Supplementary Materials and Methods

Stimulus generation and norming

Stimuli in each of the two experiments were sixteen simple filled shapes constructed from RFCs similar to those used by Op de Beeck et al. (2001, “popcorn”; 2003, “moons”); stimulus generation code available (http://cfn.upenn.edu/aguirre/code/matlablib/ODBstims/). We adjusted the parameters supplied by Op de Beeck et al. such that perceptual distances, for popcorn and moons as measured in RT to difference judgments and explicit similarity ratings, within and across 12 subjects (8 females, ages 20-33) very closely matched the distances called for by the di-octagon arrangement.

We used the Garner (Garner and Felfoldy 1970) task to behaviorally characterize the popcorn and moon stimulus axes. Nine subjects (7 females, ages 22-33) performed 640 sorting operations on exemplars of the popcorn and moon shapes (1280 total). At the beginning of each of 16 blocks of 40 trials, the subject was shown visually which dimension was to be used for sorting; a key press on each trial to indicated the value on that dimension for the stimulus. In the “filtering” condition, the unattended axis was varied randomly, while in the “correlated” condition, the value of the other axis was perfectly correlated with the attended axis (Supplementary Figure 1A). Subjects were faster (p < 0.001) sorting popcorn shapes in the “correlated” condition than in the “filtering” condition; there was no difference between the conditions for sorting the moon shapes (Supplementary Figure 1B). The conditional difference in RT between the two shape conditions was significant (p < 0.001). These results support the description of the popcorn axes as integrally perceived and the moon axes as separably perceived (Garner and Felfoldy 1970), replicating the previous results of Op de Beeck 2003).

Subjects and scanning parameters

Four right-handed women and two right-handed men aged 20-35 participated in the study. All subjects provided informed consent and the study conformed to the guidelines of the University of Pennsylvania Institutional Review Board. Structural and functional
data were collected on a 3.0-T Siemens Trio scanner using an 8-channel head coil. High-resolution T1-weighted structure images were collected in 160 axial slices and near isotropic voxels (0.9766 mm x 0.9766 mm x 1.0000 mm; TR = 1620 ms, TE = 3 ms, TI = 950 ms). Functional, blood-oxygenation-level-dependent (BOLD), echoplanar data were acquired in 3 mm isotropic voxels (TR = 3000 ms, TE = 30 ms). BOLD data were acquired in 42 axial slices, in an interleaved fashion with 64 x 64 in plane resolution. The functional data were collected in 5 runs of 159 TRs each. The first 6 s of each run consisted of ‘dummy’ gradient and radio frequency pulses to allow for steady-state magnetization during which no stimuli were presented and no fMRI data were collected. The next 15 s displayed the stimuli presented in the last 15 s of the previous run (or the final run, in the case of the first run); these periods of “scan overlap” allow the carry-over BOLD response to build to a steady state, and were removed in processing (Aguirre 2007).

Stimulus presentation and scanner task

During scanning, each shape was drawn on a mean gray background, and over a line drawn such that it bisected the shape leaving 65% to one side or the other (Supplementary Figure 2). This line was randomly tilted between 10 and 40 degrees from the vertical. A space was kept between the line and the shape such that they would not intersect. The shape was defined by a light green color that was isoluminant with the background. The stimuli were back-projected onto a screen viewed by the subject through a mirror mounted on the head coil, and subtended 5° × 5° of visual angle. Each stimulus was presented for 1400 ms, with a 100 ms ISI consisting of the mean gray background. The subject was instructed to indicate on each trial, by button press, whether the line was drawn more to the left or right of the shape. The task was assigned solely for the purpose of requiring the subject to attend to every stimulus in the experiment, and was constructed so as to not involve an explicit comparison between sequential stimuli. All subjects performed above 92% accuracy, and the mean accuracy was 96% (popcorn) and 98% (moons), indicating that subjects were alert and monitoring the stimuli as they were presented.
**Stimulus sequence**

In each of the two experiments, each of the 16 different shapes was presented to each subject 85 times in a fully first-order counterbalanced sequence. The order of stimulus presentation was determined by an n=17, type 1 index 1 sequence. The full sequence was divided into five parts for scanning as described previously (Aguirre 2007). The labels 1-16 were assigned to the 16 stimuli and the 17th label indexed the presentation of a blank trial (gray screen with fixation cross), which had a duration of 3 seconds (Aguirre 2007). This sequence provides for first-order counterbalancing of the stimuli, such that every image appeared in the sequence both before and after every other image, as well as before and after 3 seconds of a blank screen. A particular type 1 index 1 sequence was selected which maximized efficiency (Friston et al. 1999) for the balanced detection of adaptation effects proportional to stimulus similarity and the predicted Euclidean contraction effect. This sequence was identified by brute-force search of several hundred thousand sequences (Aguirre 2007) and can be obtained from our website (http://cfn.upenn.edu/aguirre/wiki/premade_sequences).

**Image pre-processing**

Off-line data analysis was performed using VoxBo (www.voxbo.org) and SPM2 (http://www.fil.ion.ucl.ac.uk/) software. Data were sinc interpolated in time to correct for the slice acquisition sequence, motion corrected with a six-parameter, least squares, rigid body realignment routine using the first functional image as a reference, and normalized in SPM2 to a standard template in Montreal Neurological Institute (MNI) space. Normalization maintained 3 mm isotropic voxels and used 4th degree B-spline interpolation. In the analysis of adaptation effects, the fMRI data were smoothed in space with a 3 × 3 × 3 voxel isotropic Gaussian kernel. The average power spectrum across voxels and across scans was obtained, and the power spectrum fit with a 1/frequency function (Zarahn, Aguirre, and D'Esposito 1997). This model of intrinsic noise was used during regression analyses with the Modified General Linear Model (Worsley and Friston 1995) to inform the estimation of intrinsic temporal autocorrelation.
Voxels that composed regions of interest were identified for each subject as the intersection of a categorically defined area, (LOC, identified by response to object > scrambled object at a threshold of t > 3) defined from data obtained during separate scans using standard methods (Harris and Aguirre 2008), and areas where adaptation to both dimensions of both sets of stimuli were found (using a threshold of t > 2 for each dimension). Note that this criteria for voxel selection is orthogonal to the Euclidean contraction covariate of interest. The ROI analyses reported here combined data from the left and right hemispheres. The location of the selected voxels of interest (Figure 9A) were presented (using BrainVoyager; http://brainvoyager.com) atop the MNI anatomical image that served as a template for spatial normalization.

**Supplementary Figure Legends**

Supplementary Figure 1 - We used the Garner task to confirm that the popcorn and moon stimulus axes are perceived as integral and separable, respectively. (A) Subjects were required to sort serially presented stimuli into two categories, divided along one of the axes. In the 'filtering' condition, the other axis was varied randomly, while in the 'correlated' condition, the value of the other axis always followed the value of the axis to sort on (thus providing additional information). (B) Subjects were faster sorting popcorn shapes in the 'correlated' condition than in the 'filtering' condition; there was no difference between the conditions for sorting the moon shapes. These patterns of results are described as belonging to 'integral' and 'separable' axes (Garner and Felfoldy 1970).

Supplementary Figure 2 – (A) Each shape was drawn on a gray background. A line, randomly tilted between 10 and 40 degrees from vertical, divided the shape such that 65% of the surface area fell to one side or the other. A space was kept between the line and the shape such that they would not intersect. The subject was instructed to indicate on each trial, by button press, whether the line was drawn more to the right (B) or left (C) of the shape.