Abstract:
The ability to perceive the 3-Dimensional world is effortless despite the fact that the input to the visual system is 2-Dimensional. Attempts to derive biologically plausible models of shape from texture have focused on how changes in orientation and spatial frequency information are processed based on the response properties of V1 neurons. However, the relative contributions of orientation and spatial frequency information in detecting slant and shape from 3-D surfaces are not well understood. Additionally, in senescence, changes in optical components of the eye result in reduced frequency sensitivity, but whether concurrent neurophysiological changes affect the ability to discriminate orientation, and whether there is a resulting effect on form processing with age have remained unclear.

An initial set of psychophysical experiments administered to younger adults showed that changes in orientation (or orientation modulations, OMs) dictated slant perception at shallow and steep slants, while changes in frequency (or frequency modulations, FMs) were only effective at steeper slants. This effect of OMs dictating slant and shape percept remained present even if a surface contained a texture with OM and FM components specifying inconsistent degrees of surface slant or curvature. Three additional psychophysical experiments were conducted to assess age-related changes in orientation and shape discrimination between younger and older observers. Consistent with previous findings in the literature, the older observers had significantly higher contrast sensitivity than the younger group. Orientation discrimination thresholds were significantly higher for older observers when stimulus contrast was expressed as absolute values. However, when thresholds were evaluated in terms of multiples of detection threshold (to normalize stimuli for visibility across observers), age-related differences in orientation discrimination were not observed. Similarly, when observers performed a shape detection task, no significant difference was observed in shape detection thresholds across different spatial frequencies when age-related differences in contrast sensitivity were taken into account. However, when observers were given a shape discrimination task, older observers showed a significantly higher discrimination threshold at the highest spatial frequency even when thresholds were normalized for visibility. These findings suggest that while contrast detection thresholds increase with age, orientation and shape processing remain largely preserved. This suggests that in the context of degradations in optical and neural inputs, the overall percept of orientation and shape remains preserved with age, consistent with findings in several other areas in the visual system (e.g., color vision, perceived contrast). Our results suggest that the preservation of orientation and frequency perception with age at least partially contribute to the stability of 3-D shape perception, for stimuli in which orientation and frequency changes are cues for 3-D shape.