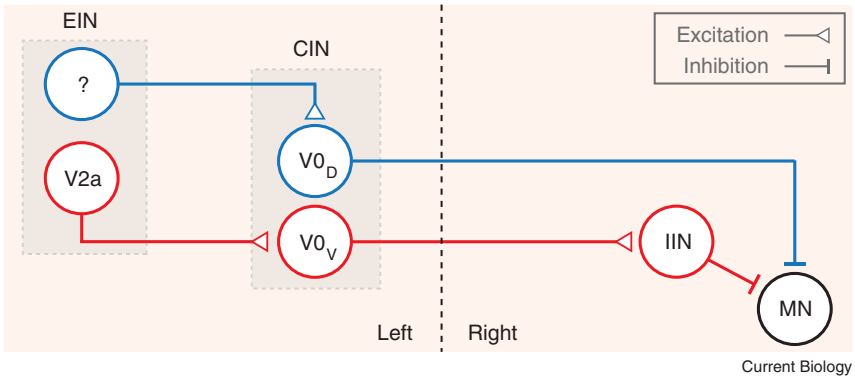

Figure 2. Proposed speed-related organization of networks involved in left–right alternation.
Wiring diagram highlights the two neuronal modules involved in alternation at different speeds. At slow speeds (red lines), the V2a interneurons drive the excitatory $V0_V$ subpopulation to inhibit contralateral MNs via the activation of IINs. At fast speeds (blue lines), the inhibitory $V0_D$ cells are activated by ipsilateral interneurons of unknown identity (?) to directly inhibit contralateral MNs. EIN, excitatory interneuron; CIN, commissural interneuron; IIN, ipsilateral interneuron; MN, motoneuron. For more details see main text.

connections via neuromodulators would certainly provide a more flexible and less permanent means to generate different gaits.

Given the phylogenetic conservation of the transcription factor code for spinal differentiation [4,5] and the observation that interneuron switching occurs not only in mice as described here but also in fish [9], it is more than likely that similar mechanisms are at play within our own spinal cord. As such, the work by Talpalar *et al.* [3] brings us several steps closer to the resolution of a journey that began a long time ago. Or, at least in the case of V0-deficient animals, several hops closer.

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Active Vision: Adapting How to Look

A new study has found that artificial occlusion of central vision leads to rapid emergence, and long-term maintenance of a new preferred retinal locus of fixation. These findings have important implications for the understanding of visual and oculomotor plasticity as well as for the development of rehabilitation techniques.

Martina Poletti[1] and Michele Rucci[1,2]

Finding a needle in a haystack is a notoriously difficult task. Part of the difficulty originates from the non-uniform resolution of the visual system. Even though the human eye covers a broad field, only a region smaller than one degree in visual angle — approximately the size of a thumb at arm's distance — offers the resolution necessary for seeing fine detail and distinguishing needles from hay. This is the portion of the scene that projects onto the central fovea, a depression in the retinal surface where receptors are most densely packed. Not surprisingly, humans normally use this region as their preferred retinal locus for acquiring fine spatial information and move this locus from one point of interest to the next by means of very fast eye movements (saccades). But what happens when this preferred retinal region suddenly becomes unusable? A new study by Kwon *et al.* [1], reported in this issue of *Current Biology*, shows that normal, healthy observers rapidly adapt to an artificial obstruction of the fovea by developing a new preferred retinal locus, which they then retain even after relatively long periods of normal unobstructed vision.

Imagine being at The Louvre looking at La Gioconda (Figure 1). At a distance of approximately one meter from the painting, only an area of a few squared centimeters falls within the foveal region with the highest visual resolution. As an observer with normal vision (observer A) looks at Mona Lisa's left eye, the rest of the painting appears blurred, the degree of blurring increasing with the distance from the current point of fixation. To examine Mona Lisa's mouth (is she really smiling?), the observer will need to move his eyes so to bring the region of interest on the fovea. The mouth will then become visible at the highest level of detail and — perhaps, for this

very reason [2] — Mona Lisa may appear less cheerful than she looked just before the observer's gaze shifted. Humans continually explore the visual world in this way, making over 100,000 saccades every day.

The normal oculomotor strategy followed by observer A fails in the presence of a central scotoma, a region affecting the fovea where visual functions are diminished or completely absent. Under these circumstances, the high-resolution fovea can no longer be used, and alternative visual and oculomotor strategies need to be developed in order to bring and maintain salient stimuli on retinal regions outside the implicated area. This issue is of great clinical interest, as central vision loss affects a significant portion of the population, with age-related macular degeneration being one of its leading causes (see [3] for a review). Subjects with central vision loss usually develop one or more new preferred retinal locations [4], which they use to fixate and, in some cases, as reference for saccadic eye movements [5]. The establishment of a new preferred retinal location is believed to be a slow process, which can take many months or even years [5,6].

To investigate visuomotor plasticity following the loss of central vision, Kwon *et al.* [1] used a gaze-contingent display control, a method in which the stimulus on the display is continually modified according to the eye movements performed by the observer [7–9]. They asked participants in their experiments to search for objects in a scene displayed on a monitor. As the subjects explored the scene, the experimenters continually updated the image by drawing a gray circle in the region currently covered by the fovea. This method resulted in an artificial scotoma, exposing normally sighted observers to visual input similar to that experienced by patients with central vision loss. The scotoma obviously made the task more challenging, as subjects could no longer rely on their high-acuity fovea, but were forced to use their low-resolution peripheral vision for searching the targets.

Kwon *et al.* [1] report that all observers quickly learned to cope with the artificial scotoma. In less than three hours, subjects started to systematically use a new preferred retinal locus to examine objects. Furthermore, they retained use of this locus for at least a week in which they went about their daily lives with normal central vision. Previous studies have already reported that normal observers can establish a new preferred retinal locus when central vision is artificially occluded [10,11], but Kwon *et al.* [1] are the first to examine in detail the time-course of this development during a natural task and its retention.

Optimal adaptation to a central scotoma not only requires finding a new retinal locus which best replaces the fovea within the limits of spared visual functions; it also implies adapting the oculomotor system so that saccades are referenced relative to this new locus. Consider observers B and C in Figure 1: both of them have adapted to the scotoma by establishing a preferred fixation locus outside the occluded region, but whereas observer B continues to plan saccades relative to the foveal center, observer C has adapted her eye movements so that they move the preferred locus directly on the object of interest. This is clearly a more efficient exploration strategy, as it eliminates the need for further corrective saccades. Like observer C, subjects in the study by Kwon *et al.* [1] quickly learned to aim saccades with the newly established preferred locus. This is surprising, as it may take years in patients with real

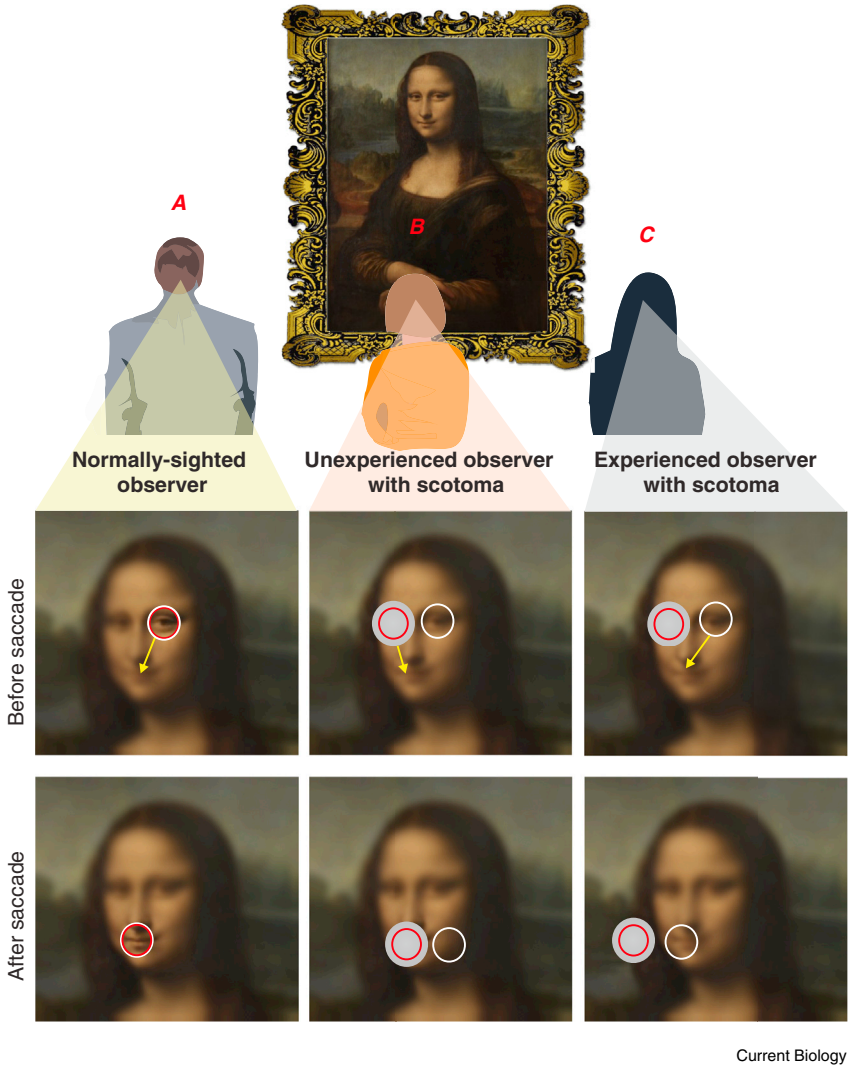

Figure 1. Adaptation to an artificial scotoma.

To examine a scene, humans control the portion of the visual field covered by the central high-acuity region of the fovea (white circle) by means of eye movements (observer A). Kwon *et al.* [1] report that, when central vision is blocked by an artificial scotoma (gray area), normal observers very rapidly learn to fixate with a new preferred retinal locus (red circle; observers B and C). They also quickly learn to use this locus as a reference for their eye movements, thus exploring the scene more efficiently (observer C).

scotomas to readjust their eye movements, and some patients seem to fail to do so [5].

The work by Kwon *et al.* [1] has several important implications. A critical question in studying adaptation to a central scotoma is what drives the establishment of a new preferred fixation locus. This question has long been debated but no clear answer is currently available. An obvious possibility is that the selected locus offers computational advantages relative to other retinal regions [12]. This may occur in multiple ways, for example because attention can be more easily maintained at this location [13], or because neurons in the preferred region are better suited to process fine detail. Better processing does not necessarily imply higher density of receptors, as fine-scale spatial information is also represented in the temporal domain by means of the modulations resulting from incessant microscopic eye movements [14–16], and both the spatial and temporal characteristics of neurons may play a role (the preferred retinal locus of fixation does not correspond to the region of highest cone density even with intact central vision [17]).

The rapid adaptation of eye movements observed by Kwon *et al.* [1] suggests the presence of other driving factors. Rather than from possible perceptual benefits during fixation, the establishment of a preferred retinal locus may be determined by oculomotor opportunities. Visual exploration by means of a single retinal locus allows adaptation of the preexisting motor plan with minor modifications. Because of its simplicity, the oculomotor system may prefer this approach over the development of more efficient, but more complicated, oculomotor strategies. Thus, the establishment of a preferred fixational locus may constitute a preliminary step toward the main goal of oculomotor adaptation.

Kwon *et al.* [1] also trained observers to use their preferred retinal locus. In a dedicated session, the experimenters continually marked, by means of a cross, the center of the region that the observer had started using as his/her preferred locus, and asked the observer to practice looking at a target using this marker. This procedure significantly improved the precision of saccades made in the presence of an artificial scotoma, leading to a level of precision comparable to that occurring with normal foveal vision. This finding highlights the potential of gaze-contingent display control as a tool for visual rehabilitation in patients with real scotomas. It suggests that similar training procedures in which the impaired region is marked explicitly (for example, by superimposing a larger artificial scotoma) may help these patients develop a new preferred retinal locus and speed up the process of oculomotor adaptation.

In sum, the study by Kwon *et al.* [1] constitutes an important step forward in the investigation of the mechanisms underlying visual and visuomotor plasticity in the presence of a central scotoma. It highlights the efficacy of training in improving visual exploration under such conditions and points at potentially beneficial rehabilitation techniques. These approaches may help improving the quality of life of patients affected by central vision loss and contribute to the general goal of ensuring that these patients continue to enjoy the beauty of our visual world, as well as Mona Lisa's ambiguous smile.

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Neuronal Development: SAD Kinases Make Happy Axons

The polarity proteins LKB1 and SAD-A/B are key regulators of axon specification in the developing cerebral cortex. Recent studies now show that this mechanism cannot be generalized to other classes of neurons: instead, SAD-A/B functions downstream of neurotrophin signaling in sensory neurons to mediate a later stage of axon development — arborization in the target field.

Lei Xing, Jason M. Newbern, and William D. Snider*

A key event in neuronal development is the specification of different functional domains of the neuron. Polarity proteins, including Par (partitioning-defective) proteins, and their effectors have emerged as critical factors controlling the first step in this specification — neuronal polarization [1,2]. LKB1, the mammalian homologue