Visual Literacy

A term that expands the concept of verbal language to include an understanding of basic images as signs, as well as an appreciation of imagery and its deeper spiritual levels of meaning within the visual arts.

Visual Mind

► Visual Communication and Learning

Visual Orthographic Images

► Mental Graphemic Representations

Visual Perception Learning

► Simulation-Based Learning

Visual Perceptual Learning

Zhong-Lin Lu[1], Barbara Anne Dosher[2]
[1]Departments of Psychology, University of Southern California, Los Angeles, CA, USA
[2]Department of Cognitive Science, University of California, Irvine, CA, USA

Synonyms

Perceptual improvement; Sensory learning; Sensory plasticity; Visual plasticity

Definition

Practice or training in perceptual tasks improves the quality of perceptual performance, often by a substantial amount. This improvement is called ► *perceptual learning*, in contrast with learning in the cognitive or motor domains. Research on perceptual learning is of theoretical significance in illuminating plasticity in adult perceptual systems, and in understanding the limitations of human information processing. It is of practical significance as a potential method for the development of perceptual expertise in the normal population and for noninvasive amelioration of deficits in challenged populations by training.

Theoretical Background

Historically, the role of learning in perception was vigorously denied by early Gestalt psychologists such as Max Wertheimer. Helmholtz, however, assigned learning an extremely important role in his theories of perception (Helmholtz 1911). In 1967, Eleanor J. Gibson published the first book on perceptual learning, with the view that perceptual learning is a process of discovering how to transform previously overlooked potentials of sensory stimulation into effective information (Gibson 1967). A resurgence of research on perceptual learning occurred in the late 1980s and early 1990s, when Dov Sagi and others systematically documented various specificities of perceptual learning and put forward the hypothesis that perceptual learning may occur in early sensory cortical areas (Karni and Sagi 1991). Since then, perceptual learning in adult human observers has been documented in a wide range of perceptual tasks (Fahle and Poggio 2002).

The most distinctive finding in perceptual learning is that some of what is learned is specific to stimulus or task factors such as retinal location (Karni and Sagi 1991), spatial frequency (Fiorentini and Berardi 1980), orientation (Ball and Sekuler 1982), or background texture (Ahissar and Hochstein 1996). Perceptual learning that is highly specific to retinal location and stimulus has been claimed to reflect neural plasticity in basic visual processing mechanisms (Karni and Sagi 1991).

Recent studies have investigated mechanisms of perceptual learning, that is, what is learned during perceptual learning, using psychophysics (Dosher and Lu 1998; Dosher and Lu 1999), neurophysiology (Crist et al. 2001; Ghose et al. 2002b; Schoups et al. 2001b), brain imaging (Schiltz et al. 1999), and patients (Xu et al. 2010).

In psychophysical studies, Dosher and Lu (1998) introduced a theoretical framework and an external noise plus training paradigm to analyze how perceptual inefficiencies improve over the course of perceptual learning. Perceptual inefficiencies are attributed to

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three limitations in perceptual processes (Lu and Dosher 2008): an imperfect perceptual template, internal additive noise, and multiplicative noise. Systematic measurements of human performance as a function of both the amount of external noise added to the signal stimulus and the length of training received by the observers make it possible to distinguish three mechanisms of perceptual learning: perceptual template retuning, stimulus enhancement, and contrast-gain control reduction. It has been consistently found that two independent mechanisms, stimulus enhancement and external noise exclusion, support perceptual learning in a range of tasks (Dosher and Lu 1998; Dosher and Lu 1999; Lu et al. 2006; Lu and Dosher 2004).

Practice-induced neuronal plasticity has been documented in auditory (Metherate and Weinberger 1990) and somato-sensory cortices (Jenkins et al. 1990; Recanzone et al. 1992) and in some visual functional Magnetic Resonance Imaging (fMRI) studies (Schiltz et al. 1999; Schwartz et al. 2002). Evidence for practice-induced neuronal plasticity in early visual cortical areas is however modest (Crist et al. 2001; Ghose et al. 2002a; Schoups et al. 2001a), although neurons in the primary visual cortex (V1) may exhibit task specific tuning (Li et al. 2004) that seems to reflect selection of task-relevant stimulus features for a particular task rather than persistent cross-task neuronal tuning changes. Law and Gold (2008) conclude, "...[our] results suggest that the perceptual improvements corresponded to an increasingly selective readout of highly sensitive medial temporal (MT) neurons by a decision process, represented in lateral intraparietal (LIP), that instructed the behavioral response." On the other hand, some recent evidence suggests greater plasticity in early visual areas might occur in non-primates (Hua et al. 2010).

Important Scientific Research and Open Questions

One major open question is whether perceptual learning reflects representation enhancement in early sensory areas or reweighting of sensory representation in the decision process. Petrov et al. (2005) introduced a task analysis framework to evaluate the diagnostic value of experimental designs for discriminating reweighting and representational enhancement in perceptual learning. A systematic review of the literature suggests that the two potential forms of plasticity – reweighting versus representational change – make similar predictions about specificity in most of the existing studies that had previously been cited as evidence for representational enhancement. Based on the results from the task analysis and neurophysiology, Petrov et al. (2005, 2006) implemented the reweighting hypothesis outlined in Dosher and Lu (1998) in a multi-channel Augmented Hebbian Reweighting Model (AHRM). The AHRM has been very successful in modeling a wide range of phenomena in perceptual learning.

Another important topic in perceptual learning concerns the role of feedback. A complex pattern of empirical results on the role of feedback in perceptual learning has emerged – see Petrov et al. (2006) and Dosher and Lu (2009) for reviews. Whereas most perceptual learning studies employed trial-by-trial feedback, several studies documented significant perceptual learning with block, partial, or even no feedback, and no perceptual learning with false, random, manipulated block, and reversed feedback (Herzog and Fahle 1997). Shibata et al. (2009) showed that arbitrary block-feedback facilitated perceptual learning if it was more positive than the observer's actual performance. At high-training accuracies, feedback was not necessary (Liu et al. 2008), and significant learning was found in low-training accuracy trials when they were mixed with high-accuracy trials (Liu et al. 2009; Petrov et al. 2006). Liu et al. (2010) conducted a computational analysis of the complex pattern of empirical results on the role of feedback with the AHRM (Petrov et al. 2005). The simulation results were both qualitatively and quantitatively consistent with the data reported in the literature.

A number of recent papers reexamined specificity of perceptual learning and found that a number of factors in the training procedures, some of which were not obviously related to specificity or transfer of learning, determined the degree of specificity, including task precision (Jeter et al. 2009), task difficulty (Ahissar and Hochstein 1997), number of trials (Censor and Sagi 2009), and training schedule (Xiao et al. 2008). Xiao et al. (2008) developed a novel double-training paradigm that employed conventional feature training (e.g., contrast) at one location, and additional training with an irrelevant feature/task (e.g., orientation) at a second location, either simultaneously or at a different time. They showed that this additional location training enabled a complete transfer of feature learning (e.g., contrast) to the second location. Understanding factors that determine specificity/transfer of perceptual learning may elucidate the functional architecture of perceptual learning.

Cross-References

- ▶ Adaptation and Learning
- ▶ Animal Perceptual Learning
- ▶ Computational Learning Theory
- ▶ Connectionist Theories of Learning
- ▶ Cross-Modal Learning
- ▶ Expertise and Learning
- ▶ Feedback and Learning
- ▶ Hebbian Learning
- ▶ Inductive Learning Spatial Attention
- ▶ Insight in Perceptual Learning
- ▶ Learning to Learn
- ▶ Perceptual Learning
- ▶ Perceptual Processing and Learning
- ▶ Signal-Detection Models
- ▶ Similarity Learning
- ▶ Speech Perception and Learning
- ▶ Supervised Learning
- ▶ Task Difficulty and Learning
- ▶ Task Sequencing and Learning
- ▶ Task-Irrelevant Perceptual Learning
- ▶ Unsupervised Learning

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Visual Plasticity

▶ Visual Perceptual Learning

Visual Representation

▶ Schema-Based Instruction

Visual Representations

▶ Pictorial Representations and Learning

Visual Search

▶ Matching to Sample Experimental Paradigm

Visual Selective Attention

▶ Attention and the Processing of Visual Scenes

Visual Spellings

▶ Mental Graphemic Representations

Visual Symbol

A visual symbol is an imaginary and/or realistic demonstration of an object, idea, or concept.

Visual Thinking and Learning

▶ Mental Imagery and Learning

Visualization

▶ Imagination Effect
▶ Learning by Doing Versus Learning by Thinking
▶ Models and Modeling in Science Learning

Visualization and Animation Tools

▶ Visualizations and Animations in Learning Systems

Visualization Techniques for Learning

▶ Mental Imagery and Learning