What might be the mechanism for this illusion?

Important concept list

1) Both top-down and bottom-up processes contribute to visual perception

2) Computations in the visual system take place through serial and parallel processing.

3) The visual system detects and acts upon past and present environmental correlations.

4) The visual system builds, and operates simultaneously on, multiple spatial reference frames

5) The visual system flexibly optimizes its resources on a moment-to-moment basis

Overview of our important concepts.

Visual perception/computation...

1) Is based on both "top-down" and "bottom-up" signaling

2) Is both serial and parallel

3) Extracts past and present correlations

4) Builds and updates multiple spatial frameworks

5) Allocates resources according to rapidly changing demands

6) Emerges from the actions of, and interactions between, excitatory-inhibitory circuits

Lecture 8: Awareness

Qualia, levels of consciousness, contents of consciousness, neural correlates of consciousness, turing test, Chinese room argument, panpsychism, priming, tachistoscopically, mask, iconic memory, sleep inertia, V1 & consciousness, claustrum, reentrant activity, network oscillations (e.g., gamma, beta, theta, delta; causes & functions), REM vs. non-REM sleep, loss of consciousness,

What do we mean by consciousness?

The subjective "state of being," made-up of **qualia**.

We can't directly measure qualia.

    - Philosophers don't like to measure, making consciousness a preferred topic.

    - David Chalmers: who's to say we aren't all 'zombies'?

Scientists attempt to gauge **levels of consciousness** (e.g., sleep vs. wake; anesthetized or not) by how a body interacts with the environment

Scientists attempt to measure **contents of consciousness** based on the explicit report of percepts (using language or an arbitrary action)

1) Is the study of consciousness scientific? Can it be functionally distinguished from perception and attention? How can we describe it?

2) What are types of behaviors that accompany consciousness? (Provides information on the possible *functions* of consciousness for a behaving system)

Behavioral correlates of consciousness

3) What underlying physical processes accompany consciousness? (Provides information on the *mechanisms* that may explain what kind of system and dynamics have consciousness.)

Neural correlates of consciousness (NCC)

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**Neural correlates of consciousness (NCC)**

1A) Is the study of consciousness scientific?
Some contemporary thoughts:

Daniel Dennett: because so much of our perceptual experience is an illusion, qualia don't actually exist. Consciousness does not have to be explained as something special and independent from neural processes.

John Searle: consciousness is "ontologically subjective", can only exist as subjective experience. (**Turing test** and **Chinese room argument**)

Thomas Nagel: the physical and mental are aspects of the same underlying "stuff." But we can't know another's subjective experience, and the idea of an uber-objective, "View from Nowhere" is paradoxical.
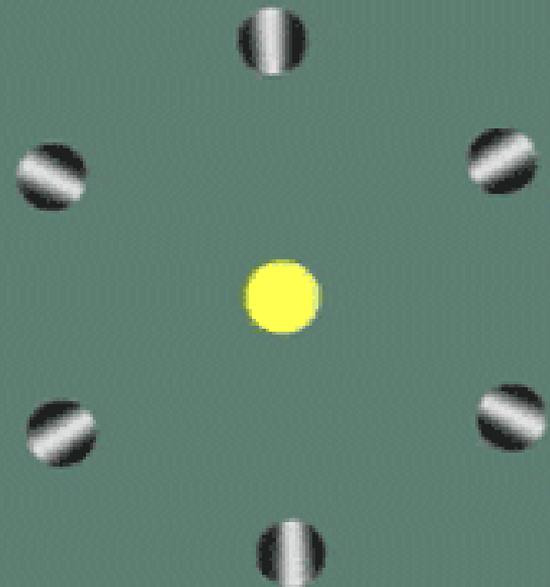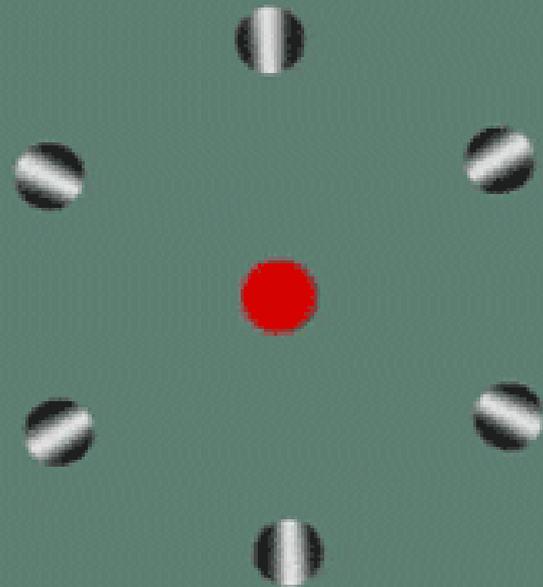
1A) Is the study of consciousness scientific?

Some more thoughts (reactions to David Chalmers' TED talk):

- Is consciousness something "fundamental" the way physical forces are?

    (Not if fundamental == independent)

- Does everything have some level of consciousness (**panpsychism**)?

    (Not explanatory/predictive: mysticism)

1A) Is the study of consciousness scientific?
Thoughts from your textbook (Palmer)

"To be brutally honest, scientists do not yet have even the remotest idea of how visual experiences—or indeed any other kinds of experiences—arise from physical events in the brain"(p618)

"Vision is the process of acquiring knowledge about environmental objects and events by extracting information from the light they emit or reflect. . . Conscious visual experience was left out [from this definition] because it is logically possible for vision to occur in the absence of awareness" (p630-631)

The **isomorphic constraint**: some things can and some things can **not** be determined based on behavior (a much larger, but still incomplete picture, can be achieved with biology)

1B) Can consciousness be functionally distinguished from perception/attention?

- Is consciousness the same as...
  - Perception?

  - Short-term memory?

  - Perceptual-motor (or perceptual-emotion) transformations?

  - Attention?

Perception ≠ consciousness:

Blindsight (lecture 3): patients with damage to primary visual cortex can still make visual judgments, but can not build a consciously-accessible percept of the stimuli or make voluntary actions to the stimulus.

Priming: images presented **tachistoscopically**, and with a **mask**, are not consciously experienced or remembered, but can influence ideas and actions in ways that are linked to the stimulus.

We can process input without (full) consciousness (cocktail party effect, or waking to some sounds and not others)

Short-term memory ≠ consciousness:

Some features of **iconic memory** (very brief sensory memories) do not persist into short-term memory, but would be considered conscious.

However, many features of iconic memory are not conscious.

Perception-to-motor/emotion ≠ consciousness:

REM sleep: consciousness without perception or motor

Motor:

- Patient DF: bilateral damage to the ventral stream; could still reach for objects with the appropriate grip configuration, and (with difficulty) draw a line oriented as a not-conciously-perceived line.

- **Event related potentials (ERPs)**: "readiness potential" for action precedes subject's awareness of selecting the action (Libet 1985)

Emotion:

Masked stimuli →skin conductance change and amygdala activity
    (some methodological issues: "incomplete masking" and inter-subject variability; Pessoa, 2006)

Attention ≠ consciousness:

Top-down attention: in some cases, priming can occur only if subjects are attending to the stimulus; even if the subject does not consciously see the stimulus.

Bottom-up attention: salient stimuli (e.g., male & female nudes) can attract attention even when the figures are not consciously observed.

We can be conscious of the elements in an image presented for 30 ms, even though we don't have time to use top-down attention.

1B) Can consciousness be functionally distinguished from perception/attention?

- Is consciousness the same as…
  - Perception?

  - Short-term memory?

  - Perceptual-motor (or perceptual-emotion) transformations?

  - Attention?

No… but it's also not independent

1C) How can we describe it?

Temporal: the contents of consciousness tend to remain stable from a few hundred milliseconds to a few seconds, are usually continuous over time (linking present and past)

Information: tend to have a foreground (attended domain), a background (unattended but still perceived or maintained), a limited capacity but an immense range (senses, thought, emotion, memory, imagination, language, action planning), and depend on the history of associations we have formed.

> (May be considered "unified", although this is debated amongst philosophers and psychologists)

Used synonymously with "awareness," but **not** "self-awareness"

1) Is consciousness a "thing"? Can it be functionally distinguished from perception and attention?

2) What are types of behaviors that accompany consciousness? (Provides information on the possible *functions* of consciousness for a behaving system)

Behavioral correlates of consciousness

3) What underlying physical processes accompany consciousness? (Provides information on the *mechanisms* that may explain what kind of system and dynamics have consciousness.)

Neural correlates of consciousness (NCC)

2) What behaviors accompany consciousness?

Just discussed!

Are there things we can't do for unconscious stimuli that we can for conscious stimuli?

Cheesman & Merikle (1986):

- Used a masked, **Stroop task**

- Influence of conflict for both conscious & unconsciously perceived words

- When words are consciously perceived, the frequency of conflict trials influences the effects of conflict (i.e., more information is being integrated to generate expectations)

Behaviors at different levels of consciousness:

- How do subjects behave during **sleep inertia**?

- How do anesthetics influence behavior, and what accompanies the loss of consciousness?

What behaviors accompany consciousness?

What may be the *functions* of consciousness?

Baars, 1988: Consciousness provides a **global workspace**—the content of consciousness is available to diverse cognitive processes

Dennet: There is not "function" of consciousness, it is only the reflection of the most strongly processed information at a given point in time.

Crick & Koch, 1995: A key function of consciousness is to "produce the best current interpretation of the visual scene in a compact form and make this information available to the planning stages of the brain."

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Neural correlates of consciousness (NCC)

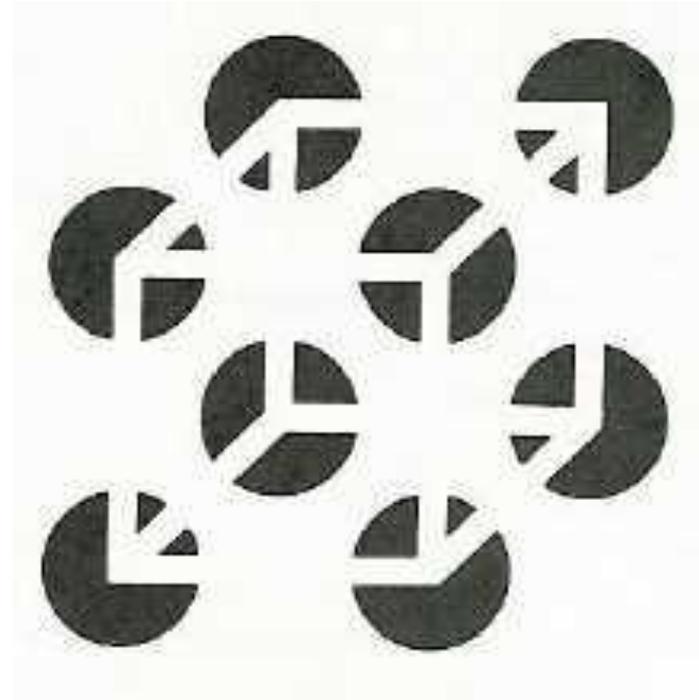**Neural correlates of consciousness (NCC)**

When probing brain activity, where do we see activity that correlates with conscious awareness, and where do we not?

     - Brain regions (V1? IT? Basal Ganglia?)

     - Cortical layers?

     - Neurons synchronized at a certain frequency?

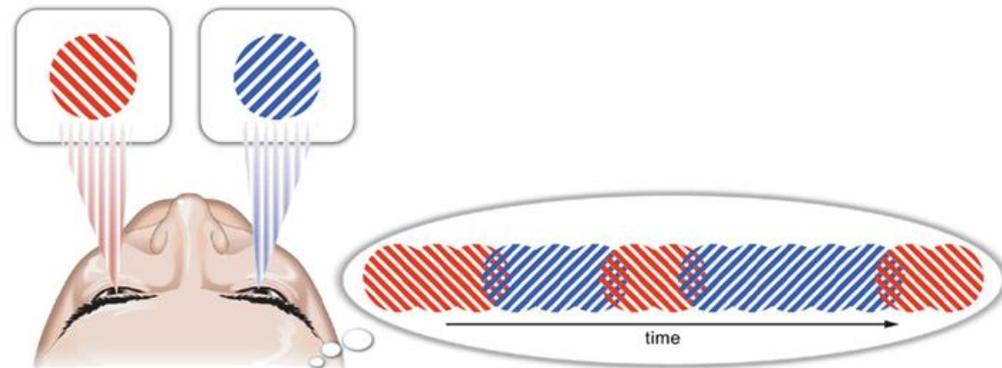   - Neurons within specific networks?

Multistability

Multi-stable images can be used to study NCCs

(Question: how might we model multi-stability at a circuit level?)

(figure from http://www.csus.edu/indiv/w/wickelgren/psyc103/ClassVisionHigher2.html

(figure from http://journal.frontiersin.org/Journal/10.3389/fnhum.2011.00155/full

NCC: region analysis

V1 – only a small fraction of cells change activity according to which percept is being experienced

V2 & V3 – "filling in" observed in monkey single neurons (deWeerd et al., 1995)

IT – almost all neurons respond only to which percept is currently active

Human imaging studies: V1 activity can be modulated by attention independent of conscious percepts and behavior (Lee et al., 2007; Bahrami et al., 2007)

V1 may provide the information that conscious perception is based on, but conscious percepts do not appear to correspond with V1 activity.

NCC: region analysis

Francis Crick: the **claustrum** may provide a site where information can be rapidly integrated and bound across many different regions

Recent study: turning consciousness on and off by stimulating the claustrum?
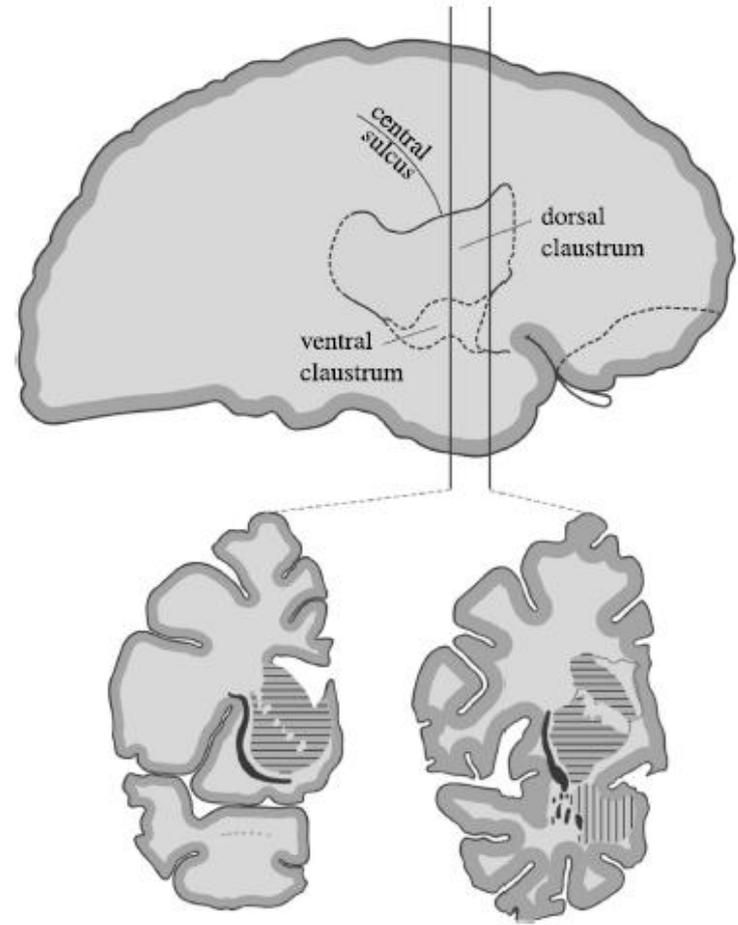
NCC: neural dynamics

Is consciousness based on sustained (>100 ms) neuron firing? (As opposed to phasic < 100 ms activity.)

- Consciousness seems to be a phenomenon that rolls forward on the scale of hundreds of miliseconds, so might rely on neuron activity at similar timescales

- Most studies looking at sustained vs. burst activity and consciousness have been performed in V1, making them difficult to interpret

NCC: reenterant activity

Discussed in class many times!
- attractor circuits
- corollary discharge/motor efference copy
- top-down feeding back on bottom-up
- Donald Hebb's "cell assemblies"
    (Lorente de No's anatomical work)

Consciousness probably depends on feedback connections, but most brain functions do!

How might feedback be important??

NCC: network oscillations

Electrical waves in regions of the brain represent synchronized activity of neurons within those regions or inputs to those regions

alpha   spindle   ripple

K-complex →

1 s

100 ms
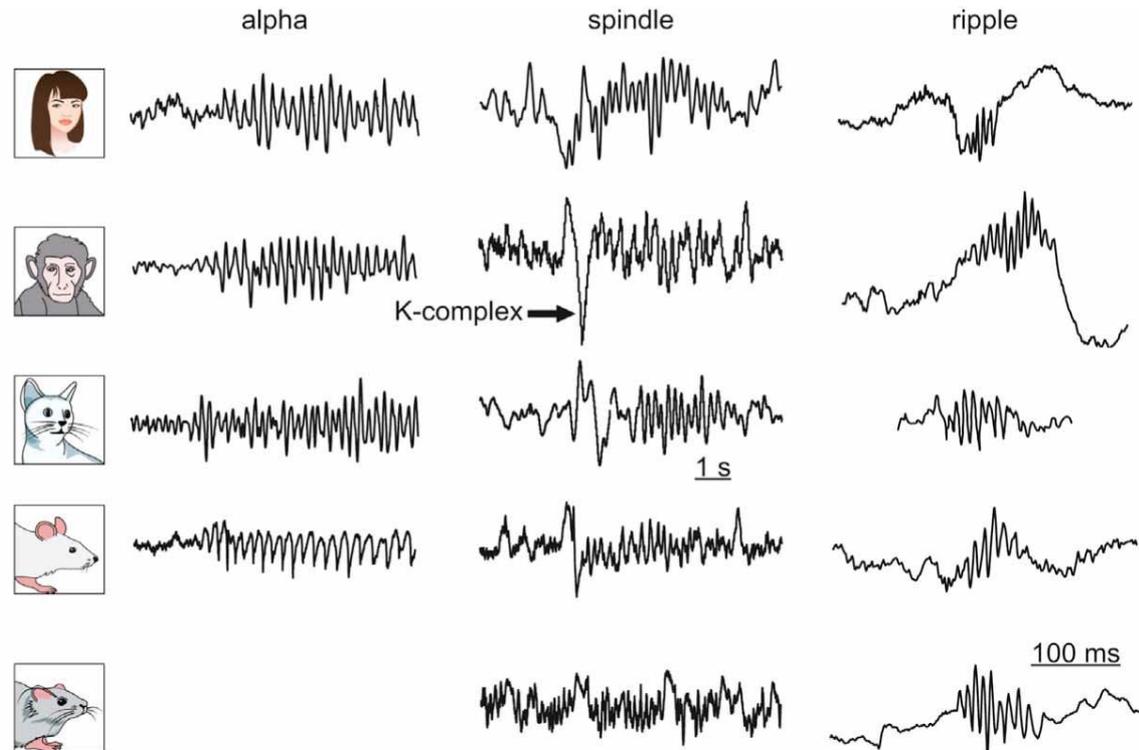
NCC: oscillations

Many frequencies at which neurons in the brain synchronize.

Notable examples:

Gamma (~40-70 Hz, and 70-120 Hz)—increased with increased thalamic/cortical input to a region
(circuit mechanism discussed in Lecture 3)

Beta (~15-30 Hz)—sensory regions during perceptual integration, motor systems during action

Theta (5-10 Hz)—hippocampus during attention & behavior, (may also explain certain ERP phenomena)

Delta (1-4 Hz)—in the cortex during slow-wave sleep

NCC: oscillations/synchronization

Consciousness of percept often correlates with increased synchronization (coherence of oscillations) and increased correlated metabolism between regions

(However, it's not clear that disrupting synchrony causes perceptual impairments.)

NCC: oscillations

Possible *mechanisms*:

- "Pacemaker" neurons

- Interactions between inhibitory and excitatory neurons within a circuit (e.g., gamma)

- Interactions between circuits

Possible *function*:

- synchronization between regions may improve information flow → increased binding of the elements of an experience

NCC: levels of consciousness

non-REM vs. REM sleep

- brain stimulation in non-REM remains localized and short-lived relative to waking or REM sleep

Anesthesia

- Decrease in neuronal excitability by either increasing inhibition or decreasing excitation.

- Transition to unconsciousness (**loss of consciousness**, or LOC) correlates with cortical EEG change (thalamic EEG takes an extra 10 min)

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Neural correlates of consciousness (NCC)

An information-based theories of the physical basis of a subjective state/consciousness

Tonnoni:

      - Consciousness has lots of information

      - Consciousness is also unified/integrated

So: "the level of consciousness of a physical system is related to the repertoire of causal states (information) available to a system as a whole (integration)"

Is this a converse error (affirming the consequence)?
If conscious, then integrated information
integrated information; therefore conscious.

An information-based theories of the physical basis of a subjective state/consciousness (continued)

Measure of integrated information: φ

Computer simulations reveal that high φ is best achieved with networks of information-specialized nodes with many inter-connections (as we see in the thalamo-cortical system)

In the brain, some cortical loops may be "insulated" (able to influence the state of the whole without being affected by it)

The set of elements underlying consciousness is not static, but forms a dynamic complex/**dynamic core**

THANK YOU!

…Class overview?

Overview of this class: brain regions

      1) Top-down: nervous-system structure

      2) Bottom-up: eye, retina, LGN

      3) Frequencies: V1

      4) What?: occipitotemporal cortex

      5) Where?: superior colliculus, occipitoparietal cortex

      6) Learning: V1, occipitotemporal & occipitoparietal cortex, medial temporal lobe (incl. hippocampus)

      7) Attention: "descending" connections from frontal & parietal cortices

      8) Awareness: cortex & claustrum

Overview of this class: network/circuit properties/computations

      1) Top-down: bottom-up, top-down, feed-forward, feedback

      2) Bottom-up: serial & parallel, inhibitory interneurons for lateral inhibition, different cell types with different functional specializations

      3) Frequencies: further extraction/transformation of information; e.g., decomposition into frequency components through specific patterns of feed-forward projections, further refined by local connections ("global inhibition" circuit)

      4) What?: further extraction/transformation of information: correlated activity in a moment → representations of grouped stimuli, correlated activity over history → invariant object representations

      5) Where?: proprioceptive information & motor efference combined with visual to transform retinal space into other spatial frameworks (using combined, "gain field" representations for XOR; 1D & 2D attractor circuits for head-direction and allocentric space, intermediate layer combined representations for movement in space

      6) Learning: connections → representations, formed based on "innate" signals and correlated activity; use of "random" index code in hippocampus

      7) Attention: circuit signal-to-noise, biasing of processing

      8) Awareness: network oscillations, "protected" vs. dynamic core systems for information integration

Overview of this class: behavior/cognition

     1) Top-down: gestalt principles

     2) Bottom-up: increased resolution of visual percepts → corner spot illusion (lateral inhibition); reacting to movement; blind spot

     3) Frequencies: vision as a combination of multiple features (including higher & lower spatial frequency components)

     4) What?: view invariance, gestalt grouping principles, figure-ground, color, semantic & emotional meaning (intrinsic vs. learned)

     5) Where?: selection of actions based on different coordinate frames (e.g., eye movements--retina frame, body movements—head/body frame), depth perception (& depth cues), motion perception, head-direction, navigation & path integration

     6) Learning: developmental formation of visual perception, perceptual memory, episode-based (contextual) memory, imagination

     7) Attention: selecting things/features/spaces in the environment to visually process

     8) Awareness: qualia & consciousness, integrating everything

Overview of this class: important concepts.

Visual perception/computation…

1) Is based on both "top-down" and "bottom-up" signaling

2) Is both serial and parallel

3) Extracts past and present correlations

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6) Emerges from the actions of, and interactions between, excitatory-inhibitory circuits