Appendix A. Screen Coordinates

During Experiment 1, in half of the trials we reversed screen coordinates to avoid participants’ memorizing screen position of the mouse instead of attending to resulting image distortions. For example, to adjust the highest reach and grain settings, observers moved the mouse to the top right corner in regular trials, and lower left corner in the reversed trials. Figures A1 and A2 show adjustments for each trial per observer. As evident from overlapping adjustments for trials with regular (blue icons) and reversed (red icons) screen coordinates, we did not find a difference between the two. We ran paired sampled t-tests separately on grain and reach values for each layer, analyses yielded no significant differences for regular and reversed screen coordinates (for all conditions, \(t(26) < 0.5, p > 0.63\)).

Figure A1: Scatter plots for reach and grain adjustments from Experiment 1 water trials. This plot shows data per observer (separate plots) in water trials. Grain settings are plotted (x-axis) against reach settings (y-axis). Each plot shows 16 trials half of which are regular (blue diamonds) and other half are reversed (red discs). Participant initials are inscribed inside each plot.
Figure A2: Scatter plots for reach and grain adjustments from Experiment 1 glass and haze trials. This plot shows data per observer (separate plots) in glass (a) and haze (b) trials. Grain settings are plotted (x-axis) against reach settings (y-axis). Each plot shows 16 trials half of which are regular (blue diamonds) and other half are reversed (red discs). Participant initials are inscribed inside each plot.
Figure B1: Individual and mean data from Experiments 1, 2, and 3. (a) Experiment 1: Grain (y-axis) and reach (x-axis) adjustments for each observer (n=16) are plotted in separate icons for haze (red) trials. Each icon represents an observer's mean adjustments for all trials averaged over objects. Group mean is also plotted with a larger icon ± standard error of the mean. Normalised histograms for haze trials pooled across participants are shown outside the axes. Histograms along the horizontal axis show data for grain adjustments, along the vertical axis we show histograms for reach adjustments. (b) Data from Experiment 2 (n=14) are shown, coherent block and incoherent blocks on the left and right respectively. (c) Data from Experiment 3 (n=10) coherent block on the left, incoherent block on the right.
Figure C1: Predicted classes for water, glass, and haze from Experiments 1-2. (a) Grain (horizontal axis) and reach (vertical axis) adjustment data for all 672 trials, including the third layer, haze, in Experiment 1. Hollow icons depict trials where participants adjust for water (blue circles), haze (red circles), and glass (green circles) layers. Underneath the hollow icons, we show classifications for three clusters of water (blue discs), haze (red discs) and glass (green discs). (b) Same trial data from Experiment 2, for the coherent (b1) and the incoherent (b2) blocks (1536 trials each).
Figure C2: Predicted classes for water, glass, and haze from Experiment 3. (a) Grain (x-axis) and reach (y-axis) adjustment data for all 960 trials, including the third layer, haze, in Experiment 3, coherent (a1) and incoherent (a2) blocks. Hollow icons depict trials where participants adjust for water (blue circles), haze (red circles), and glass (green circles) layers. Underneath the hollow icons, we show classifications for three clusters of water (blue discs), haze (red discs) and glass (green discs).

Appendix D. Object Differences

In Experiment 1, we used 8 different shapes (Figure 4a). Comparing means with a repeated measures ANOVA (8 objects x 3 layers) revealed no significant differences either in posthoc pairwise comparisons either for reach or grain values (Figure D1).

In Experiment 2, we used 4 objects as stimuli (Figure D2, top row). Here we compare means with a repeated measures ANOVA including all layers (4 objects x 3 layers x 2 coherences) separately for each parameter, we report Bonferroni corrected posthoc pairwise comparisons. For reach values, we find no significant main effect of object (F(3,45)=0.63, p = .6), hence pairwise comparisons between objects remain insignificant. For grain values, we found a significant main effect of object (F(3,45)=51.7, p < 10^{-7}) revealing overall highest grain values for the dark glossy object (\(\mu_{\text{dark glossy}} = 6.4 \pm .1\)) and lowest grain values for the light glossy object (\(\mu_{\text{light glossy}} = 6.0 \pm .1\)). Difference between glossy objects were significant (\(\Delta \mu_{\text{light-dark}} = 0.44, p < 10^{-7}\)), but not for diffuse objects (\(\Delta \mu_{\text{light-dark}} = 0.02\)).

Similarly, in Experiment 3, we compare means with a repeated measures ANOVA (4 objects x 3 layers x 2 coherences) separately for each parameter (Figure D4). For reach values, there is a main effect of object (F(3,27)=7.3, p < .001). Pairwise comparisons reveal a significant difference between glossy objects (\(\Delta \mu_{\text{light-dark}} = 0.30, p < .03\)).
but not for diffuse objects ($\Delta \mu_{\text{light-dark}} = 0.09$). Also, reach values for the light diffuse object were significantly higher than light glossy object ($\Delta \mu_{\text{light-dark}} = 0.50, p < .02$). For grain values, we do not find any significant main effect of object, however, posthoc comparisons reveal a significant difference only between glossy dark and light objects ($\Delta \mu_{\text{dark-light}} = 0.32, p < .04$).

Appendix E. Textures
Figure D2: Scatter plots for reach and grain adjustments for each object from Experiment 2. Data per observer (transparent icons, n = 16) in water (first row), glass (second row), and haze (last row) trials are plotted separately for the coherent (a) and the incoherent (b) blocks. Grain settings are plotted (horizontal axis) against reach settings (vertical axis). Each column shows data for a different object used in Experiment 2, corresponding fiducial images are included above the plots: dark diffuse, light diffuse, dark glossy, and light glossy.
Figure D3: Scatter plots for reach and grain adjustments for each object from Experiment 2. Data per observer (transparent icons, \( n = 16 \)) in water (first row), glass (second row), and haze (last row) trials are plotted separately for the coherent (a) and the incoherent (b) blocks. Grain settings are plotted (horizontal axis) against reach settings (vertical axis). Each column shows data for a different object used in Experiment 2, corresponding fiducial images are included above the plots: dark diffuse, light diffuse, dark glossy, and light glossy.
Figure D4: Scatter plots for reach and grain adjustments for each object from Experiment 3. Data per observer (透明 icons, n = 10) in water (first row), glass (second row), and haze (last row) trials are plotted separately for the coherent (a) and the incoherent (b) blocks. Grain settings are plotted (horizontal axis) against reach settings (vertical axis). Each column shows data for a different object used in Experiment 3, similar to Experiment 2 but with occluded boundary: dark diffuse, light diffuse, dark glossy, and light glossy.
Figure D5: Scatter plots for reach and grain adjustments for each object from Experiment 3. Data per observer (transparent icons, n = 10) in water (first row), glass (second row), and haze (last row) trials are plotted separately for the coherent (a) and the incoherent (b) blocks. Grain settings are plotted (horizontal axis) against reach settings (vertical axis). Each column shows data for a different object used in Experiment 3, similar to Experiment 2 but with occluded boundary: dark diffuse, light diffuse, dark glossy, and light glossy.
Figure E1: (a) Eighteen coloured textures from the McGill database (Olmos and Kingdom, 2004) that are used in Experiment 4 are first converted to grayscale intensity images (576 x 576 pixels). (b) Logarithm of two dimensional Fourier Transform (2D FFT) for each texture. (c) Mean of 18 textures 2D FFT calculations. (d) Plots show 2D FFT values for each texture after subtracting the mean FFT in (c). Some patterns’ resemblance are immediately observed such as T11 & T18, or T14 & T17.
Figure E2: (a) Reach and grain adjustments of eighteen textures for water trials from the pilot Experiment (Participants are the same as Experiment 3, \(n=10\), 2 repetitions, all remaining parameters are the same as Experiment 3). (b) Power of the binned 2D FFT radial profile is plotted (vertical axis) to show one dimensional Fourier analysis (horizontal axis, max bin = 19 pixels, total image radius = 289 pixels) for each texture.