Mental Iconicity Seminar
Prof. Gabriel Greenberg
W9: The problem of retinotopy
3.3.26

Paper comments

- Grade range, paper
- Improve on the source.
    - Clarity, explicitness, definitions, precision, disambiguation.
- Include diagrams and images.

---

1. What's at stake

Three grades of information use:

- **Carrying information**
    - State A carries information about state B, without functioning to do so.
    - **Example 1:** the tree ring carries information about the age of the tree.
    - **Example 2:** the reflection in the water carries information about the person staring down.
- **Registering information:**
    - State A registers information about state B iff (1) A carries information about B; (2) it is part of A's function to carry information about B.
    - **Example 1:** plants register information about the direction of the sun (and turn towards it accordingly)
    - **Example 2:** retinal photo-receptster register information about the identiy of the person you are looking at, but don't represent this information.
- **Representing information (content)**
    - State A represents information about state B iff (1) A registers information about state B; (2) A satisfies a standard of semantic significance.
    - Possible standards:
        - **Part of a mind:** functioning information must be part of an overall mental organization.
        - Direct computation requirement
        - **Constancy tracking:** functioning information must be the result of a constancy computation.
        - Content level explanation:

    - **Example:** areas in late ventral stream processing *represent* the identity of the person you are looking at.

What is the significance of retinotopic layout to information processing?

- **Hypothesis 1:** Retinotopic layout has no relevance for information processing.
- **Hypothesis 2:** Retinotopic layout registers spatial information, but does not represent spatial content.
- **Hypothesis 3:** Retinotopic layout represents spatial content iconically.

Two organizing questions

- Do locations in retinotopic layouts represent spatial locations?
- If so, are locations in retinotopic layouts iconic representations of spatial locations?

Against Hypothesis 1:

- **Retina-Cortex correlations.** Correlations between the retina and the cortex shows that retinal location information is used by the early visual cortex.
- **Cortex-Perception correlations.** Correlations between cortical retinotopy and later perceptual states shows that retinotopic information in the cortex is used by later visual processing.
- **So:** retinotopic information is not thrown away; it has *some* significance for information processing.

---

2. Opposing Hypotheses: H2 vs H3

Hypothesis 2: retinotopy as information registration

- **Local representation:** Collection of single-entity representations.
- **No global representation:** No visual field representation.
- **Global registration:** Spatial information is registered by retinotopic areas.
- **Memory architecture:** Spatial location is comparable to memory address: it structures computation (e.g. by allowing different local representations to coordinate) but it isn't itself representational.
- **Retinotopy as by-product.** Retinotpic layout is a by-product of evolution from a spatially organized retina.

> "Their topographic organization presumably facilitates the coordination of these local representations (as well as contrast enhancement by way of lateral inhibition, etc.), but the representations are still local." (Lyons)
>
> "If these analogies hold even roughly, it would be unsurprising to see structurally corresponding activations at the retina and at the input (and other early) cortical layers, simply because cells in the retina are activating subsequent neurons in early visual areas in ways corresponding to their own spatial outlay." (Langland-Hassan)

Hypothesis 3: retinotopy as iconic representation

- **Global representation:** Holistic visual field representations.
- **Local representation:** Single-entity representations are constituent parts.
- **Representational content:** Spatial information is represented by retinotopic layout.
- **Correspondence:** Spatial information is carried by retinotopic layout according to general, natural rules of correspondence.
- **Iconicity:** Retinotopic representations are iconic and picture-like.

> "These areas do not simply have a topographically organized physical structure; they function to depict information. If a patch of cortex in one of these areas is damaged (for example, because a tumor had to be removed), this damage will produce a scotoma (i.e., a ''blind spot'') in the corresponding part of the visual field." (Kosslyn)
>
> "Why does the brain use space on the cortex to represent space in the world? Although the ease of genetic coding or other factors may play a role, the best current guess is that this structure has been retained through evolution for a simple reason: this trick makes explicit and accessible information needed for the tasks at hand." (Kosslyn)
>
> "In short, each location on the topographically organized cortex corresponds to a specific location in space, and distance between the locations on cortex corresponds to distance between the corresponding locations in space." (Kosslyn)
>
> "The iconic nature of visual spatial representation and representational content is grounded in the iconic nature of visual sensory information registration and in the spatial layout of aspects of the central brain that correspond to space-mapping areas in visual perception." (Burge p. 305)

> "Four factors—visual representational content, visual non-representational information registration, cortical central brain areas that underlie spatial perception, and visual receptors—figure in the discussion. All ground either iconic information registration or iconic spatial representation. All are structurally related." (Burge p. 305)
>
> "The mapping of geometric or topological structures common to physical space, visual receptors, visual information registration by banks of retinal and cortical neurons, and the format of visual representational content lies at the base of the iconic nature of visual spatial perception." (Burge p. 305)

What is the substantive difference?

---

3. Argument against retinotopic representation (for H1/H2)

Argument 1: Physical distance isn't functional for neural nets.

1. **Retinotopy.** Retinotopy is a property of physical distance relations in cortical areas.
2. **NN function.** Physical distance isn't functional for neural nets.
3. **Brains.** Brains are neural networks (more or less).
4. **So:** retinotopy isn't functional for the brain.

"One might argue that the crucial variable is not the actual physical distance on cortex, but rather a kind of ''functional distance'' defined by connectivity among neurons in a brain area. Start by taking the extreme case, where physically distant neurons are connected directly to each other and thus function as if they were adjacent, whereas physically nearby neurons are connected indirectly to each other via intermediate neurons and thus function as if they were very far apart. If the neurons in an area were so arranged, would the area in fact depict? Now take a less extreme case, where physically distant neurons tend to have more intermediate neurons between them—and thus, the crucial variable is not actual distance on the cortex but rather the number of connections that intervene among neurons. Would such an area still depict?

We have two responses to this concern (which was expressed to us in conversation by the distinguished philosopher Ned Block): (1) In point of fact, most connections between neurons in topographically organized areas are short and inhibitory (at least in the monkey brain, about which we know considerably more than we do about the human brain). This is

a good example of how neuroanatomy constrains theory. We cannot simply posit an arrangement of connections by fiat; there is a physical device, and there are known facts about how it is constructed (and how it operates). (2) The fact that topographically organized areas are physically depictive is irrelevant for present purposes. The neurons in these areas could be interconnected arbitrarily, but as long as fixed connections to areas farther downstream ''unscramble'' the activity in earlier areas appropriately, the earlier areas will functionally depict. We know that such an orderly mapping to later areas occurs because of the systematic relations between loci that are damaged in an area and loci in the visual field where blind spots appear." (Kosslyn)

Argument 2: Argument from cortical magnification.

1. **Iconicity as isomorphism.** If retinotopic states were iconic representations, cortical space would be isomorphic to visual space.
2. **Cortical magnification.** Cortical space is distorted and magnified relative to visual space.
3. **So:** cortical space is not isomorphic to visual space.
4. **So:** retinotopic states in the cortex are not iconic representations.

Argument 3: Argument from absence of computational role.

1. **Pylyshyn's razor:** "If we gain no explanatory advantage by specifying what an NL represents, then nothing is gained by treating the NL as a representation."
    a. "we need to show that these properties of the NL function to represent properties of the world for the organism."
2. **No evidence for function.** There is no evidence that retinotopic layouts function to represent spatial locations.
3. **So:** retinotopic layouts are not representational.

"In that case nothing is gained by saying that these distances represent properties in the world, since by hypothesis the distance on the NL is all that is relevant to explanations involving distances…Therefore, it is not a representation in the strong sense; it does not represent the property as something in the world, notwithstanding that, if spread out on a flat surface, the pattern of activity looks like a map." (Pylyshyn)

The direct computation requirement

4. Argument in favor of retinotopy as iconic representation

Argument from retinotopy-perception correlations (R-space, V-space)

1. **Correlations.** There are correlations between locations of activity in R-space and locations of events in V-space.
2. **Functional information.** Best explanation of (1): Locations in R-space function to carry spatial information about locations in V-space.
3. **Representation:** Best explanation of (2): Locations in R-space represent spatial information about corresponding locations in V-space.
4. **Iconicity:** Best explanation of (3): iconicity

Justification for 3 to 4:

- The only other way for locations to be represented by coordinates, stored at the exact location that corresponds with the represented location in space.
- There is no evidence for this; it would be massively inefficient; and a massive coincidence.

Justification for 2 to 3:

- This is what is at issue between H2 and H3.
- Just because spatial information is registered, is it really represented?
- What would we have to do to show that it *is* represented?
- Direct computation requirement.

Afterclass notes:

- Distinguish:
    - H1A: Spatial information that correlates with (is implied by?) retinotopic layout is not relevant to information processing.
    - H1B: Spatial information carried by retinotopic layout is not relevant to information processing.
- H1A is defeated by the observation of cortex-perception correlations.
- H1B is defeated by the argument from absence of computational role.