*Archives Italiennes de Biologie, 135:* 157-167, 1997.

# VISUAL PERCEPTUAL LEARNING: A SIGN OF NEURAL PLASTICITY AT EARLY STAGES OF VISUAL PROCESSING

A. FIORENTINI AND N. BERARDI

*Istituto di Neurofisiologia C.N.R., Via S. Zeno 51, 56127 Pisa, Italy*

## INTRODUCTION

As our ancestors already knew, *eventus docet*, or, slightly rephrasing it, "practice makes it better".

Procedural learning (learning "how") is a form of implicit (non-declarative) learning, which involves the acquisition of a new skill through practice. Motor learning is very familiar: we have all learned to ride a bike, or to skate, or to play an instrument. Improvement in perceptual skills is perhaps more elusive, although our ability for instance to discriminate european faces (as opposed to chinese) or, for musicians, to discriminate tones is probably the result of perceptual learning.

Almost 15 years ago the existence of a visual perceptual learning with unique characteristics of selectivity was demonstrated by three groups (3, 4, 12, 13, 26). Despite the differences in the stimuli and tasks used, all three learning processes displayed selectivity for the stimulus attributes, such as orientation (12, 26), retinal location (4, 13) and size (12, 13) suggesting they involved early visual processing.

These seeds fell in the field and took root. Ten years later, there has been a blooming of papers on perceptual learning and new seeds have probably been sown. It is time to harvest such a rich crop and store what we have learned from it.

### I. *Examples of perceptual learning.*

Several examples of visual perceptual learning have been reported in the past and recently. Some of them show an improvement in the detection (e.g. contrast threshold for detecting oblique gratings, 20) or in the discrimination of visual stimuli (e.g. the orientation of lines) (29, 30, 36). Some types of hyperacuities, like steroacuity (10) and vernier acuity (9, 21, 24), are also improved by practice. Common to all these visual tasks is the fact that the effects of practice are retained for a very long time, typically for months or years. Interestingly, however, some basic functions like grating resolution (5) and the discrimination of gratings differing for their spatial frequency (13) do not show any improvement with practice, nor is there any appreaciable learning for some hyperacuity tasks, like bisection of the interval between two lines (19) or three-dot alignment (5).

On the contrary, a number of other tasks that require identification or discrimination of more complex stimuli show a substantial effect of practice, that is reflected either in the decrease of the discrimination threshold or in a shortening