Phenomenological consequences of the axial anomaly of QCD are ubiquitous. They range from effects on the mass spectrum of hadrons and the order of the chiral phase transition, to the chiral magnetic and related effects which are (possibly) relevant in heavy-ion collisions. All these phenomena are inextricably linked to non-trivial topological fluctuations. While the nature of such fluctuations in the confined phase is still unsettled, at temperatures well above that for the chiral phase transition, for instance, they can be described by a dilute gas of instantons. In this regime, it is well known that instantons of unit topological charge generate anomalous quark correlations which give rise to many of the effects mentioned above. Here we generalize this by demonstrating that instantons of arbitrary topological charge $Q$ generate anomalous correlations of $2N_f|Q|$ quarks. Even though semi-classically such topological field configurations are suppressed exponentially, these correlations can give rise to novel anomalous effects related uniquely to fluctuations of higher topological charge. We explicitly work out the local effective interaction for $Q = 2$ in the limit of small instantons sizes. At low energies and for two quark flavors this is a quartic meson interaction. We study its qualitative impact on the mass spectrum within a simple mean-field picture and discuss further applications.