

# Age of Acquisition Effects on the Functional Organization of Language in the Adult Brain

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# Participants

- 22 Adults ; 11 female, 11 male
- Right handed
- >90 db [meaning profoundly deaf]
- All varied AoA: from birth to 14 years of age
- Split into three groups:
  - Infancy: Birth to 3
  - Early Childhood: 4-7
  - Late childhood: 8-15

# ASL Sentence Types

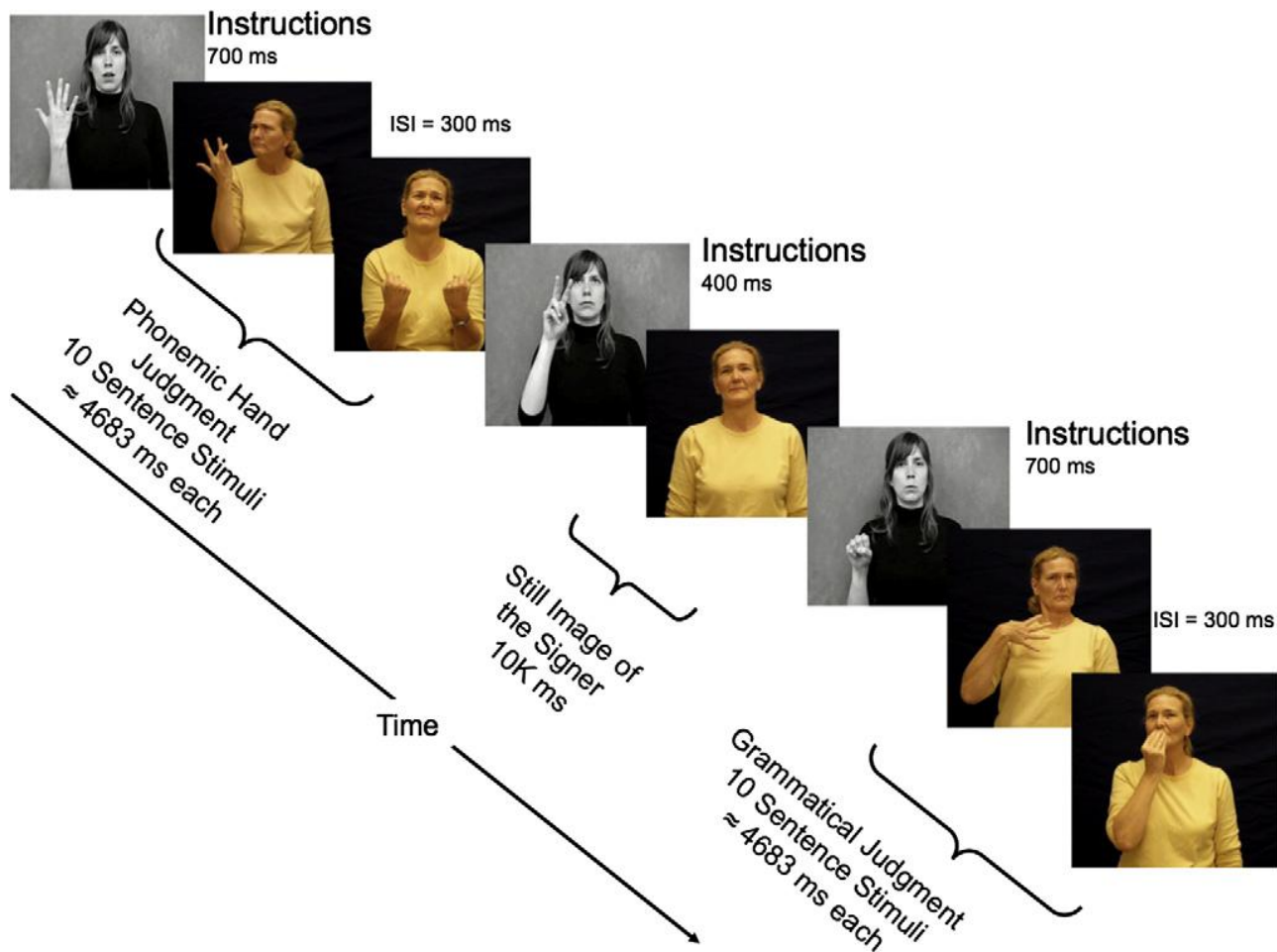
- Simple – SVO word order (with plain non-inflecting verbs) would be tampered with
- Negative – Verbs will be shown to be negated by headshakes or the sign NOT added to the subject-noun phrase.
- Inflecting Verbs -
- WH- Questions – Who, what, when, where, and why questions.

*All had been made ungrammatical and grammatical.  
They had been split 45 and 45. A total of 90 each for  
the whole experiment.*

# Procedure

- Three runs for each participant, going through 3 blocks of groups of 10 for each grammatical and phonemic-hand judgment.
- Baseline was administered throughout the experiment at random.
- RT was also recorded.
- The participant is to press the button when the sentence is right in the grammatical judgment.
- The participant is to press the button when the last sign in the video is signed with one hand in the phonemic judgment.
- For each activity the participant will be given directions on how to proceed.

# Procedure



# Behavioral Results

Task/measure Mean (SD)	R	t	p
Grammatical judgment			
d' 1.56 (.91)	.65	3.81	.001
RT 1544 (338)	.30	2.07	.04
Phonemic-hand judgment			
d' 1.96 (.84)	.29	1.36	.19
RT 1490 (333)	.10	.63	.53

*Shows declined activation in syntactic processing  
and increased time needed to evaluate them.*

# Grammatical and Phonemic-hand judgment Comparisons to baseline [A and B in slide of 4 brains fMRI images]

Brain region	Grammatical judgment > baseline				Phonemic-hand judgment > baseline			
	x	y	z	t	x	y	z	t
Left inferior frontal gyrus, BA 44	-48	14	0	5.34				
Right inferior frontal gyrus, BA 44	48	14	0	6.07				
Left anterior insula	-38	16	2	6.95	-30	18	6	4.16
Right anterior insula	38	16	2	5.34	38	14	6	4.65
Right SMA (anterior)	2	20	46	7.90	2	16	48	5.35
Left motor cortex	-36	-24	66	6.22	-36	-24	66	5.91
Left motor cortex	-34	-10	62	5.41	-34	-12	66	5.35
Right cerebellum	20	-54	-24	5.78	20	-54	-24	5.84
Right SMA (posterior)					2	-4	58	5.14
Right caudate					18	16	12	5.00
Left post-central gyrus, BA 1, BA 2					-56	-22	18	6.05
Left inferior parietal lobule, BA 7, BA 40					-46	-36	56	5.21
Left inferior temporal gyrus, BA 37					-52	-72	4	4.09
Right inferior temporal gyrus, BA 37					52	-68	0	4.36
Right lingual gyrus, BA 18 (occipital)					16	-72	10	4.65

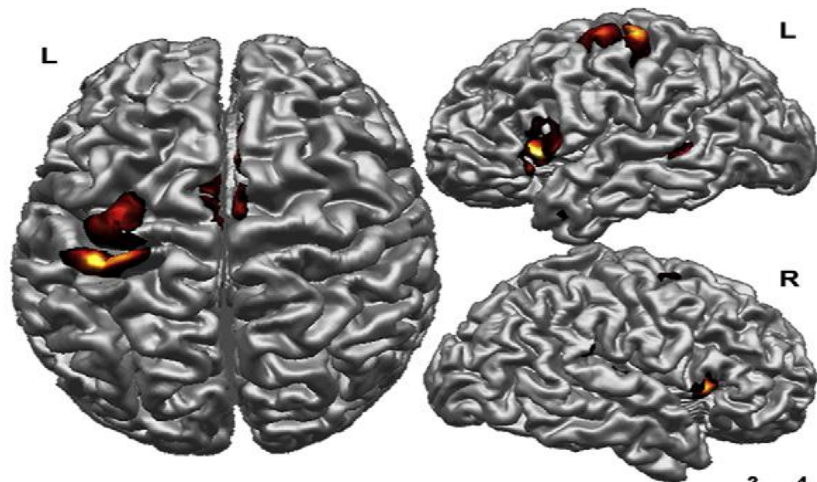
# Grammatical and Phonemic-hand judgment Comparisons to baseline [C and D in slide of 4 brains fMRI images]

Brain region	Grammatical judgment > hand judgment				Phonemic-hand judgment > grammatical judgment			
	x	y	z	t	x	y	z	t
Left inferior frontal gyrus, BA 44	-56	20	8	5.21				
Left inferior frontal gyrus, BA 44	-46	24	-12	5.53				
Left inferior frontal gyrus, BA 44	-48	14	28	4.82				
Left anterior insula	-46	16	-6	5.69				
Right inferior frontal gyrus, BA 44	50	18	0	5.06				
SMA	0	24	56	5.69				
SMA	0	24	48	5.77				
Left post-central gyrus, BA 1, BA 2					-50	-18	18	6.51
Left caudate					-6	16	4	4.23
Left fusiform gyrus, BA 37					-30	-52	-18	5.43
Left primary visual cortex, BA 17					-10	-68	16	4.95
Left superior occipital gyrus, BA 19					-16	-82	56	5.55
Left inferior occipital gyrus, BA 18					-30	-90	2	4.76
Right post-central gyrus, BA 1, BA 2					48	-18	14	5.01
Right superior parietal lobule, BA 7					16	-78	48	6.33



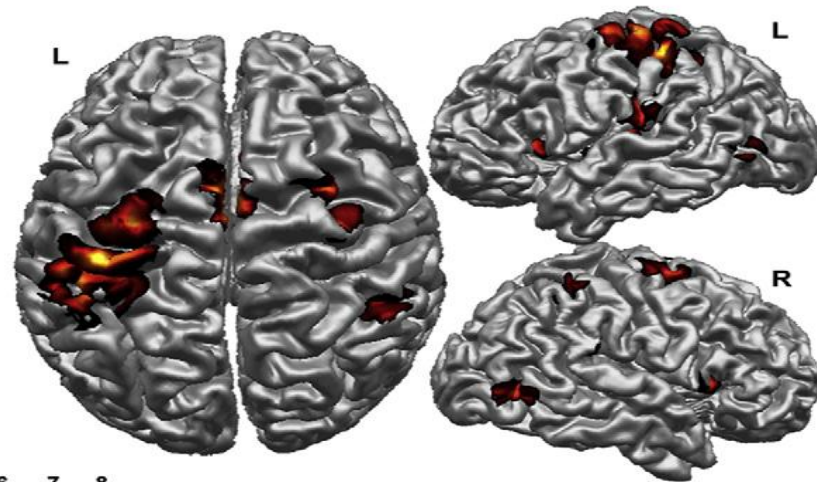
(a)

Grammatical judgment - baseline



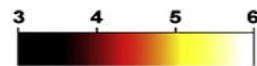
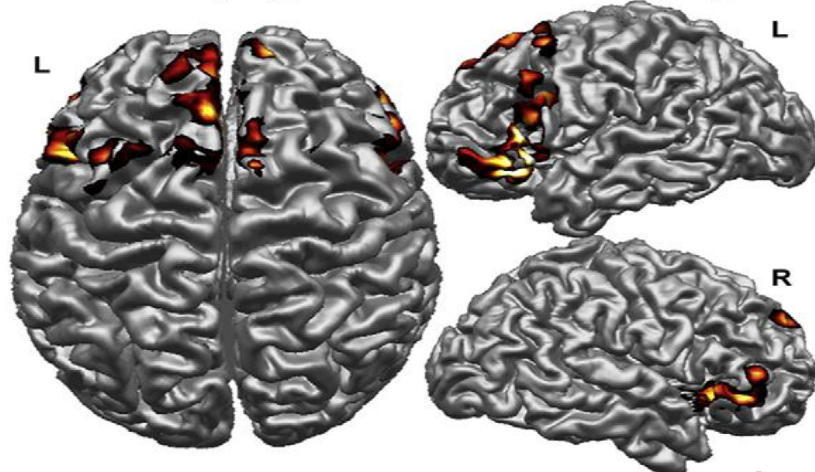
(b)

Phonemic hand judgment - baseline



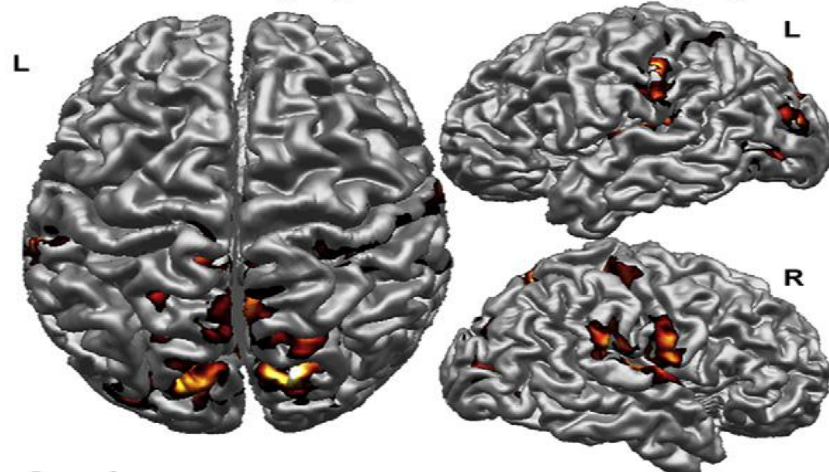
(c)

Grammatical judgment - Phonemic hand judgment

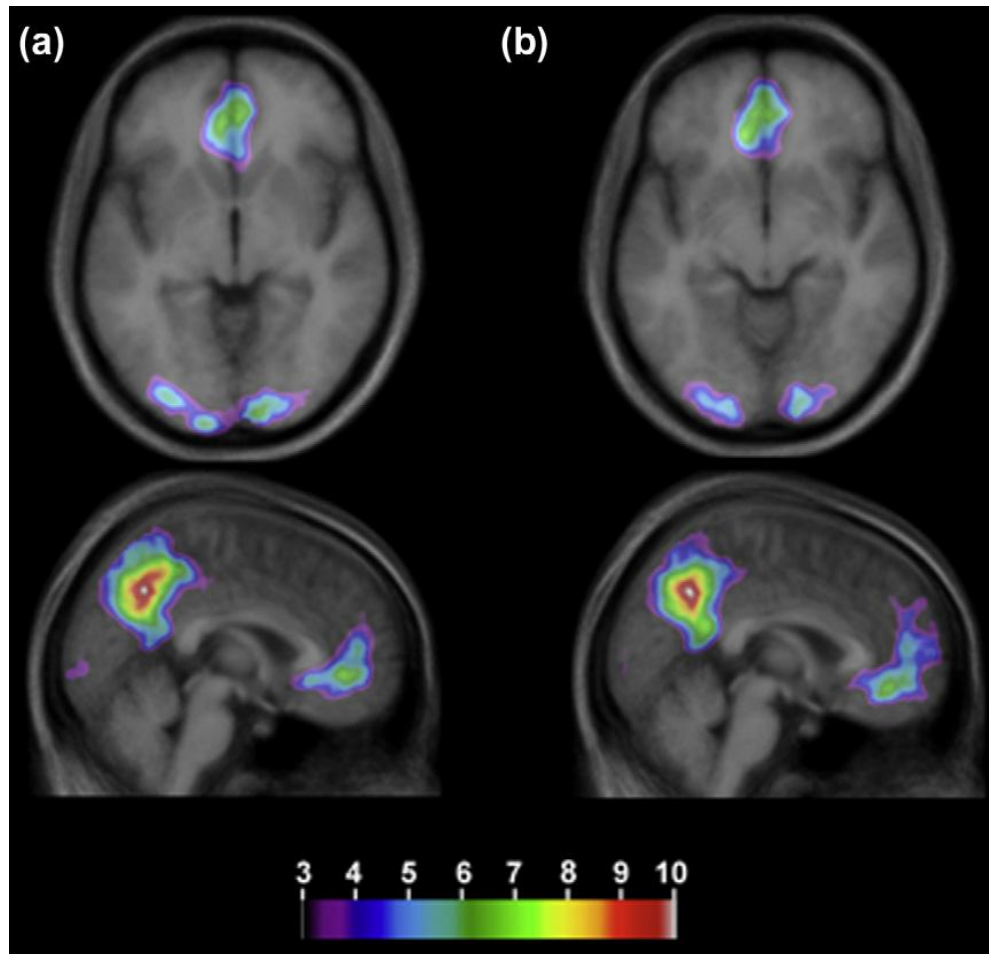


(d)

Phonemic hand judgment - Grammatical judgment



# Baseline Activation



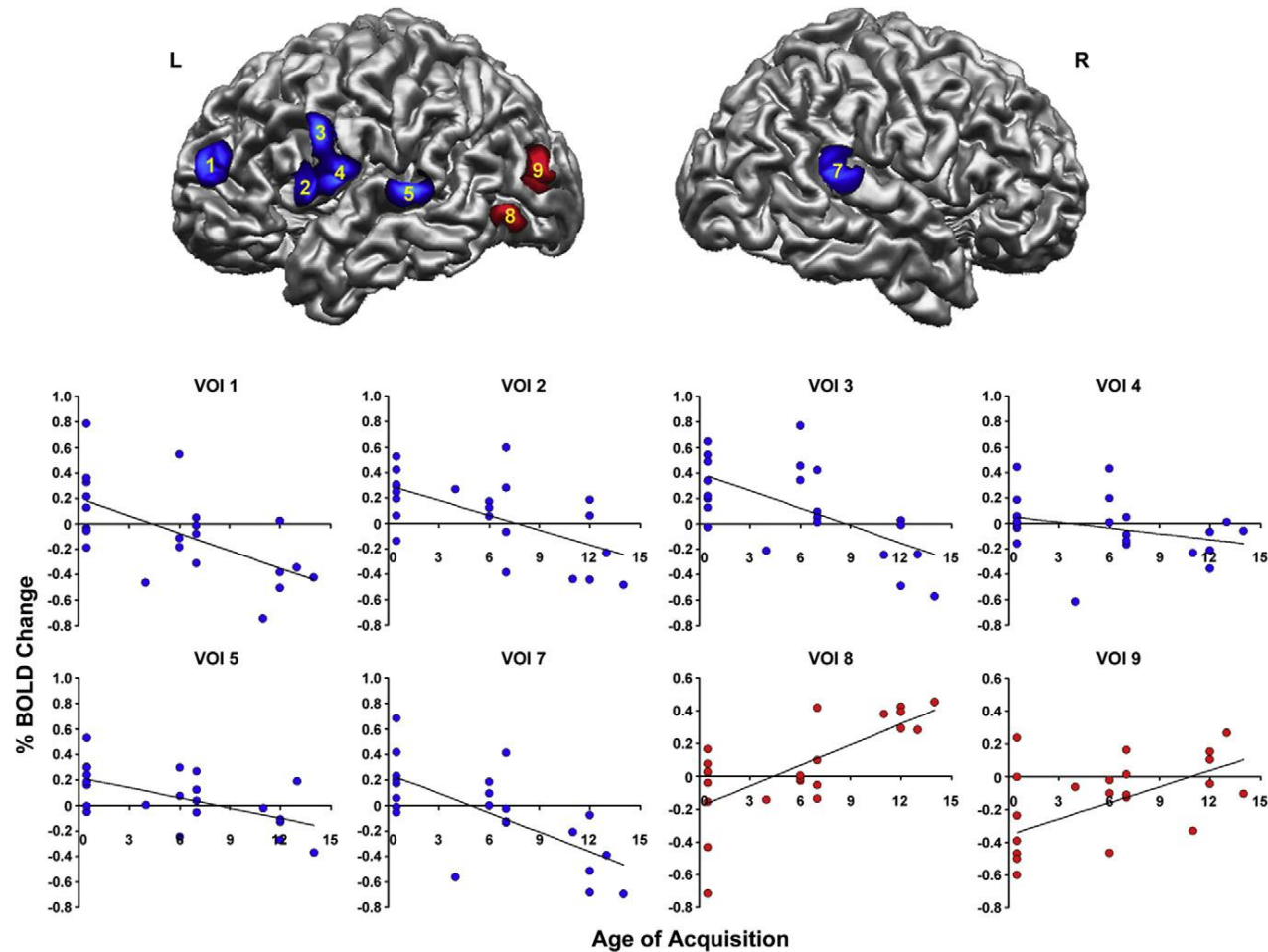
# Baseline

- During still images we see very minimal if any activation in the cortex.
- This provides clear indication that we should obtain clear results of the fMRI specific in the areas we're trying to detect for language processing in these participants.

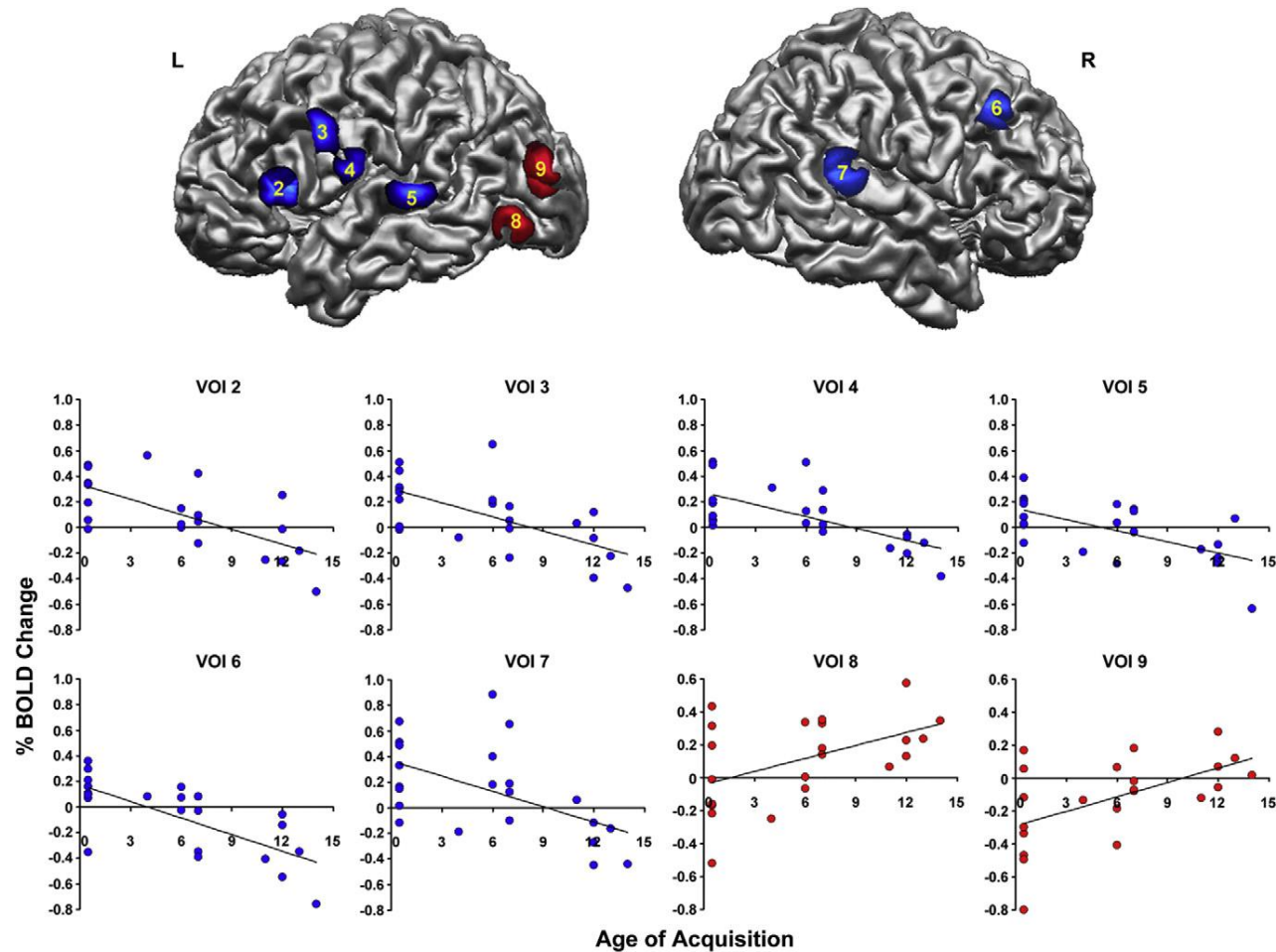
# Grammatical and phonemic-hand judgment against baseline

VOI	Region	Grammatical judgment - baseline					Phonemic-hand judgment - baseline				
		<i>x</i>	<i>y</i>	<i>z</i>	<i>R</i>	<i>p</i>	<i>x</i>	<i>y</i>	<i>z</i>	<i>R</i>	<i>p</i>
Negative BOLD/age of acquisition relationship											
1	Left dorsolateral prefrontal, BA 9	-26	48	18	-0.92	0.00					
2	Left anterior insula/frontal operculum	-36	20	12	-0.83	0.00	-34	20	12	-0.71	0.00
3	Left inferior frontal gyrus, BA 44	-46	4	32	-0.89	0.00	-48	4	32	-0.65	0.00
4	Left ventral premotor region, BA 6	-34	-8	20	-0.85	0.00	-34	-10	12	-0.64	0.00
5	Left superior temporal gyrus, BA 22	-42	-36	2	-0.86	0.00	-40	-36	0	-0.64	0.00
6	Right dorsolateral prefrontal, BA 9/46						28	24	40	-0.65	0.00
7	Right superior temporal gyrus, BA 22	54	-36	16	-0.81	0.00	52	-34	18	-0.60	0.01
Positive BOLD/age acquisition relationship											
8	Left lingual gyrus, BA 18	-14	-76	2	0.62	0.01	-16	-74	-6	0.45	0.05
9	Left middle occipital gyrus, BA 18/19	-22	-84	12	0.75	0.01	-22	-84	16	0.58	0.01

# Grammatical Judgment Against the Baseline



# Phonemic – Hand Judgment Against the Baseline



# Differences in Activation

- AoA for early onset (birth) illustrates that the grammatical judgment showed more activation in the inferior frontal gyrus and in our BOLD data left dorsolateral prefrontal.
- AoA for late onset (beyond infancy 3-7), showed more activation with phonemic hand judgments in the posterior regions like the left inferior parietal cortex and left inferior temporal gyri. Specifically in our BOLD data we see right dorsolateral prefrontal.