

Visual Cortex: A Physiological Gateway to the External World

Anna Piro^{1*}, Teresa La Rosa¹, Paola Vaccaro¹, Gabriele Curto¹ and Marianna Vaccaro²

¹Consiglio Nazionale delle Ricerche, Istituto di Bioimmagini e Sistemi Biologici Complessi – Sede Secondaria, Italy

²Università degli Studi “Magna Graecia”, Dipartimento Scienze Mediche e Chirurgiche, Italy

*Corresponding author: Anna Piro, Consiglio Nazionale delle Ricerche, Istituto di Bioimmagini e Sistemi Biologici Complessi- Sede Secondaria, Via Tommaso Campanella 115, 88100 Catanzaro, Italy

ARTICLE INFO

Received: 📅 July 24, 2025

Published: 📅 August 07, 2025

Citation: Anna Piro, Teresa La Rosa, Paola Vaccaro, Gabriele Curto and Marianna Vaccaro. Visual Cortex: A Physiological Gateway to the External World. Biomed J Sci & Tech Res 62(5)-2025. BJSTR. MS.ID.009812.

ABSTRACT

We aim to show a little but precise picture of the primary visual area, V1, in the human brain showing as it is a gateway of our brain to the external world. 28 Calabrian male patients (age range 51–84 years; mean age, 73.2 ± 1.57 years) showing a mean disease duration of 4.4 ± 0.91 years (range 1.0–23 years) were analyzed. 28 controls matched for sex and age were enrolled. An ophthalmologist examined all patients and controls in order to rule out diabetic retinopathy, cataracts, senile maculopathy, or ocular fundus' anomalies. The clinical evidence makes such a plausible suggestion because the integrity of both areas V1 and V4 is critical to be consciously aware of having seen the colors. In these patients miss the intact return pathways from V4 to V1. Patients showing the color vision deficiency both on red/green, and/or on blue axis, can have no a great compromise of the V1 primary visual area. But, very likely both great or small compromise of the visual areas is related only to V4 color vision area. Within this group, the return pathways from V4 back to V1 showed to be critical for the conscious awareness of the color attributes of vision. The operational connections between the two areas are not very compromised, and it have restored after the surgical ventricular-peritoneal shunt. This interest is within a larger Research Project approved by Calabrian Ethic Committee.

Keywords: V1; Primary Visual Area; Brain; External World

Introduction

We aim to show a little but precise picture of the primary visual area, V1, in the human brain showing as it is a gateway of our brain to the external world. The visual cortex in the brain in the area of the cerebral cortex that processes visual information (Figure 1). It is located in the occipital lobe. Sensory input originating from the eyes travels through the lateral geniculate nucleus in the thalamus and then reaches the visual cortex. The area of the visual cortex that receives the sensory input from the lateral geniculate nucleus is the primary visual cortex, also known as visual area 1 (V1), Brodmann area 17, or the striate cortex. The extra-striate areas consist of visual areas 2, 3, 4, and 5 (also known as V2, V3, V4, and V5, or Brodmann area 18 and all Brodmann area 19) [1]. Neurons in the visual cortex fire action potentials when visual stimuli appear within their receptive

field. By definition, the receptive field is the region within the entire visual field that elicits an action potential. But, for any given neuron, it may respond best to a subset of stimuli within its receptive field. This property is called “neuronal tuning”. In the earlier areas, neurons have simpler tuning. Into the role of contextual modulation in V1, where the perception of a stimulus is influenced not only by the stimulus itself but also by the surrounding context, highlighting the intricate processing capabilities of V1 in shaping our visual experiences [2]. V1 transmits information to two primary pathways, called the ventral stream and the dorsal stream [3]. The ventral stream begins with V1, goes through visual area V2, then through visual area V4 and to the inferior temporal cortex. The ventral stream, sometimes called the “what pathway” is associated with form recognition and object representation.

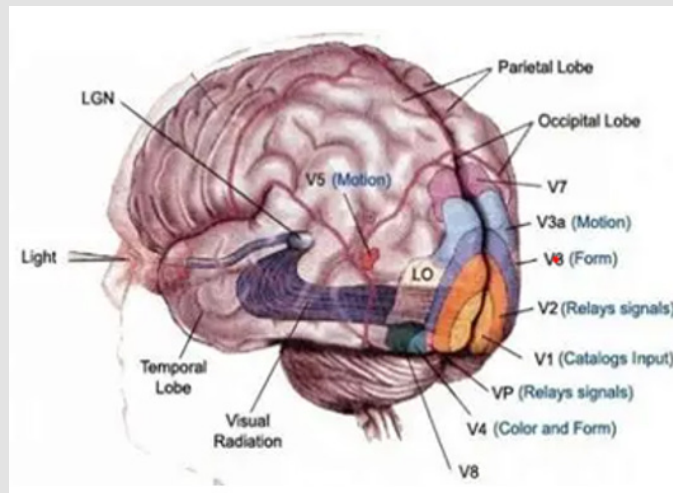


Figure 1.

It is also associated with storage of long-term memory. The dorsal stream begins with V1, goes through visual area V2, then to the dorsomedial area and middle temporal area and to the posterior parietal cortex. The dorsal stream, sometimes called the “where pathway” or “how pathway”, is associated with motion, representation of object locations, and control of the eyes and arms, especially when visual information is used to guide saccades or reaching action/perception dissociation that is a useful way to characterize the functional division of labor between the dorsal and ventral visual pathways in the cerebral cortex [4]. Primary visual cortex is highly specialized for processing information about static and moving objects and is excellent in pattern recognition. V1 is characterized by a laminar organization, with six distinct layers, each playing a unique role in visual processing. Neurons in the superficial layers (II and III) are often involved in local processing and communication within the cortex, while neurons in the deeper layers (V and VI) often send information to other brain regions involved in higher-order visual processing and decision-making. V1 has also revealed the presence of orientation-selective cells, which respond preferentially to stimuli with a specific orientation, contributing to the perception of edges and contours. V1 exhibits plasticity, allowing it to undergo functional and structural changes in response to sensory experience. The primary visual cortex is approximately equivalent to the striate cortex as Brodman area 17.

V1 possesses a meticulously defined map, referred to as the retinopic map, which intricately organizes spatial information from the visual field. In humans, the upper bank of the calcarine sulcus in the occipital lobe robustly responds to the lower half of the visual field, while the lower bank responds to the upper half. This retinopic mapping conceptually represents a projection of the visual image from the retina to V1. The importance of this retinopic organization lies in its ability to preserve relationships present in the external environment. The retinal map in V1 is connected with other visual areas, forming a

network that contributes to the integration of various visual features and the construction of a coherent visual percept [5]; seven the blind spots of the retina are mapped into V1. In humans and other animals with a fovea (cones in the retina), a large portion of V1 is mapped to the small, central portion of visual field, a phenomenon known as cortical magnification. Perhaps for the purpose of accurate spatial encoding, neurons in V1 have the smallest receptive field size (that is, the highest resolution) of any visual cortex microscopic regions. The neuronal responses can discriminate small changes in visual orientations, spatial frequencies and colors (as in the optical system of a camera obscura, but projected onto retinal cells of the eye, are clustered in density and fineness [5]. In V1, and primary sensory cortex in general, neurons with similar tuning properties tend to cluster together as cortical columns. Neurons in V1 are also sensitive to the more global organization of the scene [6].

These response properties probably stem from recurrent feedback processing the influence of higher-tier areas on lower-tier cortical areas and lateral connections from pyramidal neurons [7]. Evidence shows that feedback originating in higher level areas such as V4. For an image comprising half side black and half side white, the dividing line between black and white has strongest local contrast (that is, edge detection) and is encoded, while few neurons code the brightness information (black or white per se). The calcarine sulcus is associated with the visual cortex where the primary visual cortex is concentrated [8]. The central visual field is located in the posterior portion of the calcarine sulcus, and the peripheral visual field is located in the anterior portion. In a previous our work [9]. 7/28 patients showed a black/white vision; we find two subgroups: 4/7 without surgical ventricular-peritoneal shunt; 3/7 with the shunt. 1 patient of this last subgroup showed a normal color vision after the surgical shunt, and 2/3 showed a black/white vision after the surgical shunt, too. 14/28 patients showed a color vision deficiency. 7/14

patients had no surgical ventricular-peritoneal shunt. 3/7 patients in this group showed the double proton / deuteron, triton color vision deficiency; 2/7 patients showed the proton / deuteron color vision deficiency; 2/7 patients showed the triton color vision deficiency. 7/14 patients did the surgical ventricular-peritoneal shunt. 4/7 showed a restored normal color vision after shunt; 2/7 patients showed the proton / deuteron color vision deficiency, after surgical shunt, too; 1/7 patient showed the triton color vision deficiency, after surgical shunt, too.

7/28 patients showed normal color vision. We showed the responsibility of the primary visual area in the brain following the principal results: in the group of patients showing the black/white vision, very likely we have a compromise of the visual pathways from V1 primary visual area to V4 color vision area in the middle brain. The very compromise of the primary visual area V1 does not allow that the visual stimulus can arrive to V4 area. And the clinical evidence makes such a suggestion plausible because the integrity of both above areas is critical to see, and be consciously aware of having seen the colors. Evidently, in these patients miss the intact return pathways from V4 to V1. This integrity is restored in the patient who have a new normal color vision after the surgical ventricular-peritoneal shunt. In the group of patients showing the color vision deficiency both on red (green, and/or on blue/yellow axis), very likely there is no a great compromise of the V1. But, very likely both great or small compromise of the visual areas is related only to V4. Within this group, the return pathways from V4 back to V1 showed to be critical for the conscious awareness of the color attributes of vision. The operational connections between the two areas are not very compromised, and it have restored after the surgical ventricular-peritoneal shunt.

Acknowledgement

Authors thank Fondazione Cassa di Risparmio di Calabria e Lucania for its contribution.

References

1. Mather G (2017) The visual cortex. School of Life: University of Sussex.
2. Fisek M, Herrmann D, Egea Weiss A, Cloves M, Bauer L, et al. (2023) Cortico-cortical feedback engages active dendrites in visual cortex. *Nature* 617: 769-777.
3. Braz J, Pettrè J, Richard P, Kerren A, Linsen L, et al. (2016) Algorithmic optimizations in the HMAX model targeted for efficient object recognition. *Springer*: 377.
4. Goodale MA (2011) Transforming vision into action. *Vision Research* 51(13): 1567-1587.
5. De Angelis GC, Ohzawa I, Freeman RD (1995) Receptive field dynamics in the central visual pathways. *Trends in Neurosciences* 18(10): 451-458.
6. Lamme VA, Roelfsema PR (2000) The distinct modes of vision offered by feedforward and recurrent processing. *Trends in Neurosciences* 23(11): 571-579.
7. Hupè JM, James AC, Payne BR, Lomber SG, Girard P, et al. (1998) Cortical feedback improves discrimination between figure and background by V1, V2 and V3 neurons. *Nature* 394(6695): 784-787.
8. Ungerleider LG, Mishkin M (1982) Two cortical visual systems. In: Ingle DJ, Goodale MA, Mansfield RJ (Eds.), "Analysis of visual behavior". Boston: MIT Press, pp. 549-586.
9. Piro A, La Rosa T, Curto G, Vaccaro M, Vaccaro P, et al. (2025) Color vision as a biomarker diagnosing the blindsight. *JOJ Ophthalmology* 12(5): 1-2.



ISSN: 2574-1241

DOI: 10.26717/BJSTR.2025.62.009812

Anna Piro. Biomed J Sci & Tech Res



This work is licensed under Creative Commons Attribution 4.0 License

Submission Link: <https://biomedres.us/submit-manuscript.php>



Assets of Publishing with us

- Global archiving of articles
- Immediate, unrestricted online access
- Rigorous Peer Review Process
- Authors Retain Copyrights
- Unique DOI for all articles

<https://biomedres.us/>