Multivariate pattern analyses of functional MR imaging of the voice neural network

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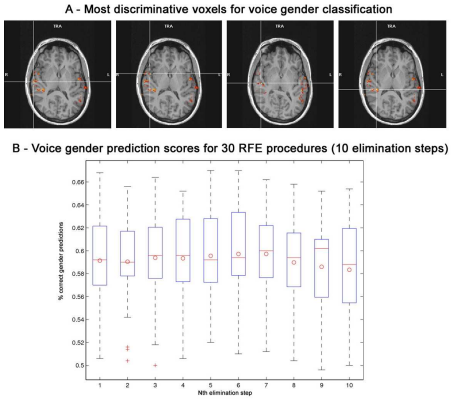
Introduction: The human voice is not only the indispensable acoustic medium of language but also conveys a wealth of information about the speaker's identity and his emotional state. While recent neuroimaging studies revealed the existence of "temporal voice areas" highly selective to human vocal sounds (Belin et al., 2000), still little is known about the cortical areas involved during categorization of voice's gender or affective content. As classical univariate statistics were unsuccessful so far to reveal specific cortical regions involved during voice gender identification (but see Charest et al., this conference), our objective was to address this issue using multivariate pattern analyses, a recent field of applied mathematics allowing a thorough discrimination of cortical activation patterns.

Methods: Normally-hearing participants were exposed to three different acoustic continua of three different vowels. Each acoustic continuum varied from a male voice to a female voice (7 steps total) using a source-filter decomposition coupled with an acoustic morphing procedure (Kawahara, 2003). Morphed voices were used for a passive listening task during functional magnetic resonance imaging using a rapid event-related carry-over design, thus allowing a thorough control on stimuli precedence effects (see Charest et al., this conference). Experimental trials were divided into a first set ("training") used to train a Support Vector Machine pattern classifier (Recursive Feature Elimination, see Formisano et al., 2008), while generalization performance was assessed using the remaining data ("test").

Results:
Univariate analysis demonstrated activations in temporal voice areas and auditory associative cortex when comparing activations for voices and silences. They also revealed a significant effect of voice gender physical modulation in the temporal voice areas (see Charest et al., this conference). In preliminary multivariate analyses on a single subject, generalization scores obtained through multivariate pattern analysis indicated that the voice gender was correctly predicted for 59±4% of the brain activation patterns (chance level 50%), even when multivariate training was restricted to neural activity into individual voice areas. The voxels that were most predictive (preserved in more that 95% of the RFE procedures) were mainly located along the posterior and anterior parts of the right superior temporal sulcus (Figure). Removing the contribution of voice areas ("virtual lesion") resulted in poor generalization scores - at chance level.



Conclusions:
Multivariate analyses applied to fMRI of the voice neural network show the importance of temporal voice areas during voice gender processing, as demonstrated by our virtual lesion approach. Our study in normally-hearing volunteers identifies landmarks for a thorough investigation of voice-related features such as speaker's identity or affective content and a more efficient analysis of functional MRI data using multivariate pattern analyses. A crucial question to be addressed by complementary analyses is related to the specific role of voice-selective areas during voice gender classification.

References:
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Category: Modeling and Analysis
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