Functional Imaging of Syntactic and Semantic Aspects During Language Development in Preschoolers

Jens Brauer & Angela D. Friederici

Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany
brauer@cbs.mpg.de

MAX PLANCK INSTITUTE FOR HUMAN COGNITIVE AND BRAIN SCIENCES LEIPZIG

Introduction

The processing of language comprehension is known to involve brain areas of the perisylvian cortex bilaterally. Especially the superior temporal gyrus (STG) and the inferior frontal gyrus (IFG) are well described in their contribution to particular subprocesses during online language comprehension [1,2]. The STG contributes to both semantic and syntactic processing [3]. Semantic processes are supported by inferior frontal and inferior prefrontal cortex whenever strategic processes are required, whereas the temporal regions are activated in a variety of tasks and paradigms [4]. In syntactic processing, BA44/45 in the IFG is involved when processing demands increase, whereas the frontal operculum (FOP) is already active at local phrase structure building [5].

The processing of language in children involves brain areas that are known from adults [6]. However, there have been few attempts to investigate in detail different aspects of information during language comprehension in children. The poster presents first results of an ongoing study about auditory language processing in preschool children.

Methods

Participants

11 children (4 male, mean age = 6;2, SD = 0;8) and 11 adults (5 male, mean age = 26, SD = 2;9) participated in the study. All children showed typical development for their age, without any known psychological or neurological deficits.

Stimuli

Table 1

Examples of stimulus materials	
Correct condition	Der Frosch quakt *'The frog croaks'*
Syntactic violation condition	Der Joghurt im schmeckt *'The yoghurt in tastes good'*
Semantic violation condition	Der Stein blutet *'The stone bleeds'*
Correct filler condition	Das Eis am Stiel schmilzt *'The iced-lolly melts'*

Procedure

Stimuli (Table 1) were auditorily presented via headphones. Adult participants listened to 50 trials of each condition and children to 30 trials. Stimuli were pseudo-randomized, and participants were asked to judge the correctness of each sentence by pressing a button provided.

Functional MRI

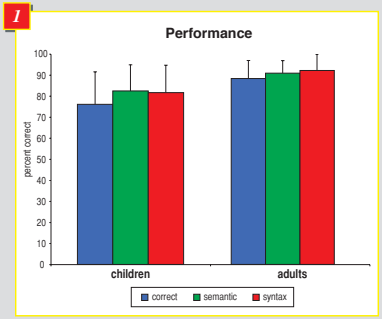
The study was conducted on a 3 Tesla Siemens TRIO (Erlangen, Germany). A gradient-echo EPI sequence was used with the following parameters: TE 30 msec, flip angle 90°, TR 2000 ms, acquisition bandwidth 100 kHz, Matrix 64 x 64 voxels, FOV 192 mm, and an in-plane resolution of 3x3 mm. 20 slices were acquired.

Data analysis

Data analysis was conducted using the LIPSIA Software Package [7].
Pre-processing steps comprised offline motion correction and slicetime correction (cubic-spline-interpolation). A temporal highpass filter (cut-off frequency 1/60 Hz) and a spatial Gaussian filter (FWHM = 4.239 mm) were used. Data were rigid linear and nonlinear registered.
Statistical evaluation was done by means of a GLM random effects analysis. Only activations exceeding $z > 3.09$ ($p < 0.001$), uncorrected, are reported.

Results

1



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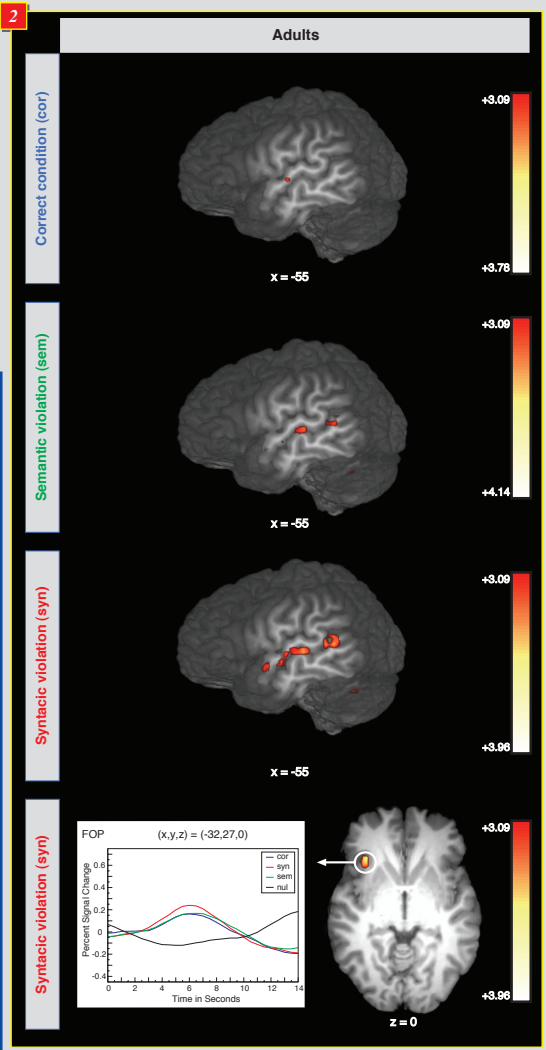

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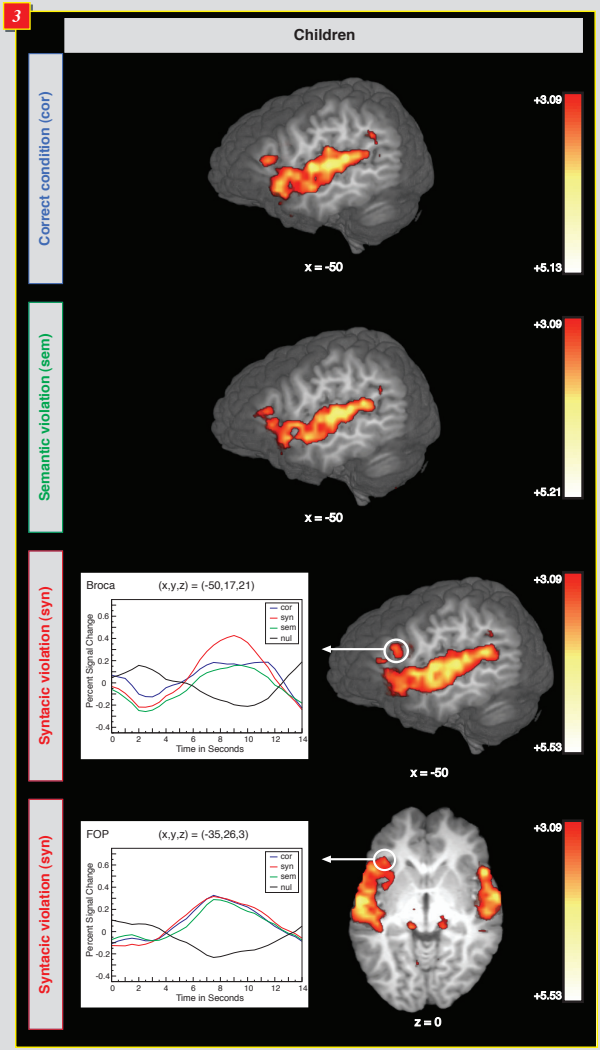

Discussion

The adult network of auditory language comprehension included the superior temporal gyrus together with the deep frontal operculum, but the inferior frontal cortex only below threshold. Children utilized typical language-related perisylvian brain areas, however, they showed a more enhanced activation compared to adults. Their STG response was stronger and more broadly distributed. They additionally recruited parts of inferior and middle frontal gyrus. Those assisting brain areas in children are known to participate in more controlled processing. Whereas in adults an apparently less complex network seems to be sufficient to process simple structured sentences appropriate for preschoolers. The children's extended activation pattern might reflect higher processing demands and possibly neural plasticity underlying ongoing development of language-related brain areas.

References

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