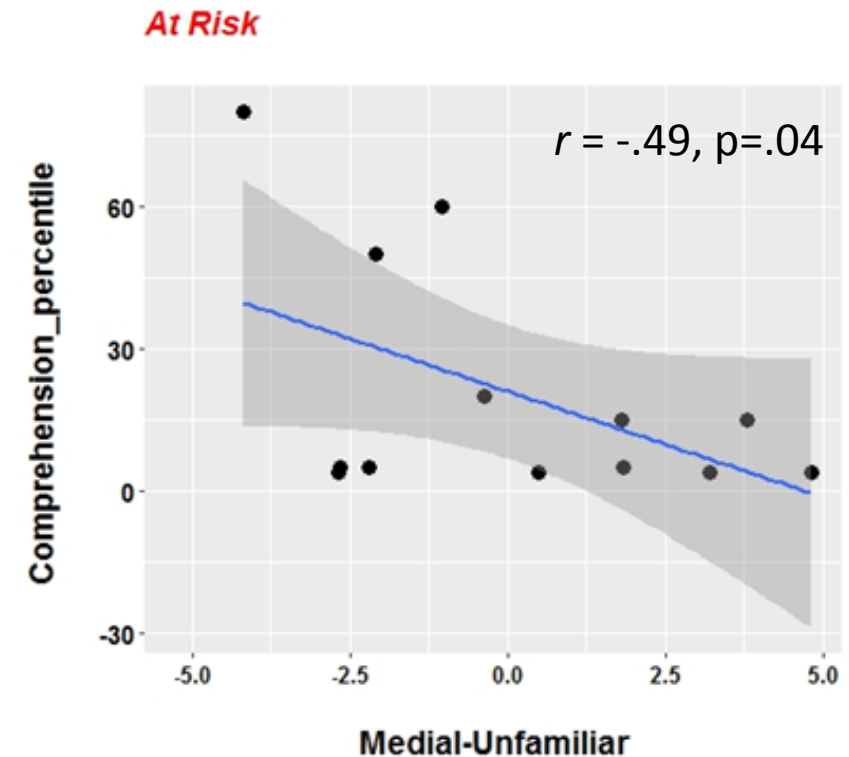


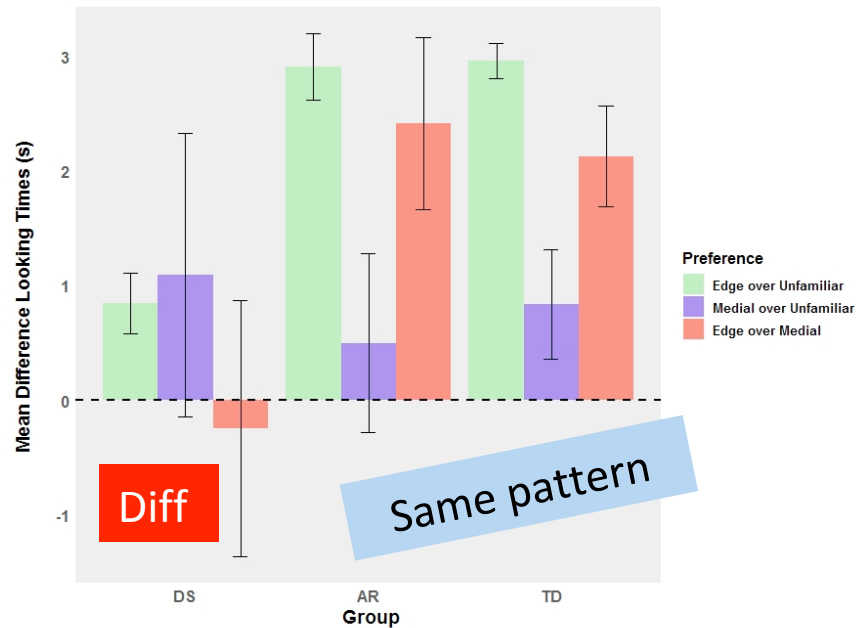
Fig. 5.



DS, AR and TD

Effect of condition, group and interaction

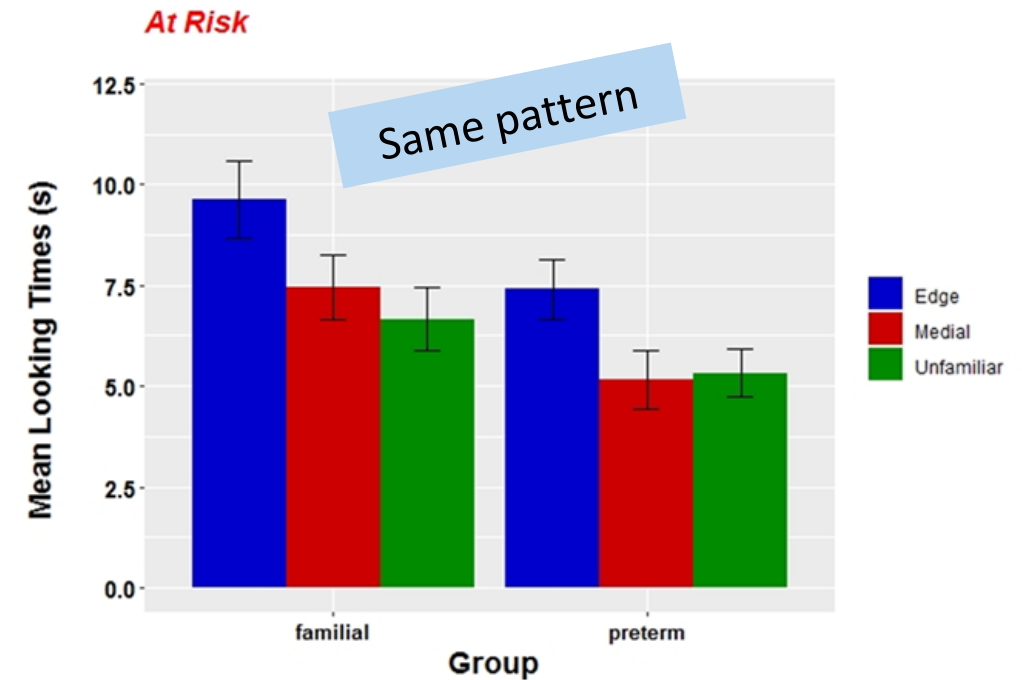
lmer(LT~ condition*Group+(1|Participant))
 Condition, $F(2,172)=18.5$, $p<.001$; Group,
 $F(2,86)=8.1$, $p<.001$; Interaction,
 $F(4,172)=2.9$, $p=.02$



Within AR: familial risk and preterm

Effect of condition, No interaction

RM ANOVA: Condition, $F(1.88, 30.06)=6.42$,
 $p=.005$; Group, $F(1,16)=4.45$, $p=.05$;
 Interaction, $F(1.88, 30.06) < 1$



Discussion

- Prosody drives early segmentation skills!
 - Segmentation is seriously delayed and follows a different developmental path in **DS** babies
 - **AR** babies successfully segmented at the **prosodic edge** only
 - Although following the TD developmental path, no emergence of segmentation in medial position yet. Segmentation abilities are delayed in the AR group
- Prosody modulated the relation between segmentation abilities and lexical knowledge
 - A link between segmentation skills and language acquisition, that had not yet been found for atypical development.
- Implications for remediation/intervention strategies
- Future research: focus on sub-groups of at risk babies





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Thank you! Obrigada!



Fonte: Diferenças



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