Emotional stress is a ubiquitous feature of everyday life but what paralyzes one person is just as likely to exhilarate the next—individual differences in coping with stress have emerged as important risk factors for neurological, psychiatric, and cardiovascular disease, yet the neurobiological basis for those differences is unknown. In the brain, the control circuit responsible for modulating emotional arousal is the limbic system, providing outputs to the autonomic nervous and endocrine systems. We hypothesized that maladaptive response to stress might be caused by system-wide dysregulation, detected through complexity. We conducted four functional magnetic resonance imaging experiments (total N=145) in which we measured self-similarity or fractality of neural time-series, power spectrum scale invariance (PSSI), as a marker for complexity. Populations tested ranged from extreme stress vulnerability (Generalized Anxiety Disorder Study, N=30) to moderate-to-normal anxiety (Trait Anxiety Study, N=50, [1]) to extreme stress resilience (Skydiver Study, N=30). We also included individuals with psychosis (Paranoid Schizophrenia Study, N=35, [2]) as a comparison group with both emotional and cognitive symptoms. In all four studies, normative responses were
associated with scale invariance at the “pink noise” range, the signature of a well-regulated control system. Deviations towards both extremes (stress vulnerability and stress resilience) were associated with the “white noise” range, showing less feedback and control, but originating from distinct components of the circuit. Limbic dysregulation for anxious individuals showed poor regulation of the amygdala, the excitatory component of the limbic circuit, associated with fear. In contrast, risk-taking individuals’ dysregulation stemmed from areas of the prefrontal cortex associated with inhibiting fear. Schizophrenia patients also showed disrupted prefrontal activity, but in an area anatomically distinct from both the other groups, associated with both emotion inhibition and cognition. In all cases, complexity analyses were significantly more sensitive than standard statistical methods for analyzing neuroimaging data, suggesting the utility of this approach for prediction of stress-resilience and risk for stress-related disease, including mental illness. Current ongoing research in our laboratory extends these findings, moving from group differences towards individual diagnostic classification, increasing sensitivity through high temporal-resolution imaging technologies such as near-infrared spectroscopy, developing ways of probing limbic dynamics without conscious perception, as well as investigating stress resilience in toddlers to establish age-thresholds for detection.

Bibliography
