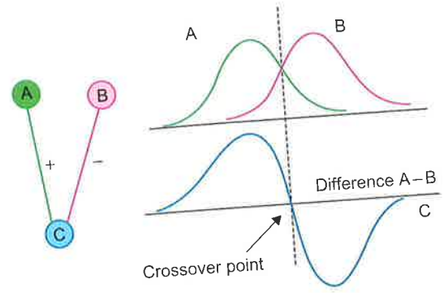

Figure 5.6 Differences between signals from neurons A and B are created by an excitatory and an inhibitory connection to neuron C.

in neural systems; it appears in color systems, edge detection, and size comparisons. Figure 5.6 illustrates the concept. Neurons A and B both have rather broadly tuned and somewhat overlapping response functions to some input pattern. Neuron C has an excitatory input from A and an inhibitory input from B. The result is that C is highly sensitive to differences between A and B at the crossover point.

The differencing mechanism explains why the visual system is exquisitely sensitive to differences, but not to absolute values. It also explains contrast effects because if one of the signals is rendered less sensitive, through lateral inhibition, the crossover point moves, but such fine discriminations are processed more slowly than the basic low-level responses. So, for rapid target finding, it is important that targets be distinct in orientation by 30 degrees or more and in size by a factor of two.

Feature Maps, Channels, and Lessons for Visual Search

To summarize to this point, because different kinds of visual properties are processed separately they can be thought of as forming separate feature maps, roughly at the V1 level. These maps cover the entire visual field, and there are many of them, each based on a different kind of feature. There is a map for redness, a map for greenness, a map for vertical orientation, a map for horizontal orientation, a map for motion, and so on.

When we are looking for something, a target set of feature properties is defined made up of the kinds of features that are found in feature maps (Eckstein et al., 2007). Eye movements are directed to feature map regions that best match the target properties. Figure 5.7 illustrates the idea. On the left is a set of symbols. On the right is how this image appears in a few of the feature maps. A search for red objects yields three candidate targets, and a search for black objects yields three different targets. A search for a left-slanted shape yields two strong and two weak targets. The oblique edges of the triangular symbols produce the weak signals, and these will somewhat distract in a search for the left-oriented bars.

Based on what we have learned so far, we can derive a number of lessons that can be applied to symbol set design. Low-level feature properties are critical.

> **[G5.4]** Make symbols as distinct from each other as possible, in terms of both their spatial frequency components and their orientation components.

> **[G5.5]** Make symbols as distinct as possible from background patterns in terms of both their spatial frequency components and their orientation components.

Figure 5.8 illustrates guideline G5.5 with a number of examples of scatterplots. The ones on the left use symbol shapes that are typical in many plotting packages.

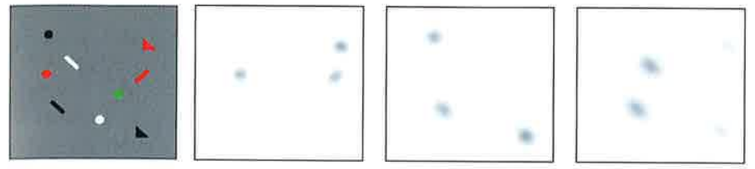

Figure 5.7 The symbols shown on the left are processed via a set of feature maps and the result directs eye movements.

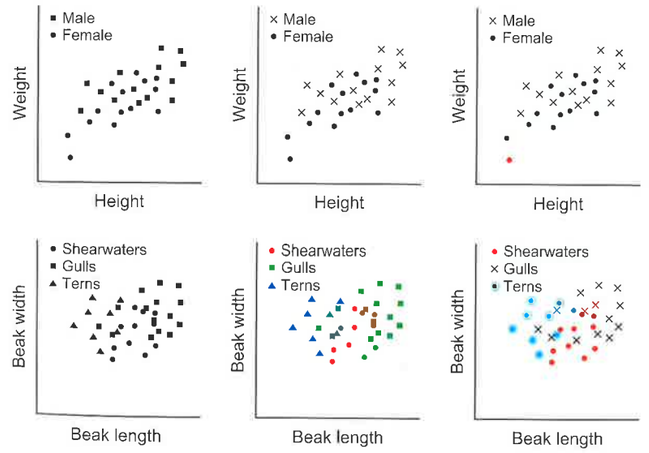

Figure 5.8 Feature channels can be used to make symbols more distinct from one another. The graphs on the right use redundant color coding in addition to more distinctive shapes.