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Perceptual Learning Part II

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Editorial

Perceptual learning: Functions, mechanisms, and applications

The first International Workshop on Perceptual Learning was held at Beijing Normal University in Beijing, China, from October 15, 2008 to October 19, 2008. The workshop brought together more than 20 world-class investigators from many complementary disciplines – psychophysics, neurophysiology, functional imaging, computational neuroscience, and perceptual rehabilitation, all contributors to the study of the functions, mechanisms, and applications of perceptual learning. Participants of the workshop not only reported the latest advances in their research, but also engaged in lively discussions and friendly debates both in the scheduled discussion period after each talk and during many social events. We all agreed that the first workshop was extremely successful in fostering exchanges of ideas and multidisciplinary collaborations.

Following the workshop, we invited all the participants and many other investigators on perceptual learning who could not attend the workshop for various reasons to contribute to a Special Issue of Vision Research on perceptual learning. We received about two-dozen submissions. Because of the large number of manuscripts, the special issue is published in two volumes. The first volume was published in Volume 49, Number 21 of Vision Research in October, 2009 (Lu, Yu, Watanabe, Sagi, & Levi, 2009). The current issue is the second volume of the Vision Research Special Issue on Perceptual Learning. It consists of the second half of the accepted manuscripts from the submission pool.

In the first paper, Zhang, Xiao, Klein, Levi, and Yu (2010) reexamined the location specificity of practice effects in orientation discrimination. Surprisingly, they find that the learning effect is transferred to an untrained location if the latter is exposed to a short pre-test before practice. It becomes clear that perceptual learning is not a single process but rather a process involving different levels of processing operating on different scales in space and time (Ahissar & Hochstein, 2004; Karni & Sagi, 1993) with bi-directional transfer of learning (Censor & Sagi, 2009, in the first special issue). Most importantly, this study adds to the accumulating results showing that details of the training schedule thought to be irrelevant for transfer affect specificity of learning, including task precision (Jeter, Dosher, Petrov, & Lu, 2009), task difficulty (Ahissar & Hochstein, 1997), and number of trials (Censor & Sagi, 2009).

Lu, Liu, and Dosher (2010) tested the Augmented Hebbian Reweighting Model (AHRM) developed by Petrov, Dosher, and Lu (2005) against empirical results on mechanisms of perceptual learning by applying the AHRM to data from experiments in which external noise was explicitly manipulated. In this elegant model, perceptual learning strengthens or maintains the connections between the most closely tuned visual channels and a learned categorization structure, while it prunes or reduces inputs from task-irrelevant channels. Reducing the weights on irrelevant channels reduces the contributions of external noise and additive internal noise. Manifestation of stimulus enhancement or external noise exclusion depends on the initial state of internal noise and connection weights in the beginning of a learning task. Both mechanisms reflect re-weighting of stable early sensory representations.

Nahum, Nelken, and Ahissar (2010) discovered in an auditory learning task that similar principles dealing with multiple stimulus learning and stimulus uncertainty in the visual domain (Zhang et al., 2008) also apply to auditory learning. Similar to Zhang et al. (2008), they found that learning of two auditory stimuli is only possible when the stimuli are presented either in separate blocks of trials or interleaved in sequence, but not when the stimuli are interleaved randomly. However, learning from the first two conditions can transfer to the random interleaving condition after training. The results are interpreted in the framework of the reverse hierarchy theory.

Dosher, Han, and Lu (2010) investigated how object attention can be reduced or eliminated by perceptual learning. Performance decrements in reporting two features of different objects compared to reporting two features of a single object (dual-report deficit) have been found by a number of studies and are usually attributed to competition between two objects. Interestingly, the present study has found that training can eliminate the dual-report deficit. It is concluded that perceptual learning can reduce or eliminate competition between different objects.

Tseng, Gobell, and Sperling (2004) found that training in a visual search task in which subjects direct their attention to a particular color produced long-term sensitization. Such long-term effects could result from either sensitization of the attended color, or suppression of unattended colors, or a combination of the two. Tseng, Vidnyanszky, Papathomas, and Sperling (2010) separately measured the effect of attention on sensitizing the target color or suppressing distracter colors. They found that only sensitization of the target color in the search task is statistically significant for the present experimental conditions. Therefore selective attention to a color in visual search task caused long-term sensitization to the attended color but not significant long-term suppression of the unattended color.

Pilly, Grossberg, and Seitz (2010) addressed the question of where perceptual learning occurs in visual processing. Participants were exposed to task-irrelevant random dot motion stimuli to target motion cells selective to contrast polarity by ensuring that the motion direction information arises only from onsets but not off-

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sets of signal dots. They found that motion direction selective task-irrelevant learning is specific to the designated polarity without transferring to the opposite polarity. They concluded that task-irrelevant perceptual learning occurs in simple cells in V1.

In this review paper, Kourtzi (2010) views perceptual learning as an important process through which sensory information and previous knowledge about the environment we inhabit come to be optimally combined. Learning is implemented through recurrent mechanisms that support adaptive processing of visual features depending on the task context and demands. From this viewpoint, there is no single locus in which perceptual learning is involved.

Ghose and Bearl (2010) investigated the physiological changes in visual representations associated with strong expectations. Specifically, they trained animals to detect a brief motion pulse that was embedded in noise. Because the nature of the pulse and the statistics of its appearance were well known to the animals, they formed strong expectations that determined their behavioral performance. The authors found receptive field changes that are consistent with increased reliability in signaling pulse occurrence. These changes were not consistent with a simple gain modulation, but rather suggest that strong expectations can create very specific changes in the visual representations at the cellular level to enhance performance.

While most studies in this special issue concentrate on how adult visual abilities are improved as a result of practice or experience, Dye and Bavelier (2010) have examined how attentional abilities are developed with children. They have found different developmental trajectories with three different types of attentional abilities: the ability to distribute visual attention across the field to search for a target, the time required for attention to recover from being directed towards a target, and the number of objects to which attention can be simultaneously allocated. These results suggest that the three different types of attentional abilities are subserved by different neural mechanisms. Interestingly, participants who had played action games showed higher abilities in all of the three attentional aspects. They concluded that playing a video game has the potential of facilitating development of a variety of attentional abilities.

Trenti, Barraza, and Eckstein (2010) used the optimal perceptual learning paradigm (Eckstein, Abbey, Pham, & Shimozaki, 2004) to study learning in a motion discrimination task. The major advantage of this paradigm is in the use of an objective measure of efficiency (Barlow, 1980) to measure visual performance and learning, allowing a quantification of the information gained during learning, and a comparison across different tasks. Trenti et al. find large sensitivity gains in motion learning relative to other tasks, such as contrast detection, but interestingly find these gains to reflect smaller efficiency gains. Surprisingly their task yields low efficiencies, in particular after the first trial, which, at least in part, could be explained by memory decay during the time between stimulus termination and the feedback provided to the observer. Thus it is possible that more immediate feedback can improve learning.

Kraft et al. (2010) examined the role of task on early, fast and initial perceptual learning for shape localization. Using identical stimulus position and stimulus types, they measured thresholds in shape localization based on either simple detection or discrimination in different visual submodalities. They found that fast perceptual learning occurred for shape detection based on luminance, motion and color differences but not for texture differences, nor in shape localization based on discrimination. They concluded that fast perceptual learning depends on visual submodality and task.

Spang, Grimsen, Herzog, and Fahle (2010) measured the orientation specificity of perceptual learning in vernier discriminations. They found that learning effects transferred to the same task in new orientations up to 10° from the initial trained orientation. There was no transfer for rotations of 20°, 45° and 90°. They inferred that the orientation half-bandwidth of perceptual learning in vernier discrimination is around 15°, comparable to the orientation bandwidth of single neurons in early visual cortices but narrower than that of neurons in higher cortical areas.

We initiated the bi-annual International Workshop on Perceptual Learning to bring together researchers in the field of perceptual learning to share methods and techniques as well as research findings, and to identify the most important issues and new research directions. As we finish editing both volumes of the Vision Research Special Issue on Perceptual Learning, planning of the second International Workshop on Perceptual Learning, to be held in Israel in late 2010, is well under its way. We strongly believe that bringing together scientists from many complementary disciplines – psychophysics, neurophysiology, functional imaging, computational neuroscience, and perceptual rehabilitation – is extremely important for advancing our knowledge and understanding of perceptual learning. We thank those who attended the first workshop, whose presentations and discussions made it such a success, and all the contributors to this special issue. We hope that the special issue will provide an excellent introduction to the current state of research on perceptual learning.

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