Am I spikes over time?

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The issue (1)

- What is the physical nature of
  - Experience
  - Percepts
  - Awareness
  - Consciousness
  - Etc.
- Presumably neural
  - But what aspect of the physical characteristics of neural tissue?
  - Action Potentials? (spikes)

The issue (2)

- Given that we knew the answers for the last slide
  - What is the physical nature of
    - » Experience
    - » Percepts
    - » Awareness
    - » Consciousness
    - » Etc.
  - Presumably neural
    - » But what aspect of the physical characteristics of neural tissue?
    - » Action Potentials?
- There's another question:
  - How does the physical correlate turn into 1st person experience?
    - What is the nature of the mapping from the 3rd person (measurable) correlate to the 1st person (personal) experience?

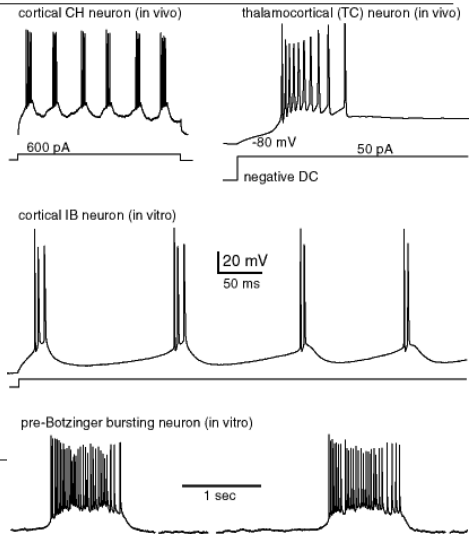
Some spikes

–Spikes, measured intracellularly

–Each spike is about 1ms long

–there's a certain amount of variation is spike shape, caused by the relative density of Na+ and K+ ion channels at the spike

–Sometimes spikes are one by one, sometimes there are bursts of spikes



Expansion/digression …

History

- Hardly a new issue!
  - Generally avoided (particularly 1st person/3rd person issues)
  - Best to continue avoiding it?
    - <optional end of seminar.>

History

- Hardly a new issue!
  - Generally avoided (particularly 1st person/3rd person issues)
  - Best to continue avoiding it?
    - <decided against>
- Recent interest:
  - Churchland's books
    - Churchland P.S., Neurophilosophy, Bradford Books, MIT Press, 1986.
    - [3] Churchland P.S., Brain-wise, Bradford Books, MIT Press, 2002.
  - Metzinger's book
    - Metzinger T., Neural Correlates of Consciousness, Bradford Books, MIT Press, 2000.

Essential approaches to 1st set of issues

- Reductionist
  - Break system into constituent parts
- Constructivist
  - Build model system up from what's known.

Reductionist vs Constructivist approaches

- Reductionist Approach
  - Neuroscience developments
    - Markram's Blue Brain project, for example
    - Microanatomy of neurons, dendrites, spines
    - Microanatomy of interconnection: the connectome
    - HBP
- Constructivist Approach
  - Building brains
    - Out of software on digital computing equipment
    - Out of silicon/other electronic systems (perhaps along with digital techniques)
    - GC5; SyNAPSE

Issues with the reductionist approach

- Concept: understand all the parts, and how they interact, and we will understand the system.
- Problems:
  - Volume of data, multiple levels of constituent parts.
  - Number of different parts
  - Difficulty integrating what's known into any kind of whole
    - How does the detailed level of operation relate to the overall task performed?

Issues with the constructivist approach

- Concept: Build models that incorporate what we know about the brain, to illustrate/predict/understand what the whole system does.
- Problems:
  - Level of detail to use
    - Actin filaments? Ion channels? Patches of membrane? Compartments of Neurons? Neurons and Glia? …
  - Nature of model: is it predictive or illustrative?
    - E.g. box-and-arrow models of reading, or face recognition
  - Parameter space of model
    - Is there enough information to tie down the different variables inside the model?
    - Are we in danger of being a "cargo cult science"?

The Computationalist view

- We already know the answer:
  - The brain is
    - A computer (1960's/70's)
    - A Perceptron-based machine (1960's)
    - A logical inference machine (Japan, 5th generation project , early 1980's)
    - A Back-propagated delta-rule based machine (mid 1980's)
    - A Reinforcement Learning Machine (1980's/90')
    - A Bayesian Inference machine (2000's)
  - Perhaps it has aspects of all (or at least some) of these.

Back to the question …

Am I spikes over time

- Clearly 1st person experience has to be relevant here
  - But what is the nature of 1st person experience?

1st person experience

- 1st person experience takes many forms
  - Sensory experience
    - Sensory percepts, qualia
      - Redness, D#1 on a piano, the smell of ammonia, …
  - Emotional experience
    - Anger, love, fear, …
  - Situated-ness
    - I'm in a room, standing giving a talk, …
  - Unified nature of experience
    - And of the unity of the perceiver (the 1st person) as well

3rd versus 1st person experience

- Physical measurability
  - What can one measure?
    - Physical changes (by definition!)
  - What **is** one actually measuring?
  - What would one like to measure?
- Does the difficulty of measuring 1st person experience mean that we should ignore it?
- If we ignore 1st person experience, does that limit the questions we can ask?
  - What are we missing?
  - Does what we are missing matter in our endeavor?

Does the nature of our understanding militate against our understanding of our nature?

Am I **spikes** over time

- Why spikes?
  - Easily measured (!)
    - Well, reasonably easily…
  - Appear to be "outputs" of neurons
    - Used for communication between neurons, and from neurons to musculature
    - Fits well in a Skinnerian (behaviourist) sense!
      - If the "I" is the sum of what I do.
- But …

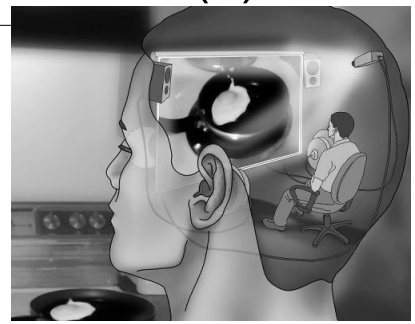
Am I **spikes** over time (2)

- Spikes are the result of a process at the neuron
  - Depolarisation due to incoming action potentials
  - Effects of neurotransmitters and neuromodulators
  - And there's complex processing
    - (of ionically based potentials, for example)
  - … occurring on the dendrites
    - And this can happen without post-synaptic firing
  - Can also have non-spike based communication between neurons
- So are spikes summaries of *all that matters* in the brain?

Am I **spikes** over time (3)

- Other candidates are, for example:
  - Ionic concentrations
    - Over space and time
  - Local field potentials
  - Physical microanatomy in the brain
  - Rapidly varying connection strengths
  - Neurotransmitter /neuromodulator localised concentrations and gradients
    - Or any combination of the above.

Am I **spikes** over time (4)



- And how do the spikes become the percepts?
  - How do the spikes correlate with the "I"
  - Is there a mechanism?
    - The homunculus paradox: can't have some other part of the brain "watching" the spikes
  - Or are the spikes themselves directly the "I"-ness
    - In which case might model neurons might be aware as well?
      - ~~Doesn't seem likely!~~

Am I spikes **over time**?

- How much time? How long is the present instant?
  - How long (or how short?) a time is the length of "I" ness?
    - Very short? (a few (hundred) milliseconds)
    - Moments? (a few seconds)
    - Enough time to formulate and say a sentence? (perhaps 20 seconds)
    - Enough time to savour a pint? (a few minutes)
- Perceptual time differs from physical time
  - We all know that!
  - Event ordering is unaffected
- Feelings and emotions are more slowly varying
  - Apparently due to relative slowness of neuromodulator diffusion
    - Does that make them candidates for encoding affect?
    - Or are they epiphenomena?

Evidence

- Localised electrical stimulation can give rise to percepts
  - From colour percepts, to near spiritual experiences
    - Suggests there are electrical correlates of these percepts
    - Of course, there may be other aspects as well
- Neuroactive substances alter perception, including perception of self
  - Suggesting a chemical correlate
    - Or is it just that the chemical alters the spiking?
- fMRI shows that blood flow alters with task
  - But that is clearly an artifact, not a direct correlation.

How about percepts rather than "I"?

- The colour orange?
  - (or if that's too abstract, an orange in the field of view)
- The piano tone C1 played nearby?
- Easy to detect spikes in the optic nerve (or auditory nerve), or in the LGN or inferior colliculus, and perhaps cortically too.
  - They are all part of the physical correlate of the percept
  - Does that mean that they "are" the percept?
  - Or are there other ongoing physical phenomena that are critical to the existence of the percept?

Neuromodulators and neurotransmitters

- Known to be correlated with affect
  - Basis of all chemical treatment of mental illness, for example.
  - But other treatments also work
    - Cognitive behavioural therapy, or logotherapy
    - Do these (indirectly) alter neuromodulators and neurotransmitters?
- Is it the neuromodulators/neurotransmitters, or their effects on spiking that matters?
  - How would we tell?

Admissible vs. conclusive evidence

- What we can measure is admissible
  - But it's hard to see what would be conclusive evidence
- There is a danger that we assume that what we can measure is what is actually important
  - Action potentials, local field potentials, intracellular/ extracellular potentials

  as opposed to
  - Ionic species concentrations, distributions of open ion channels, localisation of electrical potentials on dendrites, for example
- What would we measure if we had unlimited measuring capability?

Am I spikes over time?

- To answer "yes" would imply that spikes were the only (or the critical) component of "I"-ness
  - And this is not at all clear
- The nature of the relationship between spikes
  - Or, indeed, any other form of physical correlate of "I"-ness
- … and 1st person experience is unclear

On the mathematical underpinning of physical correlations

- What are the issues?
  - What is the nature of the mathematical description of physical underpinnings that could support the arising of 1st person experience?
    - what would be required of it?
- What sort of mathematics might be required to underlie this mapping?
  - Category theory, as proposed by Ehresmann and Vanbreemersch?
  - Some form of communicating agent theory in the style of Milner's work?
  - Some form of algebra in the style of Cardelli's work?

And some last comments…

- Why do we want to answer this question?
  - Understanding of ourselves
    - Clinical, philosophical.
    - Advertising?
      - What would it be like if advertisers really understood awareness & consciousness?
  - Imbuing our own creations with selfhood
    - Robots with real volition, awareness, etc.
- What are the ethical issues that would arise if we did understand (and could replicate) the physical correlates of selfhood?

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(but all the mistakes are my own)