Schizophrenia and Red Light: fMRI Evidence for a Novel Biobehavioral Marker

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Introduction

Research on visual processing in humans and primates has identified two physiological subsystems in the visual system (Livingstone and Hubel 1987). The magnocellular (M) visual pathway is responsible for processing location information and motion, while the parvocellular (P) visual pathway is responsible for processing detail and color.

Early single-cell recording research with non-human primates reported that a small portion of M pathway neurons showed tonic suppression of on-center responses when the monkey was exposed to diffuse red light (e.g., Wiesel & Hubel 1966). Research using psychophysical tasks has inferred a similar effect in humans based on behavioral performance change in response to red light (e.g., Breitmeyer and Breier 1994; Breitmeyer and Williams 1990; Brown and Koch 2000).

A recent study found evidence of reduced accuracy on a particular condition of a visual backward masking task (which required identification of the location of the initial target) with a red, compared to grey, background in healthy adults (Bedwell et al 2003). This study reported that, in contrast to the control group, a subset of nonpsychotic first-degree relatives of persons with schizophrenia showed the opposite behavioral response to red light (increase in accuracy), while performance on the neutral (grey) background condition did not differ from controls (see below figure).

Methods

- Examined 13 nonpsychotic first-degree relatives of persons with schizophrenia and 11 controls. Matched on age, gender, and visual acuity.
- Used fMRI (1.5 T) to examine M pathway – focused on region V5/MT – well established as a primary neural center in M pathway. Each scanning volume consisted of 15 adjacent, axial, 5 mm slices, broadly covering V5 region.
- Presented blocks of moving (expanding/contracting) and stationary concentric rings (see below figure) on alternating green and red backgrounds (counterbalanced order; closely matched on luminance).
- Used SPM2 software for fMRI analysis. Searched for V5 region based on previous neuroimaging reports of location. Used 18mm spherical search space around Talairach coordinates: ±40 (bilateral), -70, 3 (see below figure). Identified significantly activated voxels in V5 bilateral regions resulting from a motion-to-stationary block statistical contrast.

Results

Group Difference: Wicoxon Z = 2.77, p < .01

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<tr>
<th>Change in Accuracy on backward masking task in response to red light from earlier study (Bedwell et al 2003).</th>
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<td>Change in Right Hemispheric Proportion of Percent Intensity of fMRI Signal</td>
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Stationary Visual Stimuli

Location of V5

Posterior View

Lateral View

Notes:

The group difference on the proportional hemispheric measure appeared to be driven by changes within each hemisphere that occurred in the opposite direction between groups. Group difference was not statistically significant within either hemisphere.

Relatives showed evidence of a hypoactive M pathway with the neutral (green) background, as they showed a statistically reduced right hemispheric proportion of percent intensity of fMRI signal (Mann-Whitney U = 38.0, p = .05).

After statistically adjusting for this group difference with the green background, the change to red light group difference remained, but was somewhat less robust, F(1,21) = 4.12, p = .06.

Purpose and Hypothesis

Purpose:
Investigate the neural mechanisms underlying previous finding that implicated a differential M pathway response to diffuse red light in relatives of persons with schizophrenia.

Hypothesis:
As a group, relatives will fail to show the normal suppression of the M pathway to red light (as seen in controls). This will be driven by a subset of relatives who show the opposite response (increase in M pathway activity) to red light.

Discussion

Results provide physiological confirmation of results from an earlier psychophysical study (Bedwell et al 2003), which suggested that the M pathway response to red light is in the opposite direction than expected in a subset of relatives of persons with schizophrenia. This effect appeared to be independent of a group difference in M pathway activation with the neutral (green) background. This effect may represent a novel biobehavioral marker for schizophrenia, but requires further replication and refinement of psychophysical methods.