# Implementation of $^1$H MRS at 3.0 Tesla for the analysis of the biochemistry and function of the amygdala in patients with borderline personality disorder and healthy controls

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**Introduction:**

The core of borderline personality disorder (BPD) is a neuronal dysfunction in a frontolimbic network. The amygdala is a key region of the limbic system and plays an important role in impulsivity, affect regulation and emotional information processing, and thus are likely related to BPD symptoms [1]. In contrast to other brain regions the amygdala is an extremely difficult region to acquire MR spectra from. We implemented a method for $^1$H MRS at 3T where we acquire data only within the small volume of the amygdala. The purpose of this study is to determine alterations of the metabolism in the amygdala of female patients with borderline personality disorder.

**Methods:**

In a pilot study a cohort of female BPD patients and group-matched healthy controls (HC) was recruited for in vivo single voxel $^1$H MRS at a 3T whole body MR scanner (Siemens, Erlangen, Germany). All participants underwent the following assessments: the state-trait-anxiety-inventory (STAI), beck-depression-inventory (BDI), barratt impulsiveness scale (BIS), borderline symptom list (BSL) and the questionnaire for the assessment for dissociative symptoms (FDS). None of them was under medication.

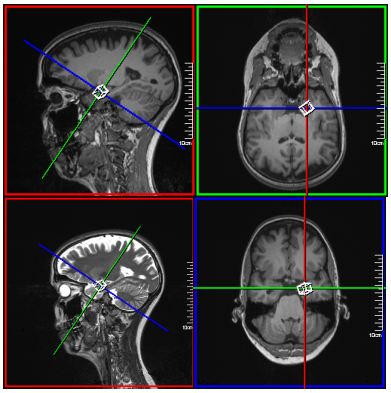

Fig.1: Position of the single voxel in T2 and T1 images for left amygdala

The placement of the amygdala voxel is crucial and was performed with high precision: for this purpose we acquired T2 weighted sagittal scout images and a sagittal 3D mprage data set. From the later we reconstructed transverse and orthogonal coronal planes. Guided by these images, we planned the single voxel (12x10x12 mm$^3$) in the left amygdala step by step (see figure 1).

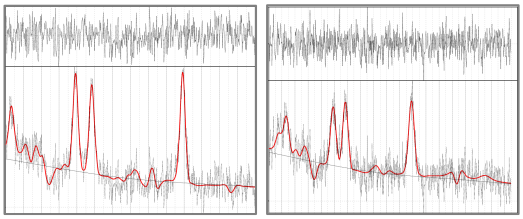

Fig.2: Example spectra with LCModel fit with SNR=5 (left) and with SNR=3 (right) of the single voxel for left amygdala

First we used the T1 sagittal mprage slices because of the good grey/white matter contrast for localizing the amygdala. Second we loaded the T2 sagittal scout, great care was to be taken not to include partial volumes of blood vessels or ventricles in the voxel. Last but not least we checked the final voxel position in the reconstructed transverse and coronal planes. Spectra were acquired with a PRESS sequence using the following parameters: TE = 80 ms, TR = 3000 ms.

Due to the fact that the anatomically structure of the amygdala is rather small, the size for a cubic voxel within the amygdala is even smaller. An acquisition time of 15 minutes (300 averages) was chosen to get enough SNR in this small voxel (see figure 2). We obtained sufficient quality amygdala spectra (SNR $\geq$ 3) in 14 (age 26.89 ± 6.2) out of 19 patients and 13 (age 27.54 ± 9.3) out of 19 group-matched healthy controls.

Because of the location of the amygdala near the hippocampus and cornu inferior of the lateral ventricles area, is this a difficult region for MRS due to local field inhomogeneities and flow artifacts. The MRS data were analyzed with the software package LCModel [2] using a simulated basis data set for TE = 80 ms for all quantified metabolites. Spectral fits were accepted when the standard deviation of the fit was 20 % or less. Unfortunately, we had to exclude the glutamate results because of insufficient quality with SD more than 20 %. Finally a automated segmentation of the high resolution T1 weighted 3D images into grey matter (GM), white matter (WM) and cerebrospinalfluid (CSF) using the SPM 2 algorithms and MATLAB 6.5 [3] was performed for each individuum to determine the composition of the spectroscopic voxel.

**Results:**

Amygdala spectra of 14 female patients (age 26.89 ± 6.2) and 13 matched healthy controls (age 27.54 ± 9.3) could be evaluated. A trend of decreased levels of all metabolites in the left amygdala was observed in patients. Significantly lower levels were determined for N-acetylaspartate (NAA) and total creatine (tCr) in the left amygdala (see figure 3).

As expected patients scored significantly higher on measures of anxiety (STAI), depression (BDI), impulsivity (BIS), severity of borderline symptoms (BSL) and dissociative symptoms (FDS). There was no significant correlation between neurochemical concentrations and psychometric findings.

The segmentation of the amygdala voxel corrected for chemical shifts of the individual metabolites resulted in a mean amount of 87.43 % GM and 6.49 % Liquor.

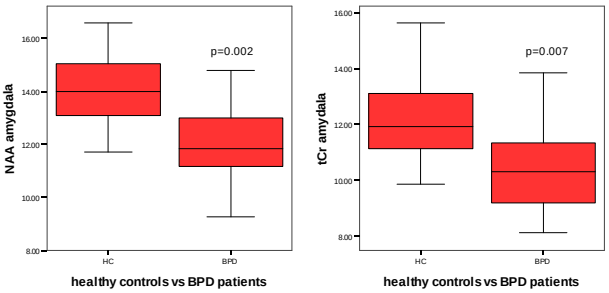


Fig. 3: Boxplots of NAA (left) and tCr (right) concentrations in mmol/l in the left amygdala of healthy controls and patients with BPD

**Discussion:**

The amygdala is an extremely difficult region for MRS. To our knowledge there has only been one other MRS study investigating the amygdala region in BPD patients and healthy controls. Tebartz van Elst et al. (2007) found a significant increase of amygdala creatine concentrations in BPD patients [4]. Our results in contrast show significantly lower levels of NAA and tCr in the left amygdala. We investigated an amygdala voxel of only half the voxel size used in the study of Tebartz van Elst et al., which ensured that we acquired data only within the small volume of the amygdala.

NAA is the most prominent peak in the spectrum of metabolites and represents a marker of neuronal functionality and viability. Decreased NAA indicates disturbed neuronal functioning in the amygdala of BPD subjects which might be associated with disturbed affect regulation and emotional information processing. tCr represents a marker of the energy metabolism of neurons. A decrease of tCr may point to a dysfunction in energy metabolism in the amygdala of BPD patients [5].

**References:**

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