Dotslashen: a Bayesian decision support system for fMRI clinical investigation

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Introduction: Functional magnetic resonance imaging (fMRI) technique is gradually leaving the domain of the Basic Research and gaining applicability in brain clinical investigation [1,2]. One of the main challenges toward this goal is the determination of what should be a "normal" fMRI exam. To delineate the fuzzy boundaries between a healthy and altered brain activity one usually rely on previous experience [3]. The use of a normative fMRI database based on epidemiological sampling criteria from a population could be an invaluable tool for the clinical application of fMRI exams. In this work we present a computational tool designed to extract knowledge and help the clinicians to interpret the information contained in a normative databased produced in our Institution.

Methods: Thirty seven normal volunteers subdivided according to gender and age, participated of these study. Each participant performed fMRI tasks involving visual, motor, somatosensory, language and semantic paradigms comprising 16 conditions (the database is currently composed of 37x16 = 592 activation maps). All subjects have also performed neuropsychological tests, and were recruted from the same population as the patients of our Institution. All images were acquired in GE twin gradient system with a 4 channel head coil, stimuli delivery and behavior response were performed using Eloquence system (InVivo). The acquisition parameters are: GRE-EPI, TR 2s, FA 70, 24 AC-PC slices, 3.75 x 3.75 x 5 mm voxels, 100-210 volumes. The MR system had QC performed daily [4]. Data was pre-processed for movement and spin history correction, the statistical inference used a non-parametric approach [5] and the BOLD effect was modeled using two Poisson functions, with maps thresholded at $p < 0.003$ using XBAM (www.brainmap.co.uk). This method have shown to be provide a false-positive control considered excellent compared to conventional parametric tests.

Results: We developed a Decision Support System (DSS – Dotslashen) to assist clinicians to decide whether a given brain activation, or lack of activation, is expected from a healthy subject or not. This process is carried in a populational context and the DSS allows the clinician to make interpretable probabilistic statements such as "*It is very likely that the majority of subjects have these regions activated*" or "*It is likely that almost no subject has these regions activated*". This is achieved comparing the findings from the patient's fMRI exam with a normative database. The DSS is based on: (i) a relatively comprehensive database of fMRI exams from volunteers defined as *healthy* and (ii) a Bayesian statistical approach to extract knowledge from the database. According to patient demographics such as age, handedness, gender, etc., the clinician defines a compatible *target* subpopulation in the database. The clinician then defines a *query* subset of tasks and brain regions to be interrogated. Our system returns the brain activation pattern of the *query* based on the database's *target* population. For example, one may want to know what is the activation pattern of a typical right handed male, 30 years old, in a series of motor-related brain regions. In this case, a possible *target* is defined by all 18 to 45 right handed subjects. One of the possible queries could be the *query*: *Motor** and *SMA_left OR SMA_right*, meaning activation in left or right supplementary motor areas (SMA) activated in at least one of the motor-related tasks. The answer to this *query* is that the frequency of activation is $p = 0.78$, its 90% credibility interval is $[0.63;0.89]_{90\%}$ and the probability **Pr**($p > 0.6$) is 97%. The DSS translate probabilistic quantitative information to qualitative interpretable statements. In this example, the statement is: it is very likely that the majority of subjects have the left or right SMA activated in motor-related tasks.

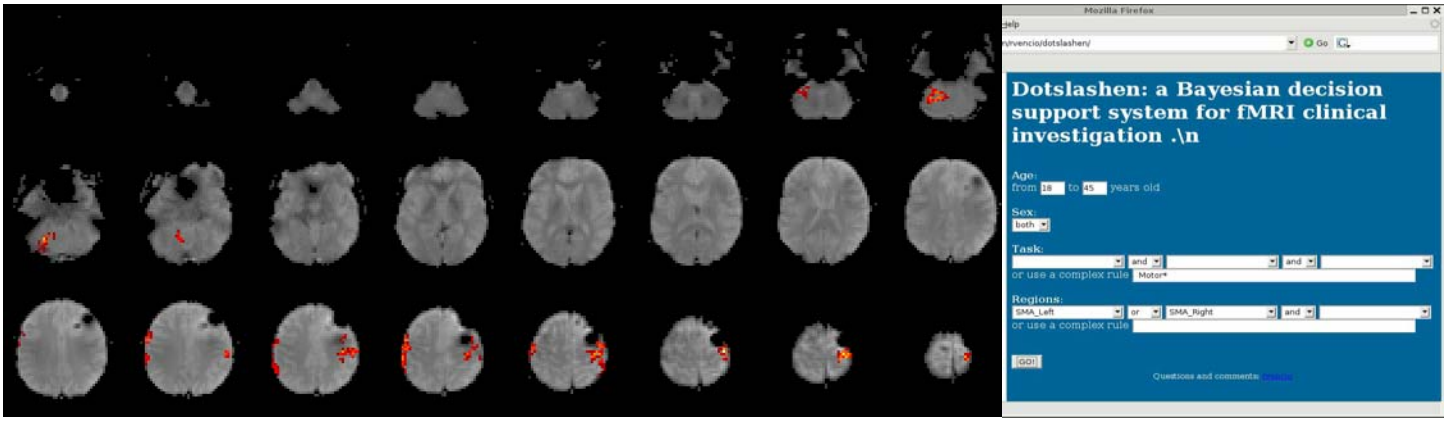

Figure 1: The *left* panel shows an example of an individual Brain Activation Mapping (iBAM) for the *Motor Fast Right* task from a patient. The *right* panel shows a screen-shot from the Dotslashen's web-based interface.

Conclusion: The design of our system is concluded and validation procedures are now under clinical investigation. The web-availability and the user-friendness are features that make our DSS a useful tool for clinical investigation of brain activity using fMRI. Future directions include efforts to continuously populate the database scanning more subjects, integrating the database with task performance, results from neuropsychological tests and other future parameters.

References:

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