NeuroPsicologia dello *Sviluppo* e Riabilitazione

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Report

Reduced Neural Integration of Letters and Speech Sounds Links Phonological and Reading Deficits in Adult Dyslexia

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for letters and speech sounds [13, 14]. Reading problems in dyslexia have been primarily associated with a deficit in

[7, 11]. The present functional magnetic resonance imaging (fMRI) study investigated the neural processing of letters and speech sounds in unisensory (visual, auditory) and multisensory (audiovisual congruent, audiovisual incongruent) conditions as a function of reading ability. Our data reveal that adult dyslexic readers underactivate superior temporal cortex for the integration of letters and speech sounds. This reduced audiovisual integration is directly associated with a more fundamental deficit in auditory processing of speech sounds, which in turn predicts performance on phonological tasks. The data provide a neurofunctional account of developmental dyslexia, in which phonological processing deficits are linked to reading failure through a deficit in neural integration of letters and speech sounds.

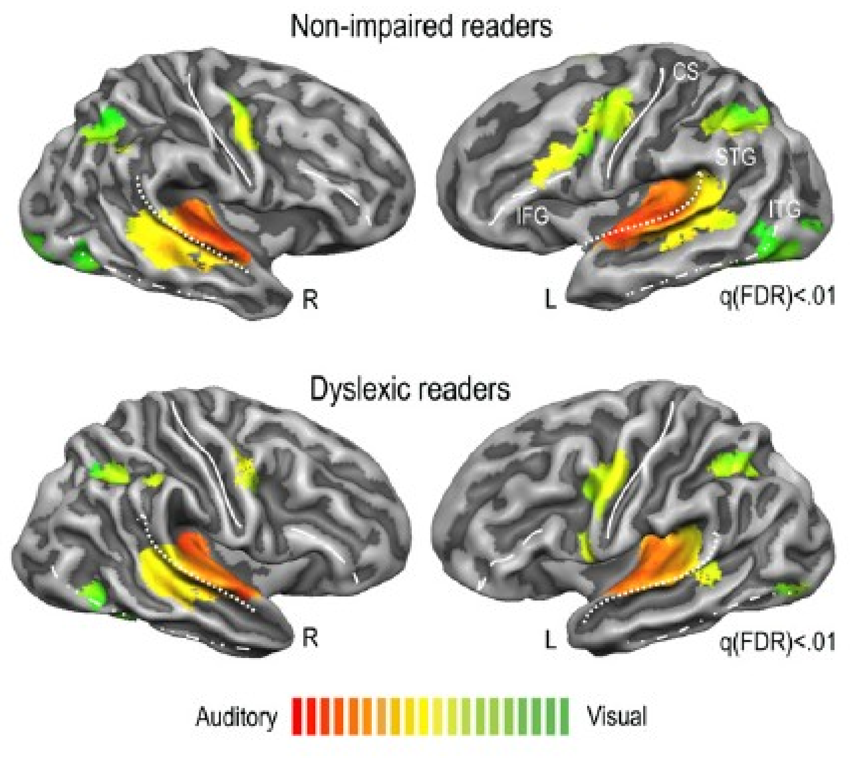
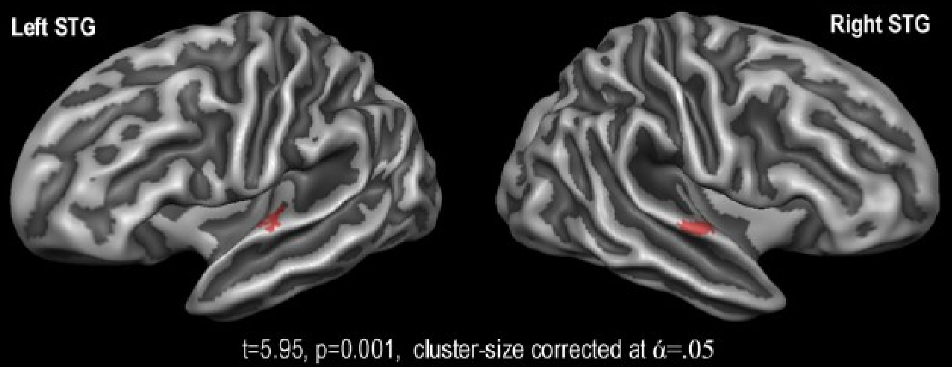
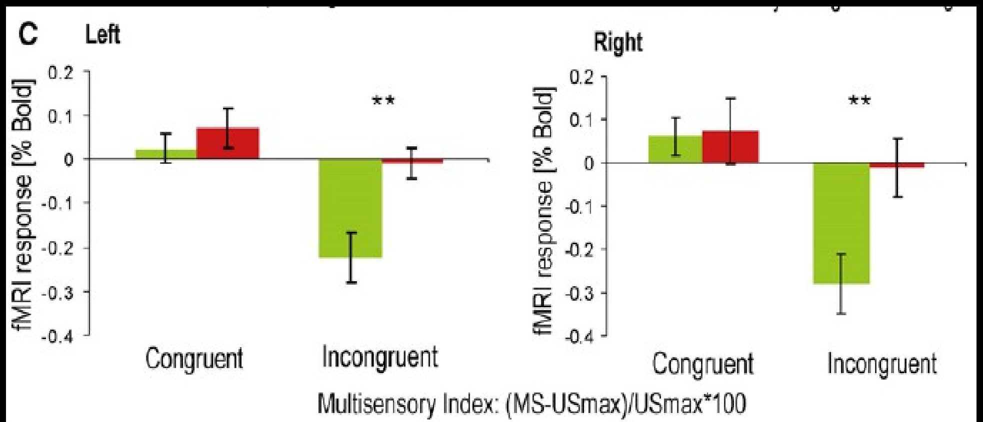


Figure 1. Activation for Letters and Speech Sounds

Response pattern for regions processing speech sounds (red), letters (green) or both unisensory conditions (yellow) in non-impaired (upper panel) and dyslexic readers (lower panel).





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Behavioral/Cognitive

An Investigation into the Origin of Anatomical Differences in Dyslexia

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read at the same level as the dyslexics. Consistent with previous reports, dyslexics showed less GMV in multiple left and right hemisphere regions, including left superior temporal sulcus when compared with age-matched controls. However, not all of these differences emerged when dyslexics were compared with controls matched on reading abilities, with only right precentral gyrus GMV surviving this second analysis. When similar analyses were performed for white matter volume, no regions emerged from both comparisons. These results indicate that the GMV differences in dyslexia reported here and in prior studies are in large part the outcome of experience (e.g., disordered reading experience) compared with controls, with only a fraction of the differences being driven by dyslexia per se.

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REPORT

Neuroanatomical precursors of dyslexia identified from pre-reading through to age 11

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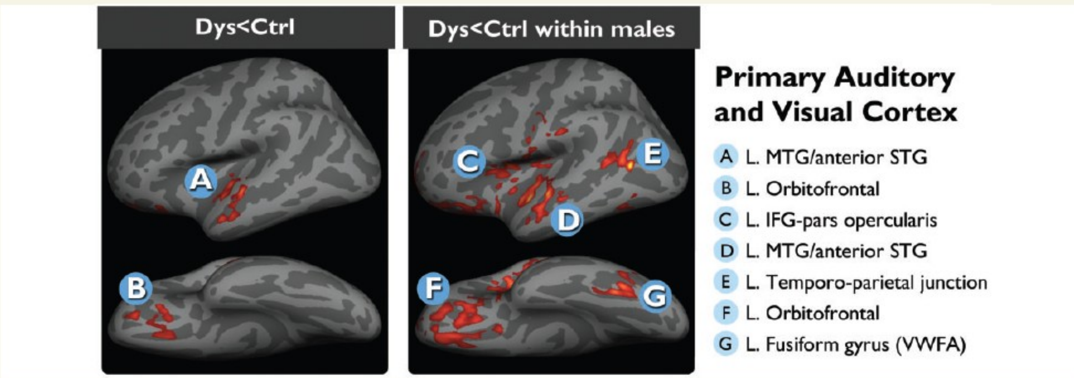

Figure 2 Neuroanatomical signature of dyslexia. Regions of thinner cortex in the left hemisphere observed in children diagnosed with dyslexia (Dys) compared to those who were not (Ctrl). These data are cross-sectional from MRI 3, when the children were in the sixth grade. The *left* panel shows the whole group differences, whereas the *right* panel shows the differences when only the males were considered. IFG = inferior frontal gyrus; MTG = middle temporal gyrus; STG = superior temporal gyrus; VWFA = visual word form area.

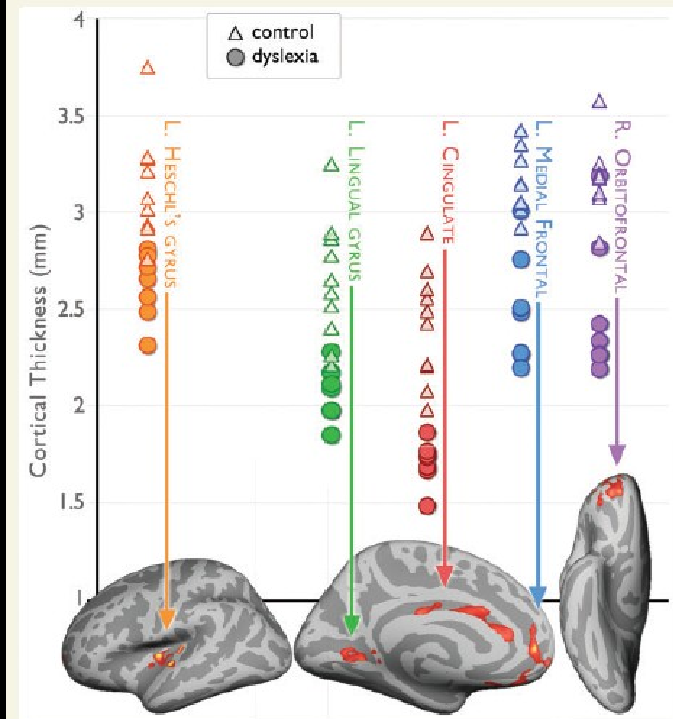

Figure 1 Early signs of dyslexia. Pre-reading differences in cortical thickness between children who later went on to develop dyslexia (Dys) and those who did not (Ctrl). Images: regions in which Dys < Ctrl before the onset of reading. Raw cortical thickness values are plotted for each of the regions.

Developmental dyslexia is a common reading disorder that negatively impacts an individual's ability to achieve literacy. Although the brain network involved in reading and its dysfunction in dyslexia has been well studied, it is unknown whether dyslexia is caused by structural abnormalities in the reading network itself or in the lower-level networks that provide input to the reading network. In this study, we acquired structural magnetic resonance imaging scans longitudinally from 27 Norwegian children from before formal literacy training began until after dyslexia was diagnosed. Thus, we were able to determine that the primary neuroanatomical abnormalities that precede dyslexia are not in the reading network itself, but rather in lower-level areas responsible for auditory and visual processing and core executive functions. Abnormalities in the reading network itself were only observed at age 11, after children had learned how to read. The findings suggest that abnormalities in the reading network are the consequence of having different reading experiences, rather than dyslexia *per se*, whereas the neuroanatomical precursors are predominantly in primary sensory cortices.

Cell PRESS

Neuron
Clinical Study

Altering Cortical Connectivity: Remediation-Induced Changes in the White Matter of Poor Readers

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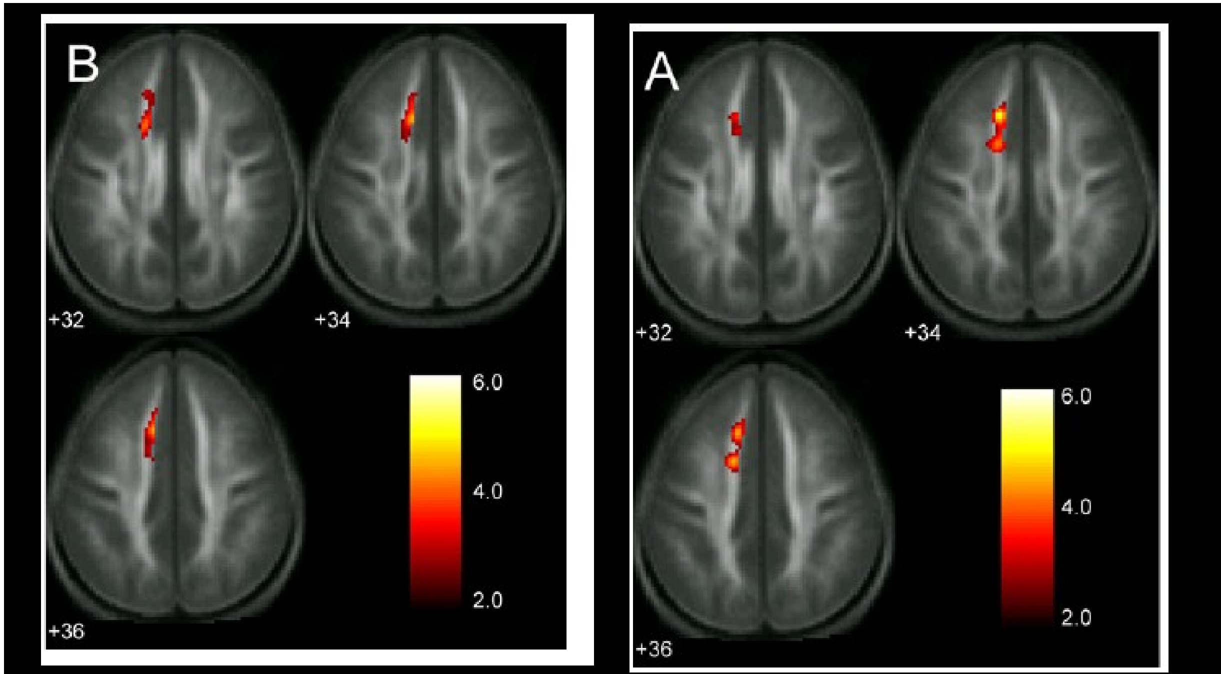
Neuroimaging studies using diffusion tensor imaging (DTI) have revealed regions of cerebral white matter with decreased microstructural organization (lower-fractional anisotropy or FA) among poor readers. We examined whether 100 hr of intensive remedial instruction affected the white matter of 8- to 10-year-old poor readers. Prior to instruction, poor readers had significantly lower FA than good readers in a region of the left anterior centrum semiovale. The instruction resulted in a change in white matter (significantly increased FA), and in the very same region. The FA increase was correlated with a decrease in radial diffusivity (but not with a change in axial diffusivity), suggesting that myelination had increased. Furthermore, the FA increase was correlated with improvement in phonological decoding ability, clarifying the cognitive locus of the effect. The results demonstrate the capability of a behavioral intervention to bring about a positive change in cortico-cortical white matter tracts.

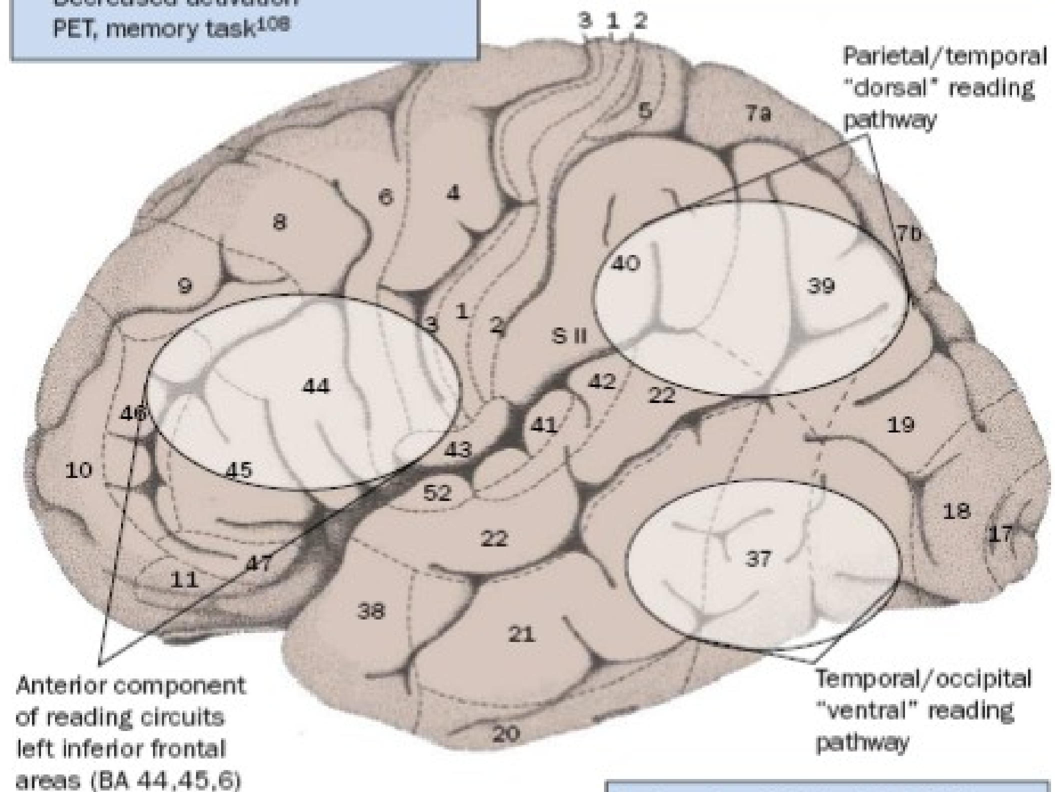


Dal Circuito Neurocognitivo della Lettura alla neurochimica della dislessia

Dysfunction of left inferior frontal area
Increased activation:
fMRI, hierarchically organised tasks with phonological process;[106]
PET, implicit and explicit word and pseudoword reading[107]

Decreased activation
PET, memory task[108]

Reduced activity in left parietal/temporal regions
PET, rhyming task;[108,109]
PET, pronunciation and decision making tasks;[110]
fMRI, hierarchically organised tasks with phonological process[106]
PET, reading[111]



Reduced activity in left inferior temporal/occipital area
MEG, letter perception[101]
PET, implicit and explicit word and pseudoword reading[107,112]

Cerebellum: reduced activity in reading task[107]

Glutamate and Choline Levels Predict Individual Differences in Reading Ability in Emergent Readers

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Reading disability is a brain-based difficulty in acquiring fluent reading skills that affects significant numbers of children. Although neuroanatomical and neurofunctional networks involved in typical and atypical reading are increasingly well characterized, the underlying neurochemical bases of individual differences in reading development are virtually unknown. The current study is the first to examine neurochemistry in children during the critical period in which the neurocircuits that support skilled reading are still developing. In a longitudinal pediatric sample of emergent readers whose reading indicators range on a continuum from impaired to superior, we examined the relationship between individual differences in reading and reading-related skills and concentrations of neurometabolites measured using magnetic resonance spectroscopy. Both continuous and group analyses revealed that choline and glutamate concentrations were negatively correlated with reading and related linguistic measures in phonology and vocabulary (such that higher concentrations were associated with poorer performance). Correlations with behavioral scores obtained 24 months later reveal stability for the relationship between glutamate and reading performance. Implications for neurodevelopmental models of reading and reading disability are discussed, including possible links of choline and glutamate to white matter anomalies and hyperexcitability. These findings point to new directions for research on gene-brain-behavior pathways in human studies of reading disability.

Key words: decoding; individual differences; MRS; phonological processing; reading; reading disability

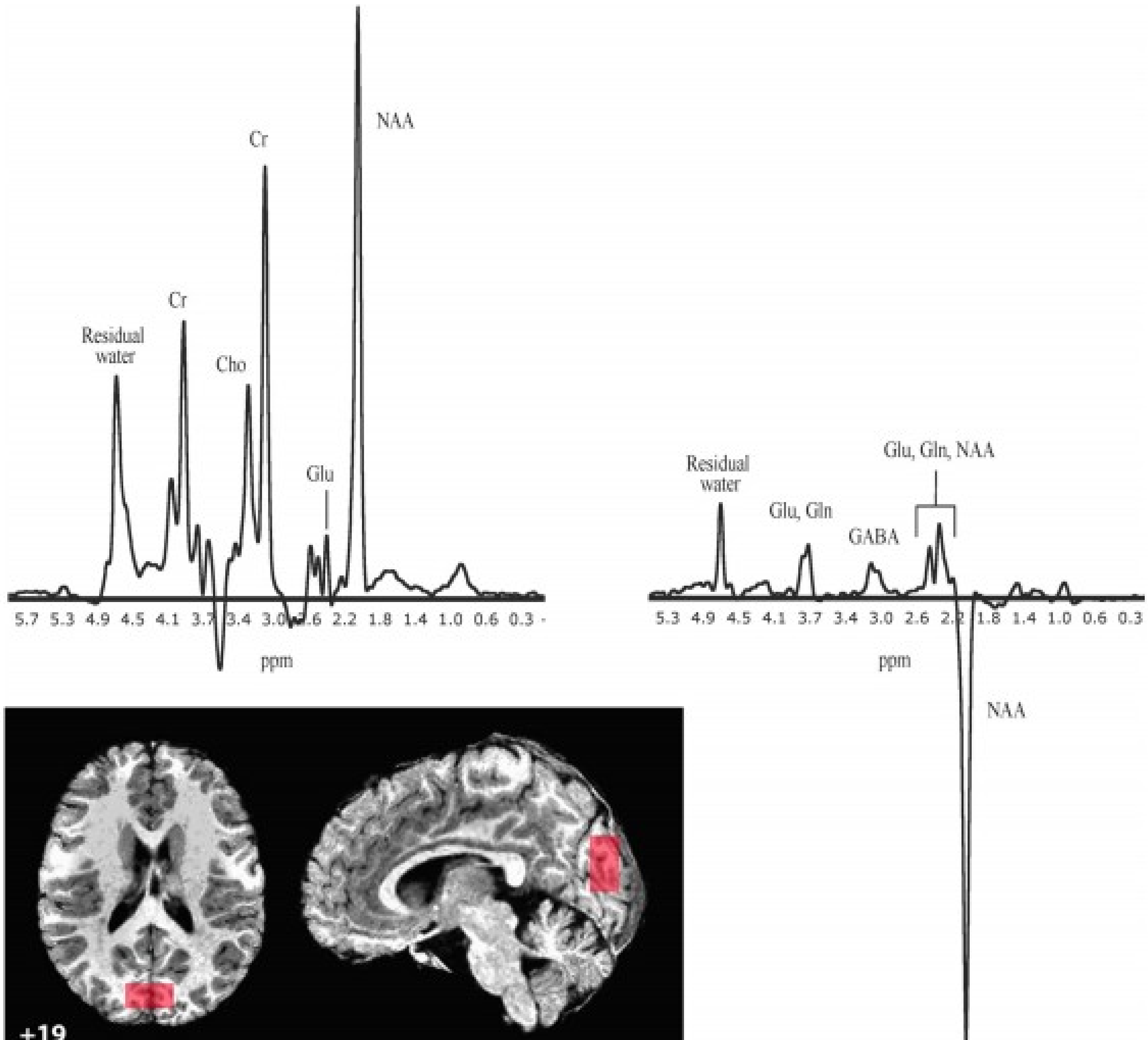

Figure 1. Sagittal and axial sections depicting the 3 × 3 × 1.5 cm MRS voxel in the midline occipital cortices with MNI *z*-coordinate of voxel center indicated (bottom left). Metabolite spectra in a single participant: MR subspectrum at 4-telsa (top left), cortical GABA detected by J-editing (top right). Gln, Glutamine.

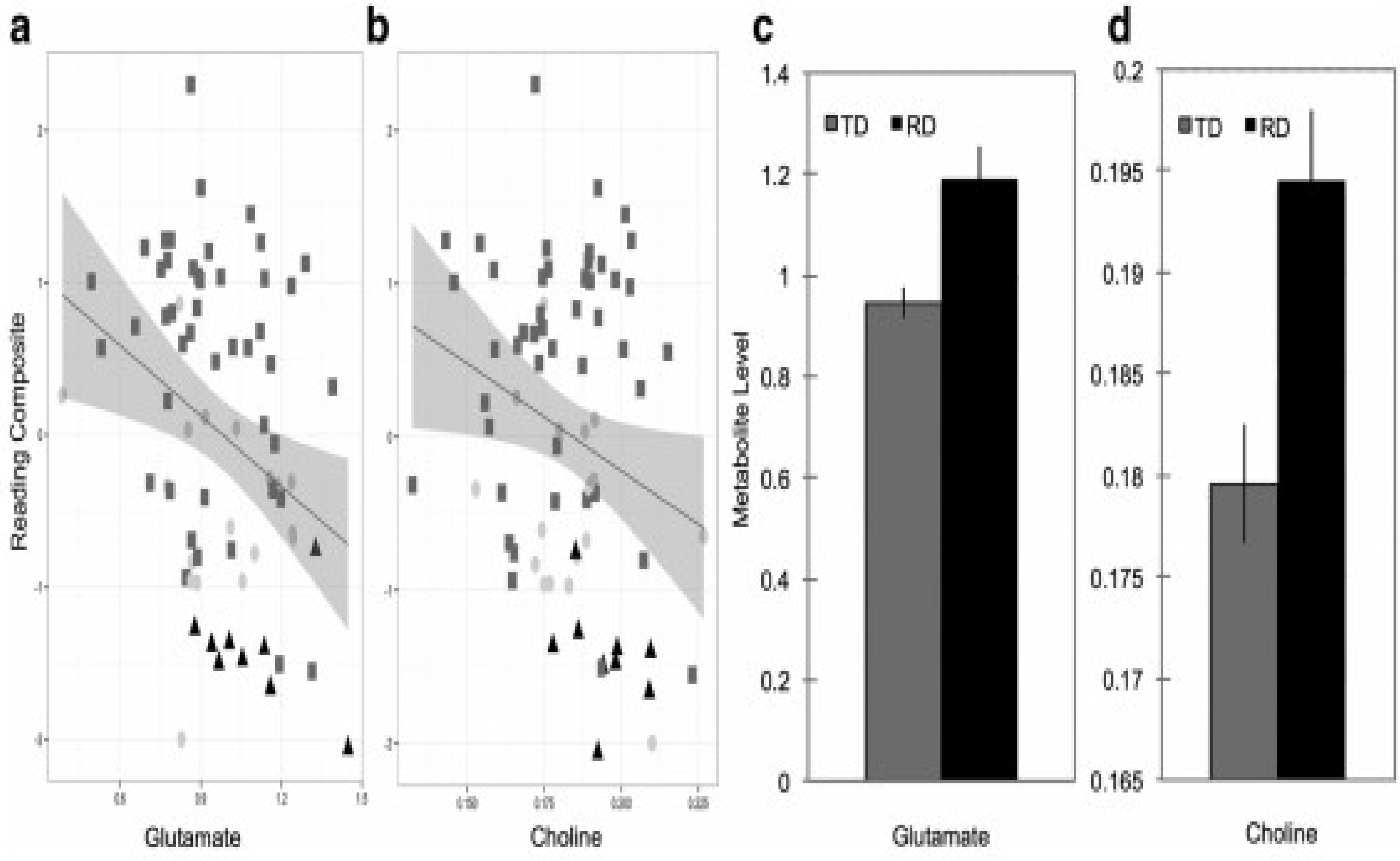

Figure 2. Relationship between metabolites and reading ability. Scatterplot of correlations between (*a*) Glu and Reading Composite scores, and (*b*) Cho and Reading Composite scores. Readers meeting criteria for TD readers are shown in dark gray squares, RD readers are shown in black triangles, and readers that did not meet either group criteria are shown in light gray circles. Bar graphs present (*c*) Glu and (*d*) Cho mean levels in TD and RD readers. Error bars represent SEM. Metabolites levels are expressed as ratios to Cr.