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COMPARATIVE ANALYSIS OF STATISTICAL METHODS FOR DETERMINING DEEP BRAIN STIMULATION SWEET SPOTS

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Introduction: The precise location of the optimal target, or sweet spot, for Deep Brain Stimulation (DBS) is still unknown. However, its determination plays a pivotal role in guiding algorithms for the automatic programming of DBS parameters. Several studies have approached this problem, mainly employing t-test and Wilcoxon test to obtain probabilistic stimulation maps. However, a thorough assessment of the chosen statistical method's influence on the sweet spot extracted from group analysis is still missing. The objective of this study is to compare the outcomes of the above mentioned statistical tests applied to DBS patients data.

Methods: The data used for the study was captured during the intra-operative stimulation tests of 6 Essential Tremor (ET) patients bilaterally implanted in the ventro-intermediate nucleus (VIM). Stimulation settings were used to compute patient-specific electric field simulations which were then transformed to a group-specific MRI template. A voxel-wise one-tailed one-sample t-test was evaluated against a voxel-wise one-tailed Wilcoxon signed rank test. Voxels significantly (p -value < 0.05) associated with tremor improvement exceeding 60% were extracted. False Discovery Rate (FDR) was then applied to correct for false positives. The resulting significant sweet spot clusters were compared by visual analysis and by computing their total volume, intersection volume, and Dice coefficient. Lastly, for validation, the overlap between electric field and sweet spot was correlated with the degree of improvement.

Results: The generated stimulation maps and extracted sweet spots are shown in Figure 1. The applied statistical methods resulted in sweet spots of sizes: 28.88 mm³ for the t-test and 58.25 mm³ for the Wilcoxon. The Dice coefficient was 66%. The significant volume obtained with the t-test was entirely contained in the volume extracted with the Wilcoxon test. Stimulations encompassing the sweet spot were positively correlated to improvement with similar coefficients for both methods.

Conclusions: Users should be aware that the chosen statistical method can largely impact the extracted significant volume in group analysis. Despite the difference in size, stimulation of both sweet spots was correlated to improvement. The definition of robust criteria to guide the method's choice is thus fundamental. This work was supported financially by the Swiss National Science Foundation (205320_207491).

Keywords: Deep Brain Stimulation (DBS), Probabilistic sweet spot

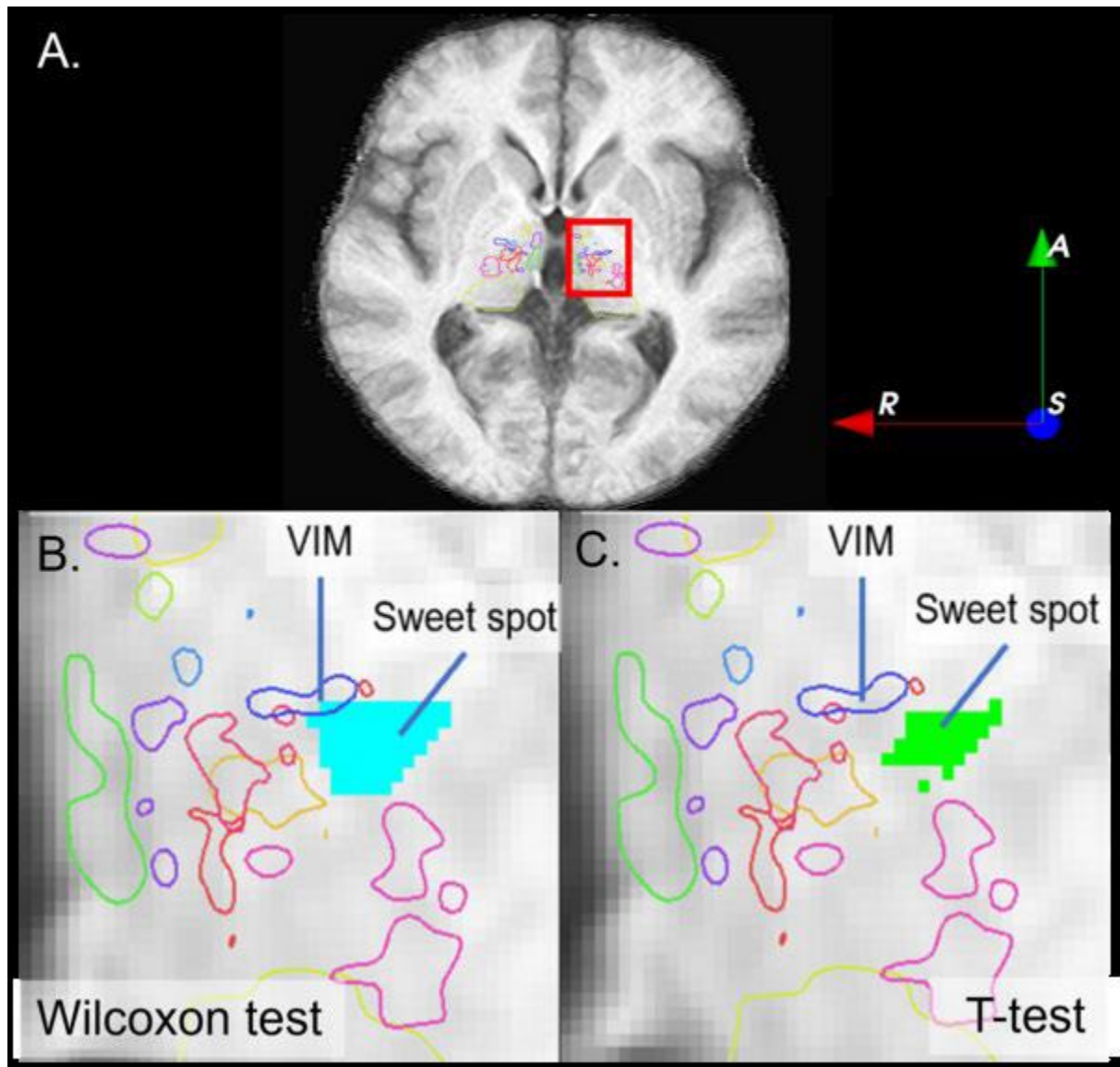


Figure 1. (A) Location in the brain of identified sweet spots (highlighted by red rectangle), respectively with (B) one-tailed Wilcoxon signed rank test (significant voxels with p -value <0.05 are colored in light blue) and (C) one-tailed one-sample t -test (significant voxels with p -value <0.05 are colored in green).