# Trans-saccadic Integration and Perceptual Stability

(O'Regan, J.K, "Solving the 'real' mysteries of visual perception: The world as an outside memory", *Canadian Journal of Psychology*, Vol. 46, No. 3, pp 461-488, 1992)

*Transaccadic Integration* is the process of updating the representation of the world after an eye movement.

*Perceptual Stability* refers to the apparent stability of the world as we move our eyes, even though the image on the retina may change drastically.

If the eyes are held fixed, but the image is moved as if the eyes were moving, a greying-out, or blurring is perceived. Why isn't this perceived when the eyes move? This is the question that underlies the phenomena of perceptual stability.

One possible solution could come from the phenomena of *saccadic suppression* is which a reduction in the sensitivity of visual neurons when an eye movement is made. It has been hypothesized that this suppression could arise from some neural inhibition coincident with an eye movement. It now appears, however, that this effect can be explained as being due mainly to retinal masking factors.

Another hypothesis that has been made is that some sort of compensatory process is being carried out, based on a *extra-retinal* signal which indicates the extent of the saccade that is being made, and which can be used to shift the internal representation of the environment in a way that compensates for the shift caused by the saccade.

Where does this extra-retinal signal come from? Possibilities are that it is derived from the eye muscles, or that it is an *efference copy* of the neural motor signals that are generating and controlling the saccade.

## Problems with the Integrative Buffer Theory

The idea that mechanisms like saccadic suppression and extra-retinal signals are needed to compensate for eye movements implicitly assumes that what we "see" has something like a photographic quality, as if projected on an internal screen (the so-called "Cartesian Theatre") or integrative visual buffer.

As the eye moves around, the new visual information obtained is somehow integrated with the current contents of this buffer, in a process often refered to as spatio-topic fusion or trans-saccadic fusion.

The displacement of the eye caused by a saccade in these types of models is compensated by a corresponding shift of the internal "projector", so that incoming visual information is inserted at the right location. During the eye movement the "projector" is turned off, so that the resulting blur is not registered.

There are a number of problems with this type of model, however.

- How is information fused, given that different resolutions and colour quality may be present depending on where in the retina the data comes from.
- The "extra-retinal" signal may be innaccurate, and errors should accumulate.
- Not only eye positions, but head and body positions have to be taken into account as well.

O'Regan and Lévy-Schoen did an experiment where pairs of visual stimuli were constructed that consisted of apparently random lines. If these two stimuli were overlaid they formed recognizable words. One of these stimuli were presented, then, after an eye movement the other is presented.

If there is a detailed integrative buffer present that fuses visual information across saccades then the words formed by the overlay of the two stimuli should be perceived. The study found that, no matter what the stimulus durations and inter-stimuli time intervals were, the fusion of the two stimuli was never perceived.

O'Regan has proposed that there is no detailed metric integrative buffer, but rather, a less detailed "semantic" or symbolic representation is maintained.

(Rensink, R.A., O'Regan, J.K., and Clark, J.J., "To See or Not to See: The Need for Attention to Perceive Changes in Scenes.", *Psychological Science*, Vol 8, pp 368-373. 1997)

A study by Rensink, O'Regan and Clark suggests that what is stored in this short term memory is a description of the scene details that were *attended to* prior to the eye movement.

An analogy can be made with motion pictures wherein cuts between different views of the same scene can be made in which changes in small details are never noticed by viewer of the movie. This is presumably because the viewer is only keeping track of items in the scene at a symbolic level, and not of precise spatial relationships.

Motion picture producers are very knowledgeable when it comes to knowing what changes viewers of a film will notice and what they will not.

For example, film viewers appear to concentrate on:

- The largest moving object
- The main characters
- The person speaking
- Bright colours
- The upper part of the body

# The World as an Outside Memory

O'Regan suggests that the visual system operates in much the same way as deos a viewer of a movie. The changes in the visual stimuli on the retina that result from an eye movement are analogous to the changes in a movie image between cuts. The visual system does not perceive any change after an eye movement because only symbolic information is being retained across the saccade.

O'Regan makes the point that people normally use their eyes to explore the world, or to actively acquire information (the active vision approach). There is no need to *compensate* for eye movements, since they are the very means by which information is being acquired.

O'Regan has proposed a quite different view of perception that the usual ones, where:

"(the percept)...is *not* simply the passive sensation we get from the retina or some iconic derivative of the information upon it. Rather, this sensation is being used to supplement a mental schema we have about the results of the possible actions that we can undertake with our eyes..."

An analogy can be made with memory - one can only perceive a lack in ones memory if the memory is actively interrogated. For example, ask yourself how many dishes were in the sink this morning. You know you saw them, but your memory of them is (probably) not there. But you did not perceive this hole in your memory until memory was actively probed.

Another example is given by the apparent lack of perception of the "blind spot" in the visual scene created by the lack of photoreceptors on the retina where the optic nerve exits. People do not normally perceive a "hole" in their perception of the world corresponding to this lack of visual stimulus. The usual explanation for this is that there is some sort of "filling-in" that is inserting some sort of visual pattern where the blind spot is, so that we do not notice a hole.

In O'Regan's view this lack of perception of the blind spot is present because we do not actively probe this area of space. One can try to see what is in their blind spot, however, and notice that there is an insensitivity to visual stimuli at this point.

O'Regan's idea has been called the "world as an outside memory" theory. The idea is that in oder to perceive some aspect of the outside world, one must actively access or probe the outside world, with sensory instrument such as the eye, and acquire the desired information. Changes in a particular aspect of the environment will not be perceived unless these aspects are actively probed.