UNIVERSITY OF MICHIGAN

A sensorimotor account of vision and visual consciousness

Kartikeya Gupta

(02/01/2023)

Agenda

1. Author Introduction
2. Structure of Vision
3. Empirical Data
4. Conclusion & Discussion

1. Author Introduction

J. Kevin O'Regan & Alva Noë

J. Kevin O'Regan

- English psychologist
- Ex-director of the "Laboratoire de Psychologie de la Perception" at the University of René Descartes, Paris

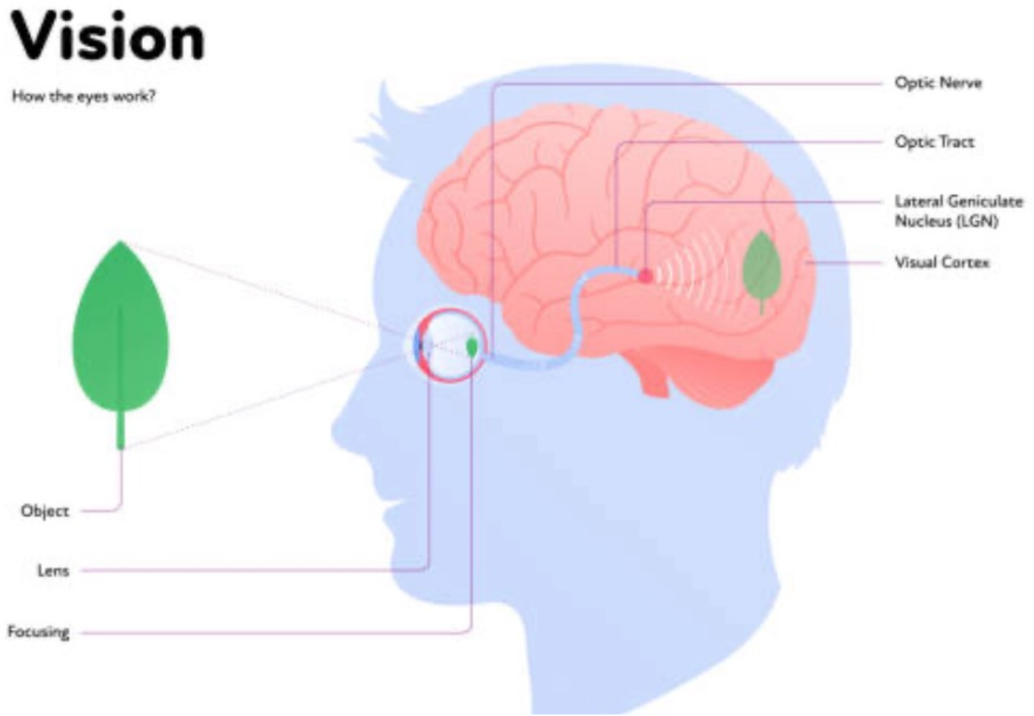
Alva Noë

- American **philosopher**
- Professor of philosophy at University of California, Berkeley
- Focus of his work is the theory of perception and consciousness

2. Structure of Vision

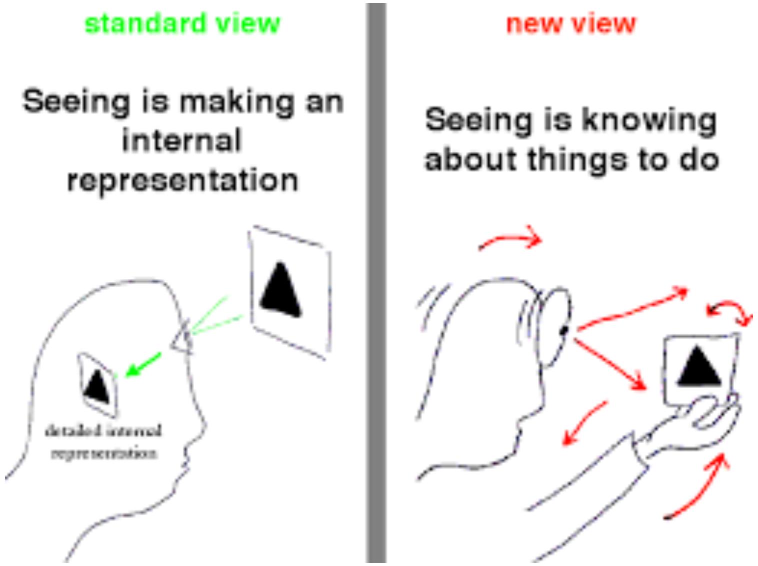
Traditional View of Vision

- Brain produces internal representation of the world
- Activation of internal representation produces experience of “seeing”
- How does an internal representation produce visual consciousness?
  - Potential “commentary” system situated in fronto-limbic complex
  - Coherent oscillations that bind together separate percepts



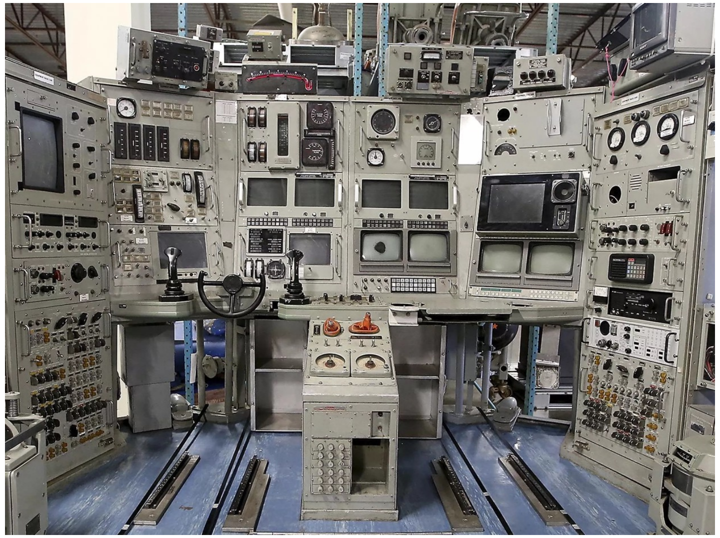
The Sensorimotor Contingency Theory

- Overcome gaps in traditional view of vision with a new approach
- Treat vision as an *exploratory activity*
- *"Vision is a mode of exploration of the world that is mediated by knowledge, on the part of the perceiver, of what we call sensorimotor contingencies"*
- Sensorimotor contingency = rules of interdependence between stimulation and movement
  - Behavior influences received sensory information, sensory information guides further behavior

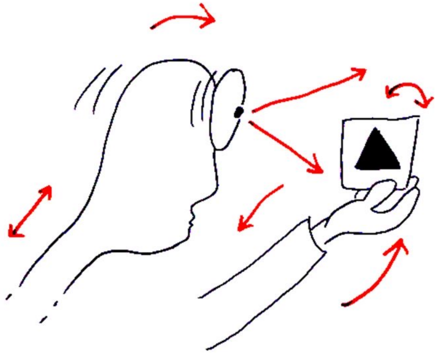


Sensorimotor Contingencies

- Scenario: Losing control in submarine, mixed up cables, inputs no longer correlate to intended outputs
  - Overcome this scenario by observing *structure of the changes* on control panel until proper control is established
- Human Brain is given solo task of deciphering nervous influx coming from all sensory modalities
- What differentiates vision from other sensory domains?
  - *Structure of rules* that govern sensory changes produced by various motor actions
  - Each sensory domain has its own set of invariance properties which govern perception in these modalities

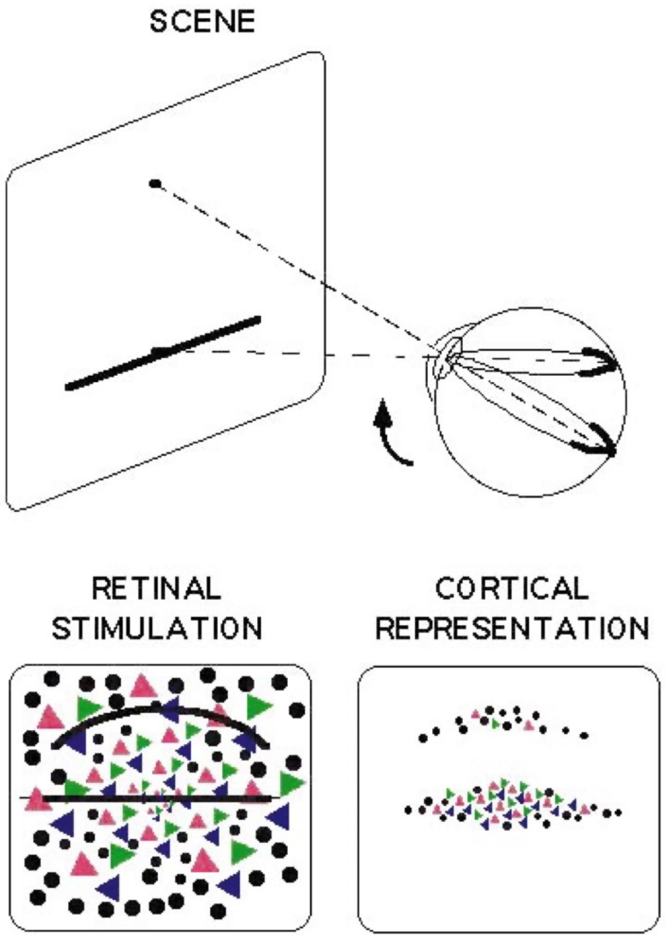


Seeing is a SKILL
Exercising the sensorimotor contingencies



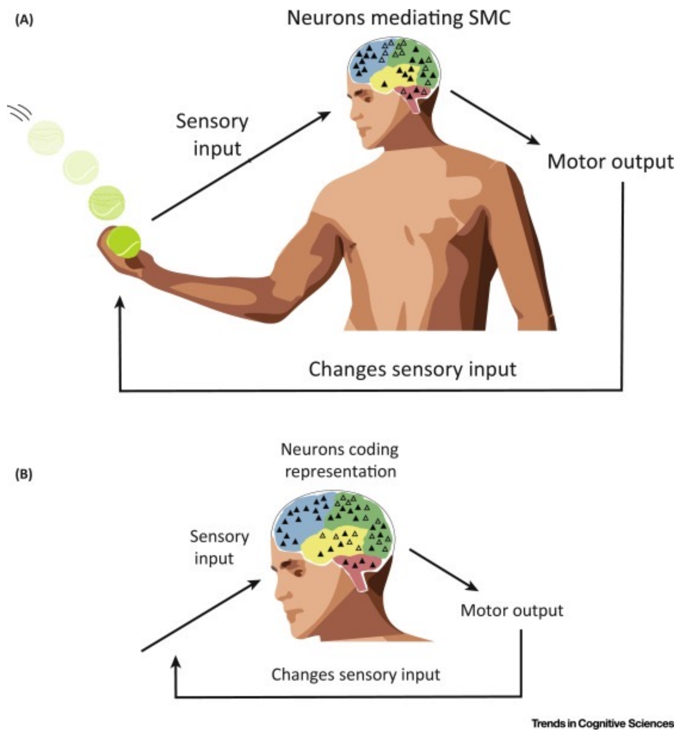
Distinguishing Visual Percepts

- A first law distinguishing visual percepts is when eyes rotate, the sensory stimulation on the retina shifts and distorts in a particular way
  - Determined by size of eye movement, shape of retina, and nature of ocular optics
- There is a subset of sensorimotor contingencies that are produced by constraints of visual-type exploration which correspond to *visual attributes* of sensed objects
- Example:
  - When looking at midpoint of line, the line traces a great arc inside your eyeball
  - If fixation point is changed, the line's curvature will change in a drastic, yet lawful way as the eye moves



Mastering Sensorimotor Contingencies

- Scenario: Missile guidance system
  - Missile is “tuned to” sensorimotor contingencies that govern airplane tracking and thus has mastery of these contingencies
  - I.e., If the missile turns left, then the target’s image shifts right
- Vision requires satisfaction of two basic conditions:
  - The animal must be exploring their environment by two main kinds of sensorimotor contingencies
    - Those fixed by the visual apparatus and those fixed by the character of objects
  - The animal must be “tuned to” these laws of sensorimotor contingencies
    - The animal must be *actively exercising* its mastery of these laws



Visual Awareness

- "Third important aspect of vision" is *visual awareness*
- For a creature (or machine) to possess visual awareness it must exercise relevant sensorimotor contingencies for the purposes of thought and planning
- "*When you integrate mastery of sensorimotor contingencies with capacities for thought and action-guidance, then you are visually aware of the relevant feature. You* ***see*** *it.*"

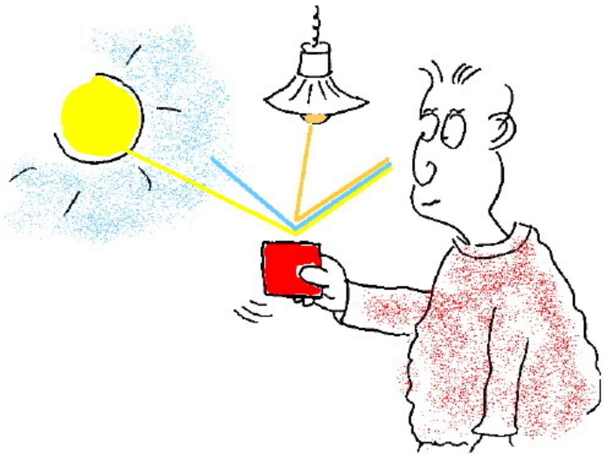
Visual Consciousness

- Two kinds of visual consciousness:
- *Transitive visual consciousness "consciousness of"*
  - To be transitively conscious of a scene is to be conscious of features of the scene (color, shape, and texture)
  - I.e., to be transitively conscious of a parked car is to say that you're able to derive features of the car and thus integrate sensorimotor contingencies into your current planning, reasoning, and speech behavior
- *Visual consciousness in general*
  - Higher-order capacity
  - Refers to the ability to consciously access and manipulate visual information in working memory, allowing for tasks such as attention shifting
  - Can contrast being visually conscious with being asleep or blind

UNIVERSITY OF MICHIGAN

World as an Outside Memory

- Visual experience is a mode of activity involving practical knowledge about currently possible behaviors and associated sensory consequences
- Visual experience rests on know-how, the possession of skills
    - The experience of seeing occurs when the outside world is being probed to the visual mode
- Thus, outside world acts as an *external memory* that can be probed at will be the sensory apparatus
- Remembering is casting one's awareness onto parts of latent memories
- Seeing is casting one's awareness onto aspects of the outside world made available by the visual apparatus



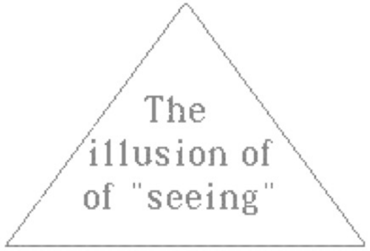
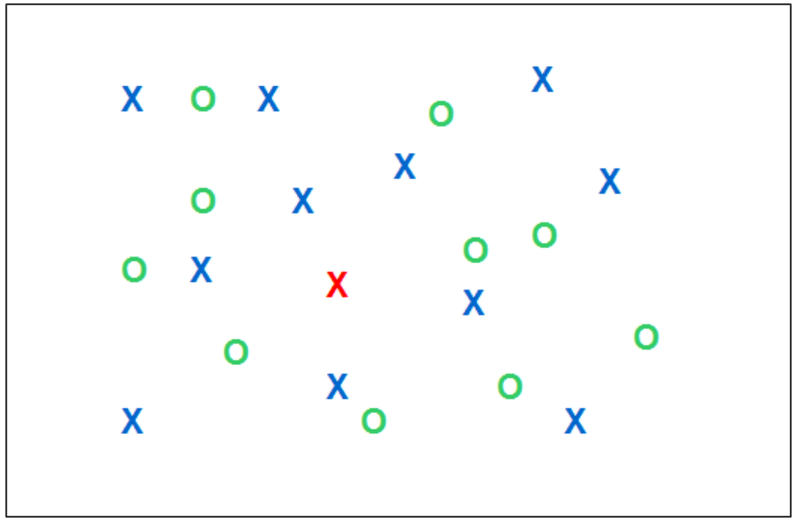


Figure 4. Ceci n'est pas: The illusion of "seeing."

3. Empirical Data

Inattentional Amnesia

- Wolfe et a. [1999] use a standard visual search paradigm
- Subject must search for a target symbol among several distractor symbols
- Display of distractors remained the same over a number of repetitions, but target symbol is changed every trial
- Would expect an internal representation of the display to form over successive trials, however researchers found no evidence of improvement in search rate
  - Subjects think they are searching through a new display every trial



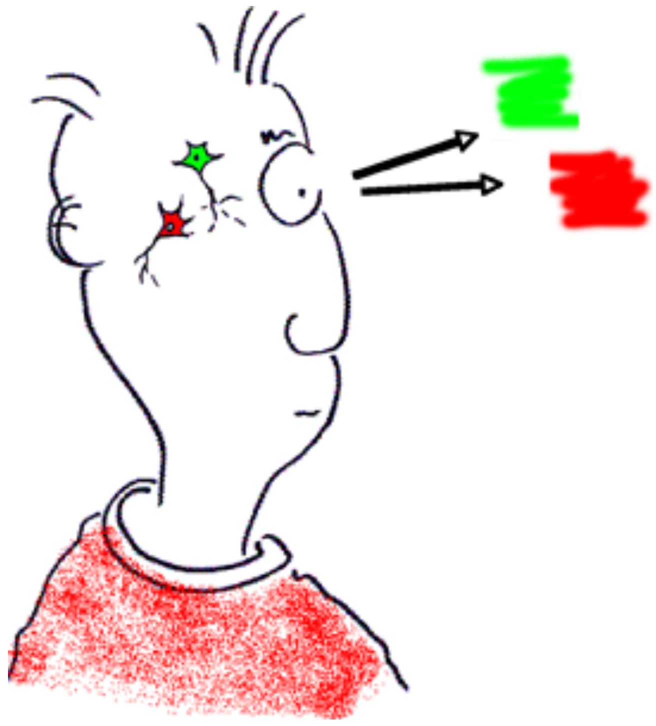
Remote Tactile Sensing

- Lenay [1997] gave a blind or blindfolded person a single photoelectric sensor attached to his or her fore finger, and subject was allowed to scan environment by pointing
  - Subjects hear a beep or feel a vibration when pointing at a light source
- Subjects established different types of sensorimotor contingencies:
  - Lateral movement allows information about direction to be obtained
  - Movement in an arc centered around the object gives information about depth
- The experience of perception derives from the *potential* to obtain changes in sensation, not from the sensations themselves
  - The location of a sensation is an abstraction constructed to account for the invariance structure of the available sensorimotor contingencies

UNIVERSITY OF
MICHIGAN

"Red" is a Structure of Changes

- Under present view, experience of seeing a red color patch depends on the *structure of changes* in sensory input that occur when you move your eyes around
- Jameson & Hurvich [1998] found that dichromats were quite good at making red/green distinctions
- Concluded that additional cues about an object allowed them to distinguish between colored objects
- The color of a surface is not so much related to the spectrum of reflect light, rather to the way the surface potentially changes the light when the surface is moved with respect to the observer



4. Conclusion & Discussion

Conclusion

Takeaways:

- Laws of sensorimotor contingencies constitute the way the brain codes visual attributes
- Vision is an exploratory activity; It is mediated by knowledge of what we call sensorimotor contingencies
- The outside world acts as “external memory” which our sensory modes probe to gain/retrieve information

Discussion Questions

1. What are the implications of a sensory-motor approach to computer vision in terms of model design and evaluation?

2. How might incorporating a sensory-motor perspective improve current computer vision models in terms of their ability to handle real-world situations and unpredictable events?
    1. Is it possible to implement such a system given our existing knowledge of machine models?

Piazza Discussion Questions

Saaketh Medepalli (saakethm) 1 hour ago
The authors describe how over the course of life, a person will encounter many visual attributes with associated stimuli, along with their corresponding sensorimotor contingencies. They note that these sets have all been recorded and are latent, ready to be actualized given the particular attribute (p. 7). Would this be physically possible to execute the brain within the 20-30 ms that it takes to recognize an object for instance? Given the sheer amount of memory it would take to make all of these associations, is it even possible to search for the right attribute quickly enough to enable an action? In order to better understand this theory, it must be tied in with the developmental studies such as the ones from last class as well as a potential model by which this can be actually implemented by the brain.
helpful! | 0

If sensorimotor contingencies are latent, is it possible to physically execute the brain within a reasonable amount of time?

Oliver A Wang (oliveraw) 47 minutes ago
I feel like there is still a step missing in this description—even though experience is rooted in the invariant nature of senses and the mastery over sense information, there is still a struggle to explain how this fits together and amalgamates into cognition. If the visual reality is viewed as an "outside memory" and perception is the feeling of mastery over this data, then where does the pattern matching skill come from?

Humans can "gain mastery" of different sensory inputs (such as the blind using echolocation or haptic sensors), but what processes actually make it possible for this to happen? Our brain relies on invariants in these senses to put information together, but the actual mechanism still seems mysterious to me.

How does the sensorimotor contingency theory fit into cognition? How does a creature "gain mastery" of different sensory inputs?

Thank You!