Do Receptor Proteins Store Holographic Data in the Brain?

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ABSTRACT

Recent technological tools using the properties of quantum phenomena opened new ways in biology. Among them, various devices of holographic optogenetic stimulation offered an outstanding opportunity for vision restoration and neural networks probing. However, the putative involvement of quantum phenomena in the brain functioning has not so far been investigated. This is all the more surprising as tunneling electron transfers between photosynthetic or respiratory chain molecules and holographic photoreceptor proteins are well substantiated in biophysics. Considering the structural analogies between holographic photoreceptor molecules and neurotransmitter receptor proteins, it is not unfounded to address the question whether neuronal receptor proteins could similarly record holographic data in the living brain. Recently devised methods, such as holographic electron imaging of atoms or molecules, might be useful to explore this field which might bring new concepts in learning and memory.

Key Words: receptor proteins, electron interference, holographic data, brain, rhodopsin

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Introduction

In a previous report (Anglade *et al.*, 2014), we discussed the putative significance of the introduction of quantum physics in neurosciences. Since atomic particles are the substructure of the molecules, phenomena predicted by the laws of quantum mechanics certainly play a major role in brain functioning (Tarlacı, 2011; Tarlacı and Pregnolato, 2015). Indeed, recent data substantiated the presence of tunneling electron transfers between oxidation-reduction centers of proteins and the functioning of photosensitive proteins as holographic molecules (Gray and Winkler, 2005; Barnhart *et al.*, 2004). Beside their general interest in biology, these results may trigger a renewal in the concepts of molecular learning and memory (Anglade *et al.*, 2014). Until now, the properties of quantum particles, such as photons and electrons, are used to devise sophisticated tools of investigation of the brain, for example devices of holographic optogenetic stimulation (Shoham, 2010). Despite these wonderful technological breakthroughs, the putative involvement of atomic particles according to the laws of quantum physics remains so far ignored in researches devoted to the functioning of the living brain. Therefore, our discussion is aimed at warning of the urgency to look in the living nervous system for still unknown functioning of

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receptor proteins through quantum particle properties. This claim is founded on a body of recent investigations made in biophysics, among them the study of the holographic properties of rhodopsin is perhaps the most substantiated (Barnhart *et al.*, 2004; Chan *et al.*, 2004).

Photoreceptor proteins do record holographic data

Rhodopsin is a photoreceptor protein present in living organisms from bacteria to mammals (Foster *et al.*, 2011). The rhodopsin molecule is composed of seven transmembrane α-helical subdomains embedding a retinal chromophore. Photons are absorbed by the chromophore of rhodopsin and their energy is stored in energetic molecules, such as ATP, through a cascade of chemical reactions (Tökés *et al.*, 2000). In unicellular organisms, rhodopsin is a transmembrane protein that promotes a behaviour of light-oriented movements called phototaxis. In this case, the capture of photons by the chromophore of rhodopsin successively generates photoreceptor currents, membrane depolarization and activation of Ca++ channels in the membrane of the flagelles (Sineshchekov *et al.*, 2002). These physicochemical events finally lead to the modulation of the flagellar movements. Being a ubiquitous light-absorbing structure, rhodopsin is also used as a visual pigment in the retinas of most animals (Foster *et al.*, 2011).

Extensive studies of the photocycle of rhodopsin were performed with the molecular form of a primitive bacteria, *Halobacterium halobium* (Tökés *et al.*, 2000). After photon absorption, the bacteriorhodopsin endows transient shifts of charges and conformational changes before recovering its initial conformation (Tökés *et al.*, 2000). Different absorption spectra reflect the different states of the protein photocycle. These properties of bacteriorhodopsin lead scientists to test the molecule for different technological applications (Tökés *et al.*, 2000). Thus, the bacteriorhodopsin appeared to be a highly efficient recording medium of holographic data (Barnhart *et al.*, 2004; Chan *et al.*, 2004). Recently, different forms of rhodopsin were used for retinal prosthesis or for light-stimulation of specific neurons. For example, channelrhodopsin-2 can be genetically introduced in well-defined neuronal populations. Appropriate delivering of laser light selectively stimulates the neurons expressing channelrhodopsin-2 (Shoham, 2010). Such optogenetic devices thus allow the detection of the target cells of the modified neurons without any electrical stimulation (Shoham, 2010).

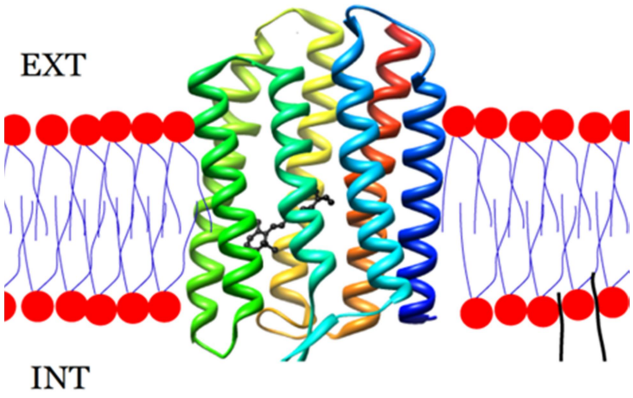

Figure 1. Structure of type II rhodopsin (RII). RII is a transmembrane protein consisting of 7 α-helical subdomains (rainbow colored) and a retinal chromophore (black) embedded inside the gathering of the α helices. EXT: extracellular side; INT: intracellular side. Modified from en.wikipedia .org.

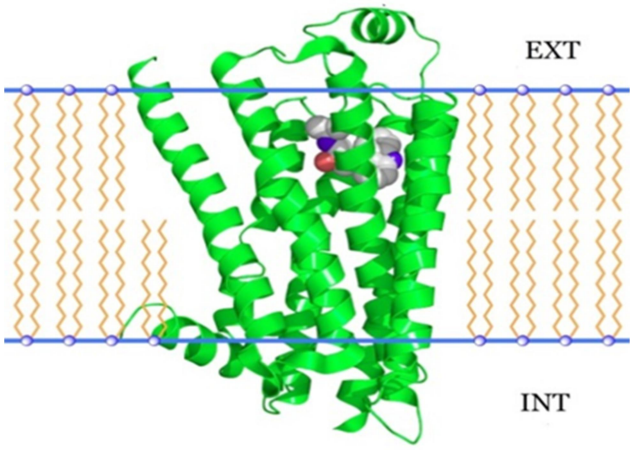

Figure 2. Structure of β2-adrenergic receptor (β2-R). Like RII, β2-R is a member of the G protein- coupled receptors. This is reflected in the striking structural analogy between RII and β2-R. The colored bowls inside the group of α-helices represent a ligand at the biding site. EXT: extracellular side; INT: intracellular side. From en.wikipedia .org.

Holographic recording molecules: from rhodopsin to neuronal receptor proteins?

Despite these technological advances, the question of a putative holographic-functioning of rhodopsin in the living organisms has not been addressed so far. Molecules of rhodopsin located in the membrane of unicellular organisms or in the retinas of most animals, capture photons at

definite ranges of wavelength (Sineshchekov *et al.*, 2002). Then, it cannot be excluded that rhodopsin records wave interferences in a way similar to a holographic medium, not only in artificial devices, as already demonstrated, but also *in situ*. Moreover, rhodopsins are members of the superfamily of G protein-coupled receptors (Foster *et al.*, 2011). Thus, rhodopsins share structural and functional analogies with neurotransmitter proteins (Foster *et al.*, 2011) (Figure 1 and Figure 2). One class of rhodopsin functions as light-gated ion channel or light-driven ion pump, another class as signaling molecule through G protein-activated biochemical cascade (Jékely, 2009). Considering the similarity between rhodopsin and neurotransmitter receptor proteins, it is possible to hypothesize a similar function of neurotransmitter receptor proteins in unknown holographic processes of wave interferences.

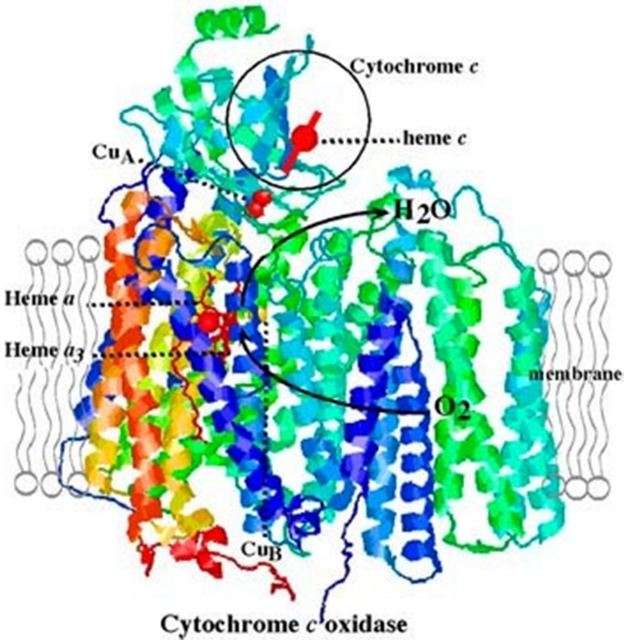

Figure 3a. Structure of Cytochrome C oxidase (CcO). CcO is an enzyme of the respiratory chain located in the inner membrane of the mitochondria. CcO is endowed with 4 redox cofactors. During oxidative phosphorylation, CcO receives electron from cytochrome C (cytC). This reaction occurs by electron tunneling between cytC and the CuA redox cofactor of CcO. Then, electrons successively transfer between the three other redox cofactors of CcO before being accepted by O2 molecules. From Lauren Congdon, Biochemistry 462b Honors Project, The University of Arizona, Last revised May 10-2006.

However, the wave interferences would be elicited by electrons, instead of photons, in the case of neurotransmitter receptors. This question is worth to be addressed since tunneling electron transfers have been demonstrated between oxidation-reduction centers of various proteins**,** particularly in the respiratory chain (Gray and Winkler, 2005; Lin *et al.*, 2005; Miyashita, 2005; Winkler, 2006) (Figure 3a and Figure 3b). Indeed, electrons can tunnel from one protein to another within an interval of about 2nm when the two proteins form a suitable donor-acceptor complex for electron coupling (Gray and Winkler, 2005). The distance of electron transfers between two proteins is, in fact, probably much exceeding 2nm when the particles are transferred by hopping several intermediate states of oxidation-reduction (Gray and Winkler, 2005; Warren *et al.*, 2012).

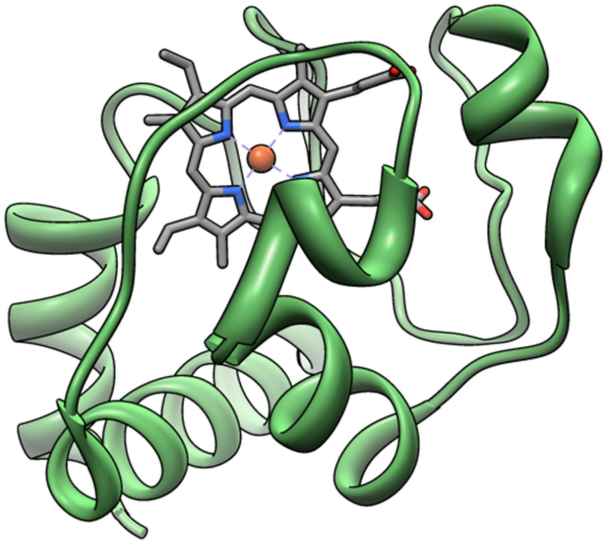

Figure 3b. Detailed structure of the cytochrome C (cyt C) peptide of the respiratory chain. The oxidation-reduction center of cyt C consists of a heme (grey) with an iron atom (red bowl) embedded in the folds of the peptide chain (green). From Bushnell et al., J Mol Biol 1990 Jul 20; 214(2):585-95. PubMed PMID: 2166170.

The presence of *in situ* inter-molecular electron transfers is even more interesting since recent experiments of holographic imaging were performed with interference patterns of photoelectrons (Huismans *et al.*, 2011). Indeed, interference patterns of electrons could be elicited by laser ionization of an atom and stored on an appropriate detector (Huismans *et al.*, 2011). Briefly, ionization of an atom or a molecule liberates electrons which can be driven back toward the ion. The interference between the electrons and the radiation emitted by electron-ion re-collision allows encoding information both about the atom and the re-collision electrons (Huismans *et al.*, 2011). The

holographic imaging of the ionized atom was subsequently obtained by means of a photoelectron spectroscopy device. In other words, it was shown that the electrons emitted by atomic structures can interfere between themselves to produce holographic patterns encoding structural and dynamical information of the corresponding atoms (Huismans *et al.*, 2011). These data raise the question of the existence of similar interference patterns of electron waves encoded by receptor proteins in the normal functioning of living tissues. Moreover, these investigations suggest that it is already possible to test receptor proteins as holographic medium for electron interference patterns by such photoelectron spectroscopy techniques or by other similar laser absorption spectroscopy (Berera *et al.*, 2009).

Holographic proteins: a molecular basis for learning and memory?

In summary, among other quantum phenomena, research for holographic functioning of proteins in the living nervous system is no longer beyond the scope of experimentation. Would it be proved, the presence of "holographic" receptor proteins in the brain might cast light on unknown intermolecular exchanges of information, probably with having a performance much superior to those known until now. This domain of investigation might renew the knowledge about learning and memory, as well as many other functions of the brain.

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