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Applying fMRI complexity analyses to the single-subject: a case study for proposed neurodiagnostics

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Methods for accurate diagnoses of neurological problems would greatly improve modern medicine. Nonlinear dynamic tools have been statistically validated at the group level to identify subtle differences in system wide regulation of brain meso-circuits. In many cases, this increases clinical sensitivity over conventional analyses alone. In order to extend these methods to neuro-diagnostics, however, we explored the feasibility of extracting information at the single-subject level. To illustrate how this may be done, we focused on two pairs of healthy individuals with psychological differences in stress reactivity. The first pair consisted of one subject of average reactivity, the other of exceptional reactivity (working as an explosive ordinance disposal technician in support of U.S. Navy SEAL missions). The second pair was chosen from a larger group of subjects (with identical task design and imaging parameters), in which we had previously established a link between prefrontal-limbic reactivity and efficiency of stress responses. We applied both statistical and nonlinear dynamic tools: principal component decomposition, cross-correlation and complexity (power spectral scale invariance). These analyses were chosen to capture key characteristics of the prefrontal-limbic meso-circuit, such as activation, connectivity, and control systems regulation. We compared single subject results with statistical results obtained for the larger group. Our conclusions suggest that complexity analyses may identify important differences at the single-subject level, supporting investigation of these techniques for neuro-diagnostic applications.