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Progress Report

1991

The role of attention in visual processing
Grant #N00014-89-J-1426
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Over the past six months, I have continued lines of research from the past year and uncovered some new phenomenon. Two papers have been written on the adaptation work on reversible perspective figures. A paper on the Schroder staircase has been accepted for publication in Perception, while similar work on the Necker cube is ready for submission.

Several new experiments have been conducted on attentional modulation of tilt aftereffects (in the tilt aftereffect, a vertical test bar is seen to tilt in an orientation opposite that of a preceding tilted adapting bar). In the original experiments, the tilted adapting bar and vertical test bar were defined by motion; dots in the bar moved in one direction, dots in the surround in a different direction. These experiments involve a distractor design; during the adaptation phase, subjects either attend to the adapting bar(they detect color changes in some of the dots defining the bar) or detect color conjunctions in a set of colored disk-annulus combinations that are arranged in a triangular configuration centered on fixation. The basic result is that tilt aftereffects are larger when subjects attend to the bar than when they detect the color combinations. This effect has now been found under conditions in which the dots are stationary in the surround and move in the bar or are stationary in the bar and move in the surround. Furthermore, the effect is present when dots are stationary in the bar and move both left and right in the surround so that there is no consistent direction of motion.

Initial pilot work had shown that tilt aftereffects produced by solid stationary bars do not show attentional effects. This had suggested that while mechanisms analyzing contours signalled by motion discontinuities can be attentionally modulated, contour mechanisms based on luminance discontinuities are more automatic. However, an experiment that compares luminance and motion bars directly is showing a more complicated result. When the luminance bar is defined by a random dot pattern with a blank surround (the same dot pattern used in the motion bar studies), attentional effects seem to be present. This effect is unexpected and raises the possibility that eye movements are contributing to the results. Although the color combinations in the irrelevant distractor task change too quickly for eye movements and are centered on fixation, fixation may be more variable in this condition than in the attend bar condition. The best control for small eye movements is to use an opponent display in which two adapting bars of opposite orientations are presented. When subjects attend to one or the other bar aftereffects of different sign should be produced. Eye movements in the two opponent conditions are identical since the motions of the dots defining the two adapting bars are identical. Previously, because of equipment

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limitations, I have been unable to set up an adequate opponent display. However, I have just purchased a more sophisticated Amiga computer that will be capable of presenting the necessary opponent displays. During the next grant period, I plan to study attentional effects on tilt aftereffects using opponent displays.

The main new result of the last six months is that strong effects of attention on size contrast have been demonstrated. Several perceptual dimensions show contrast, in which a context object induces an opposing percept in a test object. In size contrast, for example, a nearby large object makes a test object appear smaller while a small context object makes the test object appear larger. Contrast effects indicate that perceptual judgments are based on relative quantities. In my experiment subjects first see a white reference circle and then a briefly presented (150 ms) white test circle. Their task is to indicate whether the test circle is smaller or larger than the reference circle. Context circles, placed symmetrically along a horizontal and vertical axis containing the test circle, are presented along with the test circle. Two of the context circles are small and of one color (say red), two are large and a different color (say green). Subjects make a size judgment on the test and reference circle and a color judgment on one pair of context circles. In different blocks, the color judgment is made on the small pair of context circles (subjects determine whether they are the same or slightly different shade of hue), or the large pair of circles. The perceived size of the test circle changes systematically as attention is directed to the large or small context pair. The size change in the opponent conditions as attention is shifted from the small to large context pair is about 30% of the size change in blocks in which only one pair of circles (either large or small) is presented. This effect is quite robust and has been replicated.

Coren has shown that size contrast occurs at a stage following the computation of size/distance scaling. He presented equally sized context circles, placed stereoscopically either at a near distance or a far distance. Because of size/distance scaling, the near circles appear smaller than the far circles. Correspondingly, the near circles made the test appear larger while the far circles made the test appear smaller. This result provides important information on the perceptual representations involved in size contrast and therefore specify the type of representations that can be attentionally influenced.

The dual task methodology of these studies can be applied to any phenomenon in which the perception of an object is affected by some context object. Contextual effects have been used to study a wide range of perceptual computations. Although the original grant proposal centered on those perceptual mechanisms that could be isolated through adaptation phenomenon, the size contrast experiments indicate that the basic opponent methodology developed in the adaptation paradigm can be successfully applied to a wider range of perceptual phenomenon. During the next grant period, this methodology will be applied to assimilation phenomenon in which a context object induces a similar percept in a test object.