The effects of visual scene complexity on human cortex

Bies, A.J.(1), Wekselblatt, J.B.(2), Boydston, C.R.(3), & Taylor, R.P.(3), Sereno, M.E.(1)

1) University of Oregon, Psychology; 2) University of Oregon, Biology; 3) University of Oregon, Physics

Complex natural forms (e.g., mountains, trees, clouds) exhibit fractal characteristics yet there has been little systematic, neuroscientific investigation of human responses to fractal stimuli. Fractals are patterns that repeat at increasingly fine magnifications, and have fractal dimensions (*D*) that fall between Euclidian dimensions (e.g., a fractal line has a D value lying between a smooth line, $D = 1$, and a filled plane, $D = 2$). The visual complexity generated by the repeating patterns increases with their D value. The horizon lines of natural landscapes have *D* values that fall in the low to middle portion of the range $1 < D < 2$. It has been hypothesized that humans are predisposed to prefer environments and scenes with a level of complexity near that of the landscapes in which we have evolved. In support of this idea, recent research has shown that individuals' preference for particular natural scenes depends on complexity, with greater preference for low-to-mid range complexity as characterized by a scene's fractal dimension (Taylor et al., 2011). Because natural scenes do not vary across the entire range of complexity without changing content, we produced a set of abstract scenes that sample the full range of complexity quantified by the fractal dimension (viz., $D = 1.1$, 1.3, 1.5, and 1.9 for each of 16 patterns). In the current study, human participants viewed these computer-generated fractal images and rated the aesthetic value of each, during functional magnetic resonance imaging. We used a subtraction paradigm to isolate brain areas that were more active when viewing a particular dimension than the others. Primary visual cortex fell within the region more activated by viewing images with $D = 1.9$, whereas lateral occipital cortex (LO) fell within the area more activated by viewing images with $D = 1.1$. We created masks for contrasts $1.1 > 1.9$ and $1.9 > 1.1$, and found that brain activity in early visual areas ($1.9 > 1.1$) shows a significant, linear increase in activity as complexity increases, whereas later visual areas ($1.1 > 1.9$) show a significant, linear decrease in activity in response to increased complexity. Meanwhile, preference ratings do not scale linearly with complexity. Ratings were high and exhibited little change in the low-to-mid range of D, but were considerably lower at high D values. Thus, visually appealing fractal patterns of low-to-mid range fractal D stimulate higher-level visual areas such as LO, regions known to be involved in processing objects. This activity in object-processing areas provides a putative explanation for why certain patterns naturally evoke object percepts (e.g., perceiving faces or animals in clouds, rock formations, ink blots).