regarding size regulation remain unanswered. For instance, the majority of DNA compaction occurs during prophase well before the chromatin is released into the cytoplasm, and before assembly of the spindle or spindle midzone. Therefore, midzone-based trans-regulation cannot be the entire answer to measuring chromosome compaction in mitosis. It will be of great interest to follow how this new model will influence the next studies in this field.

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Perceptual Learning: Visual Function Improved by LTP/LTD-like Stimulation

A new behavioral training approach has been found significantly to improve visual function; the results further attest to the high degree of plasticity in sensory systems.

George J. Andersen

Our sensory systems, once fully developed, do not remain static. Instead, these systems are plastic and can be modified as a result of repeated exposure to stimuli. Research on this issue has included both behavioral and neurophysiological studies. Behavioral research has used a variety of techniques that result in perceptual learning (improved performance with practice) [1–3], including techniques in which stimuli are repeatedly presented at near threshold levels resulting in dramatic changes in detection and discrimination performance. Neurophysiological research has used techniques such as long-term potentiation (LTP) or long-term depression (LTD) training, in which cells are repeatedly stimulated (at relative high rates for LTP or low rates for LTD) resulting in changes in synaptic connections [4–6]. Although it is generally assumed that behavioral and neurophysiological studies are examining related if not the same mechanisms, the methodologies are quite different and, as a result, there has been no research showing a direct link between the results of these two different phenomena.

This issue was examined recently in an interesting and surprising study reported in this issue of *Current Biology* by Beste *et al.* [7], in which LTP/LTD-like visual stimulation was presented to human observers. Subjects viewed a fixation cross with bars presented on either side of fixation; LTP/LTD-like stimulation occurred by varying the luminance of the bars at different rates. For LTP-like stimulation [1–3] the luminance was repeatedly varied at 20 Hz for five seconds, followed by a five second period with no stimulation, over a 40 minute period. For LTD-like stimulation [8], the luminance was varied at 1 Hz for a 40 minute period. This type of stimulation is analogous to direct electrical stimulation of cells (at 20 Hz or 1 Hz, respectively) in neurophysiological studies of LTP and LTD.

Irrelevant distractor information was presented by varying the orientation of the bars (vertical or horizontal) and by varying the salience of the distractor information (by changing the length to width ratio of the bars). During the stimulation period, subjects passively viewed the bars and responded to a fixation task. Five experimental groups, in which stimulation was unilateral or bilateral and orientation might be varied, and two control groups, in which ubjects were presented with either the background screen with fixation or no display during the 40 minutes, were run. The experimental groups included a unilateral LTP stimulation (the 20 Hz presentation occurred on just one side of fixation), a bilateral LTP stimulation (the 20 Hz presentation occurred on both sides of fixation), a unilateral LTP stimulation group where orientation of the bar (rather than luminance) was varied, a unilateral LTD stimulation group with only luminance varied, and a unilateral LTD group where orientation instead of luminance was varied. Before and after passive stimulation, the subjects performed a change-detection task in which they

were presented two sequential presentations of the bars and asked to detect a luminance change in the bar across the presentations. Two control groups (in one control group there was no visual stimulation for a 40 minute period, and the second control group viewed the background screen and responded to the fixation task for 40 minutes) were also run.

Beste *et al.* [7] report that change-detection performance remained the same for the two control groups 90 minutes, 24 hours and 10 days post-stimulation exposure. Subjects who received bilateral LTP stimulation showed improved performance in detection changes on either the right or left side, assessed 90 minutes, 24 hours and 10 days later. This effect was dependent on the salience (or difficulty) of the distractor information. Improved performance was maintained for up to 10 days when salience of the distractor was low (a difficult condition). When saliency was high (the easy condition), improved performance occurred 90 minutes and 24 hours post-stimulation, but returned to baseline 10 days later. This finding indicates that the greatest benefits from LTP-type stimulation occur under difficult stimulus conditions. The unilateral LTP stimulation group showed the same pattern, but only for the target location that received the stimulation, indicating that the effects of LTP stimulation are specific to the location in the visual field where stimulation occurred and thus likely due to changes in early levels of visual cortex.

A different pattern of results occurred for the LTD-like stimulation condition. Overall the effects of LTD stimulation (either luminance or orientation) were obtained only 90 minutes post-stimulation. Performance returned to baseline when assessed 24 hours and 10 days post-stimulation. As predicted, LTD stimulation when only luminance change was present resulted in decreased performance for the LTD stimulated location. When orientation change was present LTD stimulation resulted in improved performance on the side contralateral to the stimulation location, suggesting that there was a suppression of activation for orientation in the visual system.

These findings have a number of important implications for theory and application. First, this research is the first study to show that using protocols that result in plasticity at the cellular level can result in improved behavioral performance in humans (*in vivo*). Thus, this research provides a direct link between behavioral research and neurophysiological techniques. Second, consistent with the results of LTP/LTD neurophysiological studies [4–6], the present study found behavioral performance changes consistent with increased and decreased performance due to the different types of stimulation used. Third, the results suggest that this type of stimulation is likely resulting in changes in synaptic connections. Although previous perceptual learning research has shown a link between behavioral techniques and neurophysiology, these studies have primarily focused on molar levels of neurophysiological changes (for example, BOLD signal changes in fMRI studies [9,10]). The new results are indicative of changes that likely occur at a more local, synaptic level. Finally, and perhaps most importantly, the study suggests a new behavioral approach that results in changes in sensory processing that have exciting possibilities for interventions. Sensory systems can decline as a result of a variety of conditions, including brain damage, disease or normal aging. Because perceptual learning can be used to change processing, it has the potential to improve function when processing is compromised as a result of these factors. An important issue for future research will be to examine whether the technique used in the present study might be useful for clinical interventions.

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Chloroplast Signaling: Retrograde Regulation Revelations

Developing chloroplasts are able to communicate their status to the nucleus and regulate expression of genes whose products are needed for photosynthesis. Heme is revealed to be a signaling molecule for this retrograde communication.

Samuel I. Beale

According to the endosymbiotic hypothesis, eons ago a cyanobacterium took up residence within a eukaryotic cell and its descendants ultimately evolved to become plastids. Part of this transition involved the transfer of most, but not all, formerly cyanobacterial genes to the nuclear genome, which presumably confers the advantages of