Spontaneous visual processing of non-rigid materials recruits intuitive physical inference regions and activates physics-based representations in the human brain

Wenyan Bi, Qi Lin, Kailong Peng, Aalap Shah, Ilker Yildirim
Yale University

The visual world of fluids and non-rigid objects such as liquids and cloths poses a fundamental challenge to perception: Their shapes are either simply mutable or can deform endlessly under external forces, yet we form rich and persistent percepts by observing how they move. Previously, using psychophysics and modeling, we found that human soft object perception is best explained by a model that incorporates 'intuitive physics', as opposed to alternative models that only consider pattern recognition. Here, we hypothesize that spontaneous visual processing of soft objects, i.e., in the absence of a physics-related task, *(i)* activates overlapping brain regions as those implicated in intuitive physical inference and *(ii)* leads to representation of physical properties (e.g., stiffness, viscosity) in these regions. To investigate, we scanned participants (N=15) in fMRI using previously validated localizers for intuitive physical inference and soft material perception. We also scanned the same participants while they passively viewed naturalistic animations of cloths and liquids with different stiffness and viscosity values and scene configurations. Despite the differences in various aspects of the two localizers (static images vs. dynamic videos and physical judgment vs. passive viewing), we found substantial overlap between the regions of interest (ROI) identified from the intuitive physics and the soft material perception localizers. The overlap of the two localizers lends support for our first hypothesis and occurs primarily in parietal (the postcentral, supramarginal and angular gyri) and occipital temporal regions (inferior temporal gyrus and lateral occipital cortex). To test our second hypothesis, we obtain the univariate activity differences between soft vs. stiff cloths and runny vs. thick liquids, and compare these differences for V1 vs. the union of the two ROIs. In preliminary analysis, we find a significantly greater effect of physical property in the union of the two ROIs than V1 ($p=.03$, paired-sample t-test). These results suggest that the perception of fluids and soft objects is a form of intuitive physics, and indicate a common 'physics engine' in the brain supporting both how we reason about and perceive the physical world.