SUPPLEMENTARY METHODS

Dissolution of inductor encapsulation: In order to correctly model with FEM the exact geometry of the coils used in the retinal preparation, we needed to determine the geometric structure of the commercial inductors we used for stimulation. Therefore, we chemically dissolved the outer layer of the device in order to expose the underlying wire through which current is injected. The coil was placed into a PTFE vial and treated with 2 mL of 48% hydrofluoric acid at room temperature for 24 h. Then the acid was removed, the coil was washed three-times with 5 mL of deionized water and transferred carefully with a plastic pipette to a glass vial. Fresh peroxo-sulfuric acid solution was prepared. A solution of 30% hydrogen peroxide in water (2.5 mL) was placed into a small glass beaker equipped with magnetic stirring bar and 96% sulfuric acid (2.5 mL) was slowly added while stirring. Mixing of the components was accompanied with a significant release of heat. The hot mixture was then added to the coil in a glass vial and let to react for 48 h. The acid was then removed and the coil washed three-times with 5 mL of deionized water and dried on air. Figure 2 shows the original coil (Fig. 2a) and after shell dissolution (Fig. 2b), which reveals a solenoidal structure with 21 turns.

Coil calculation: The overall geometry consisted of a cylinder of 3.0 mm in radius and 3.0 mm in height, which contained four different types of objects: a solenoid coil, two terminals, a quartz core and physiological solution, and was discretized to the maximum setting (i.e., extremely fine) allowed by the COMSOL and produced 33,000 triangular elements, 900 edge elements and 100 vertex elements. This step is called meshing of the geometry and it was performed in a space-variant fashion or by changing the size of the triangular elements in the geometry according to a set of rules. These rules include the specification of the: maximum and minimum element size, sampling resolution of curvature and narrow regions. The upper and lower bound on the element size greatly influence the computational time, memory usage, and accuracy of the finite element analysis. Specifying the sampling resolution of curvature reduces the numerical staircasing, which occurs for example when a sphere is approximated by tetrahedral elements. The sampling resolution of narrow regions allows for decreasing the element size so that the object would not disappear or become unrealistically magnified in the mesh. Finally, the mesh was also controlled by the physics, which essentially adapts the mesh to the physical solution, for example if there is a point source or electric field generator in the center of a sphere than the center will be sampled more finely in order to represent the electric field more precisely in space.

The next step after meshing was to set the boundary conditions or constrain the behavior of the solution at the boundary of its domain; these conditions are very important when solving differential equations of real physical problems. The exterior boundary conditions were set to $A_\varphi = 0$ (i.e., magnetic insulation), except for the vector along the z-axis, which was set to $r = 0$ (i.e., axial symmetry). The interior boundary conditions were set to $\mathbf{n} \cdot \mathbf{J} = 0$ (i.e., electric insulation) for each turn and the two terminals. In each of the 21 turns the voltage was set to 4V corresponding to our experimental conditions under maximum stimulation.

The initial values for the electric potential and the magnetic vector potential were set to zero. The simulations including meshing converged after 25s of computing time with a Dell Precision T7500 48GB running 64-bit Windows 7.

Finite Element Method Validation: In order to validate the Finite Element Method we ran a set of simulations to estimate the inductance of the coil and then compare it to the values measured. The inductor was a homogenized coil[41], or a coil with just one very large turn, instead of 21 for numerical reasons and the solution was normalized to take this idealization in account. The single turn composed of a 25 μm thick copper sheet with a 500×500 μm cross-section square and rounded edges. The homogenized coil is considered to be an ideal magnetic field generator, and it stores the magnetic field energy *W* generated by the supplied electric current *i*. This information can be used to estimate the ideal inductance of the coil and compare it with the value measured in each coil for FEM numerical validation purposes. The portion of magnetic energy W lost reduces both the efficiency (i.e., Q-factor) and the measured inductance of the coil. However, this magnetic energy does not really vanish since energy is conserved and therefore is available around the coil where we have reaped its benefits by eliciting neuronal activity. The magnetic fields (**B**) arising from μMS as well as the electric fields (**E**) were found by solving numerically the magnetostatics equation (Methods), or the set of Maxwell equations simplified by the assumption that all electric currents are constant (i.e., steady state - DC). The solution of this 3D model returned the values in and around the square inductor of electric (V) and magnetic potentials (**A**), which was used to calculate the magnetic flux density (i.e. $\mathbf{B} = \nabla \times \mathbf{A}$). In order to obtain this solution we meshed the geometry in approximately 700,000 tetrahedral elements.

All six faces of the box containing the geometry were set to magnetic insulation boundary conditions (i.e., exterior boundary conditions), or the magnetic field is zero in these faces. All the interior surfaces of the model were set to electric insulation boundary conditions except for the two surfaces that are in common to the two halves of the homogenized coil or current sheet. The current density (eq. 5) on one surface was set to generate a current of 10 A (terminal) and the other surface was set to a V_0=0 V (ground).

The magnetic field inside the coil (Fig. 6a) follows an almost linear path but outside the lines of flux are radially symmetric to the center of the coil. The magnetic field peaks inside the inductor and spreads around the external part of the coil uniformly according to the magnetic conservation law. The inside peak occurs because the volume outside the solenoid is much greater than the volume inside, so the magnitude of magnetic field outside is greatly reduced. The maximum induced electric fields were found at distances of 25-100μm from the lateral side of the coils (Fig. 6b) and the strength of the field decreased nonlinearly with increased distance. The simulations predicted an ideal inductance of 114 nH based on:

$$L_{MAX} = \frac{2}{I^2} W \qquad \text{(S1)}$$

validated both by the inductance measurements (with a LCR meter (879B, B&K Precision Corp., Yorba Linda, CA).) and the data sheet value of 100 nH ±5%. Thus the simulations were validated by both the measurements and the data sheet of the inductor and showed relatively large induced electric fields above the four wider faces of the coil.

Assembly of µMS coils: We purchased commercial multilayer inductors (ELJ-RFR10JFB, Panasonic Electronic Devices Corporation of America, Knoxville, TN) and soldered (15-mils 44-resin core SN63PB37) (Kester, Itasca, IL) the two leads to copper wire (34-AWG, polyimide enamel inner coat and polyurethane over coat) (Philmore Mfg., Rockford, IL). The coil was placed on the tip of a 19AWG needle (Becton Dickinson, Franklin Lakes, NJ) and inserted in a custom made syringe 150 mm long; the distal ends were attached to the signal and ground leads of a BNC connector. The custom made syringe consisted of a stainless steel needle 40 mm in length, tow plastic tubes, diameters of 6 and 8 mm and lengths of 80 and 180 mm, respectively so that the coil assembly could be secured to the micromanipulator for positioning near the retinal tissue.

Animal preparation and retina isolation*:* The care and use of animals followed all federal and institutional guidelines, and the Institutional Animal Care and Use Committees of the Boston VA Healthcare System and the Subcommittee of Research Animal Care of the Massachusetts General Hospital. New Zealand White Rabbits (~2.5 kg) were anesthetized with injections of xylazine/ketamine and subsequently euthanized with an intracardial injection of sodium pentobarbital. The eyes were removed immediately after death. All procedures following eye removal were performed under dim red illumination in order to preserve photoreceptor function. The front of the eye was removed and the vitreous was eliminated. The retina was separated from the retinal pigment epithelium and mounted, photoreceptor side down, to a 10-mm square piece of Millipore filter paper (0.45 µm HA Membrane Filter) that was mounted with vacuum grease to the recording chamber (~1.0 ml volume). A 2 mm circle in the center of the Millipore paper allowed light from below to be projected onto the photoreceptors so that light-elicited spikes would arise in the ganglion cell. The light stimulus was projected from an LCD projector (InFocus, Portland, OR).

Electrophysiology: Patch pipettes were used to make small holes in the inner limiting membrane, and ganglion cells with large somata were targeted under visual control (Fig. 3c). Spiking was recorded with a patch electrode (4-8 MΩ) that was filled with superfusate and positioned onto the surface of a targeted ganglion cell (cell-attached mode). Two silver-chloride-coated wires served as the ground and were positioned at opposite edges of the recording chamber, each approximately 15 mm from the targeted cell. The retina was continuously perfused at 4 mL/min with Ames solution (pH 7.4) at 36°C, equilibrated with 95% O_2 and 5% CO_2. Full-field light stimuli were used to determine whether an appropriate patch seal had been established and also to confirm that the cell was functioning normally; only those cells that generated spiking responses were tested with μMS. The μMS coil assembly was fixed in the micromanipulator such that the main axis of the coil was oriented either parallel or perpendicular to the retinal surface. The coil assembly was lowered into the bath until the coil was 100 μm above the retinal surface. Five repeats were performed every time a parameter was changed, e.g. increase in amplitude, adjustment of the position of the coil, etc.