Neural Prostheses for the Blind

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Neuroprosthetic interfaces with the nervous system

- Replace eye – stimulate cortex
- Replace ear – stimulate auditory nerve
- Stimulate skin nerves for pain relief
- Stimulate back muscle to stop abnormal spine curvature
- Activate paralysed hand muscles
- Record sensory feedback from hand
- Record cortical motor commands
- Pacemaker for heart, diaphragm
- Record myoelectric signal to control artificial arm
- Stimulate autonomic nerves to control bladder, correct impotence
- Coordinate activation of paralysed leg muscles for walking
The problem is not to transmit a high-resolution image, but to send useful information to the right locations inside the SNC.

✓ It is important to know how the visual information is encoded in the retina.
Ganglion cell spike trains are the result of extensive signal processing in the retinal network.
Development of a reconfigurable bioinspired visual processing front-end (artificial retina)

Generation of output spikes

Different approaches:
- Phase coding (firing-time): $t_d(V_x)$
- Spike frequency coding (firing-rate): $F(V_x)$
Design of electrodes for cortical stimulation

- Must have electrodes that penetrate 1.5–2.0 mm below the cortical surface.
- Able to stimulate a two-dimensional sheet of neurons.
- Biocompatibility.
- Durability.
- Able to induce isolated perceptions.
Predicted and measured responses of cat area 17 cell ensemble to upwardly moving horizontal bar
Is the occipital cortex of blind subjects able to process visual information?
Braille alexia

Lesion study

- 54 y/o woman
- Blind “since birth”
- Braille since age 7
- Braille 4-6 h/d
- Unable to read Braille after transient coma
- Normal neurological exam

Pascual Leone et al. 1999
Mapping the human visual cortex using TMS

Fernández et al, 2002
Perception of phosphene perception in blind subjects
Examples of retinotopic mapping of TMS induced phosphenes in blind subject #8
• How many electrodes are required to produce a useful visual sense?
• How stable are the phosphene thresholds on a day by day basis?
• How far apart can a pair of electrodes be positioned and still produced contiguous phosphenes?
• Does patterned stimulation produce patterned percepts?
Conclusions:

- If we can understand more about the fundamental mechanism of neuronal coding, and to safely stimulate nervous system, there will real potential to apply this knowledge clinically.

- Our results show that intracortical microelectrodes could be safely used in long-term applications, although more studies regarding safety and preservation of neuronal tissues as well as optimizations of stimulating parameters are needed preceding any clinical trial.
Never in the history have been so many new findings concerning neural prosthesis as have been achieved in the recent 10 years. Still there may be a long way to application of such findings in patients. However, it can be expected that, at least for some patients, effective therapies will be developed during the upcoming years.
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