How well can a Blind Person see after Recovery?
How can you see if visual area V1 works, but later visual areas do not?

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Recovery from Blindness.

- How well do people see after long term blindness?
- First studies performed in 1793, but few cases reported since.
- Ione Fine & colleagues, studied patient Mike May.
- These studies involve:
- (i) Psychophysics experiments.
- (ii) Neuroimaging experiments.

Patient: Mike May.

- Patient Mike May.
- Blinded at age 3 ½ years.
- Sight partially restored in one eye at age 43 – by corneal and limbal stem-cell transplant.
- 2 ½ years after surgery.

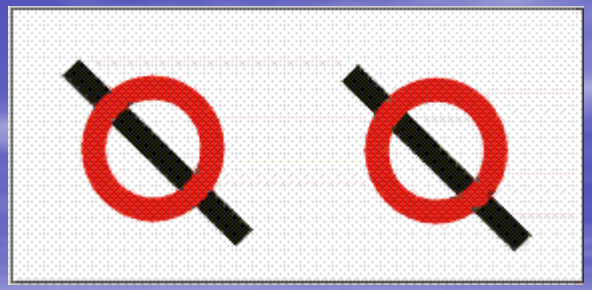
Psychophysics & Neuroscience.

- Psychophysics – show visual stimuli, ask May to perform visual tasks.
- Neuroimaging – use Functional Magnetic Resonance Imaging (FMRI) to measure neural activity while Mike May performs visual tasks.
- We know areas in the brain that are tuned for specific visual tasks.
- E.G. MT – Motion area, Face area, Scene area.

Testing Visual Abilities.

- Resolution Tests: the ability to resolve visual patterns.
- Mike May was unable to perceive high frequency patterns (rapid oscillation).
- Mike May's FMRI response to these patterns in visual cortical area V1 was 1/5 of normal subject.
- Problem in the cortex, not in the retina.

Simple Form Tasks.



- Mike May was able to perform simple form tasks:

1. Detect the orientation angle of a bar.
2. Distinguish between simple shapes – triangles and circles.

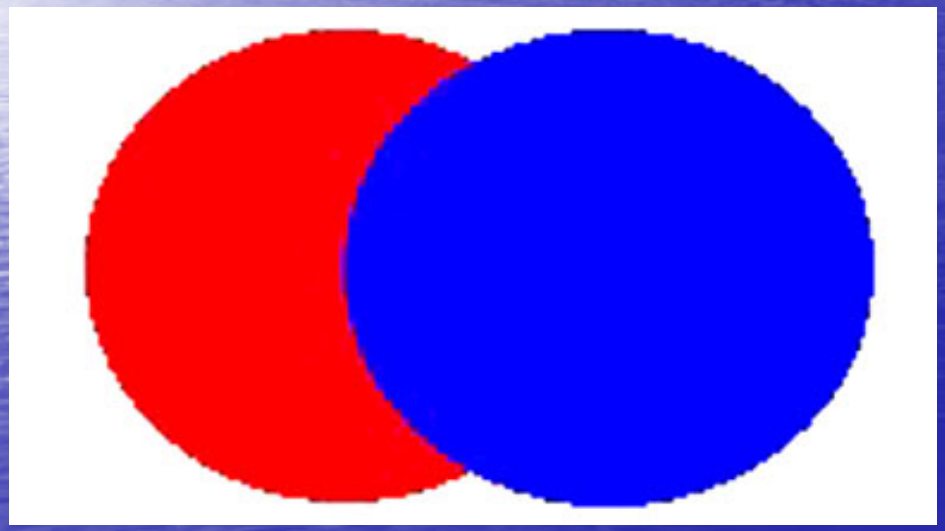
- These tasks are performed in V1, the first stage of the visual processing.

More Advanced Tasks.

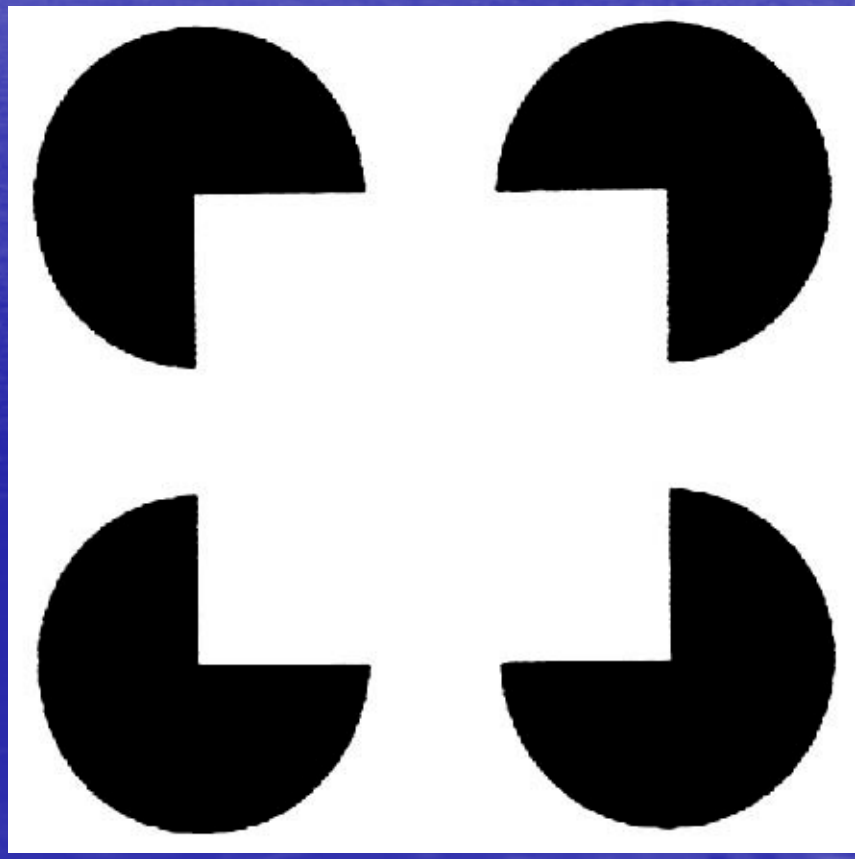
- Regular eye exams at an Oculist only test these types of abilities.
- Embodied in Retina and V1.
- But vision is about decoding the world – this involves estimating depth, recognizing objects, detecting motion.
- How well can Mike May perform at these tasks?
- Beyond V1.

Tasks involving 3 Dimensions.

Occlusion Cues:
Which object is in front?



Illusory Contours:
Can you see the square?



Mike May has difficulties with these 3-D tasks. (Guesswork).

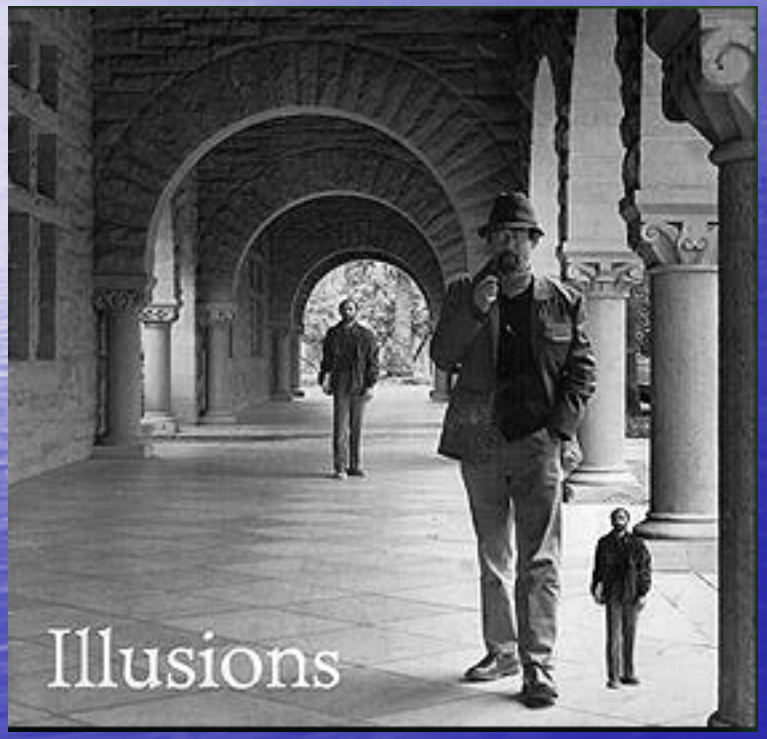
3D Depth Cues from Single Image.

- Mike May performs poorly at these tasks.

Relative Size:
Smaller cars in the image are further away.

Linear Perspective:
Parallel lines converge at increasing distance.

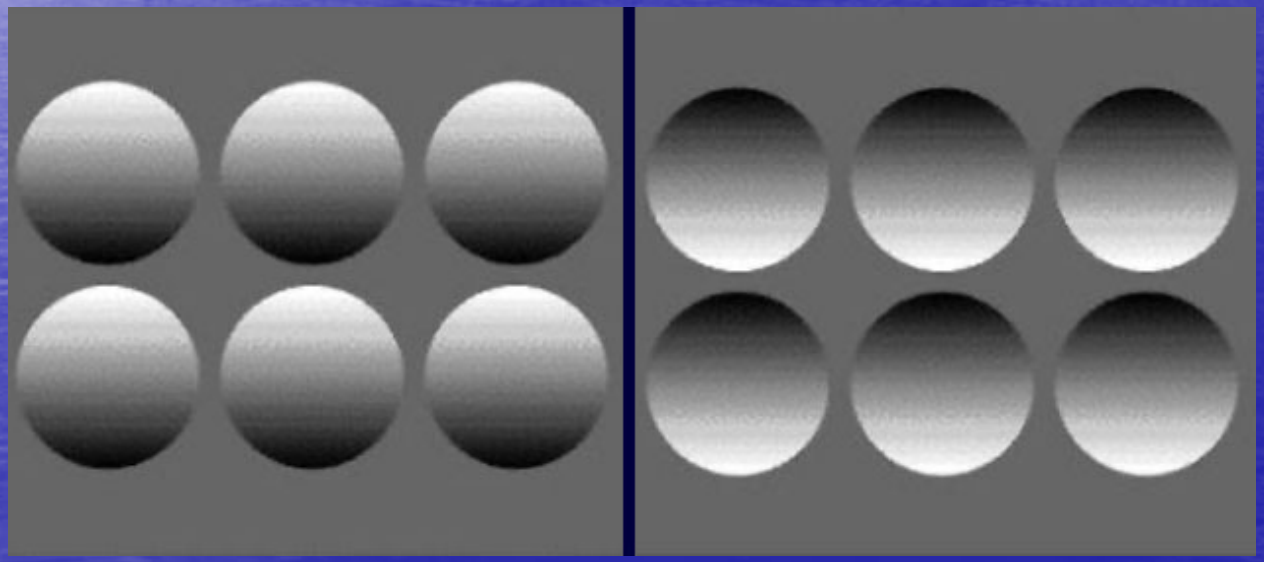
These Cues can cause illusions.



But they are reliable most of the time.

Depth from Shaded Patterns.

- Light and Shape:
- Concave/Convex // Light above/below.



Beyond V1 – except for Lee's experiment.

3D Depth and Recognition.

- *Mike May is poor at all these 3D depth tasks – particularly those involving using shading.*
- Poor at recognizing 3D objects such as faces, detecting facial expressions (happy/sad), judging gender.
- Ability to perform these tasks did not get better over time – except by guesswork.
- *"The difference between today and two years ago is that I can better guess at what I am seeing. What is the same is that I am still guessing".*

FMRI Activity for Recognition.

- Mike May shows very little neural activity in the “face areas” of the brain.
- These areas have significant activity in normal subjects.

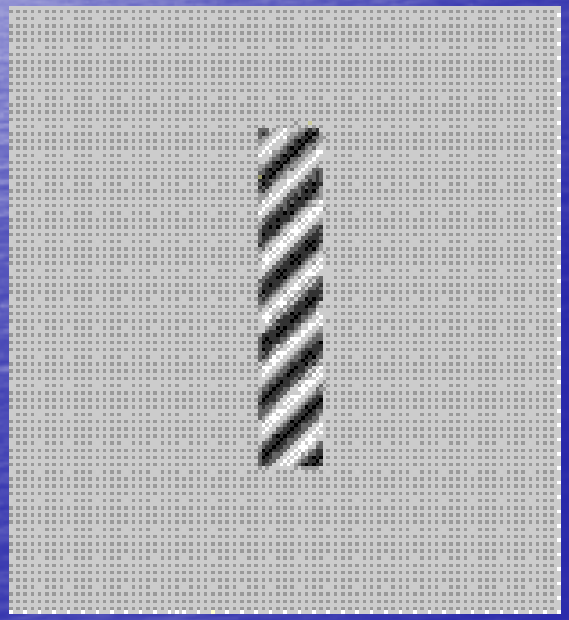
- It is not known where perspective cues, size cues, and shading cues are processed.

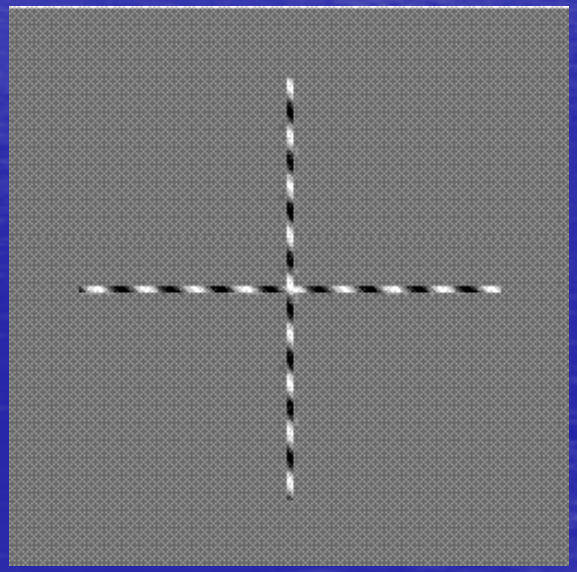
Motion Cues.

- Mike May performs a lot better for motion cues.
- These cues are processed in area MT. May shows normal activity in these areas.
- This includes the ability to see three-dimensional shape.

Motion Illusions.

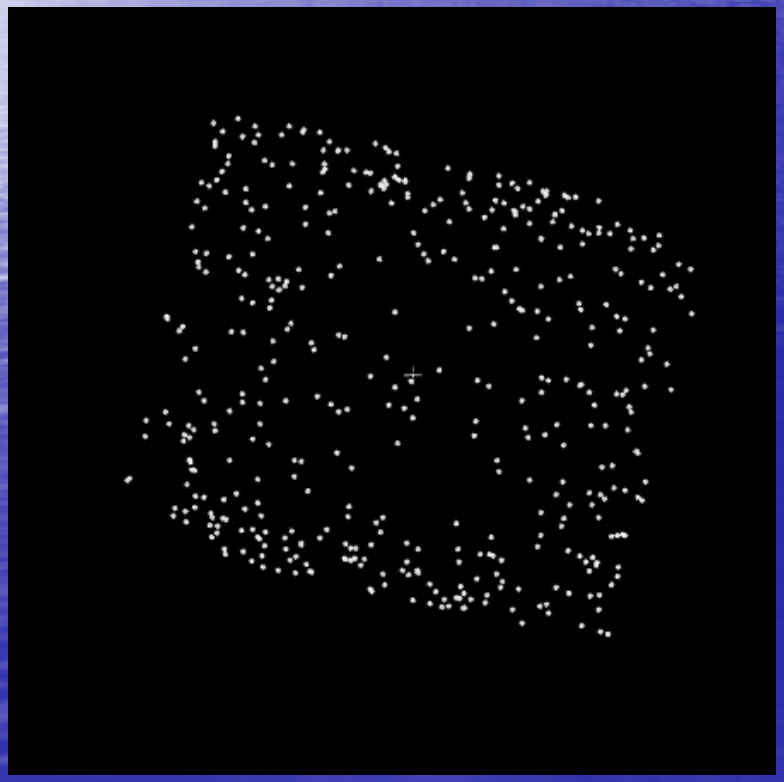
- This means that Mike May see the standard motion illusions. Barber Pole.

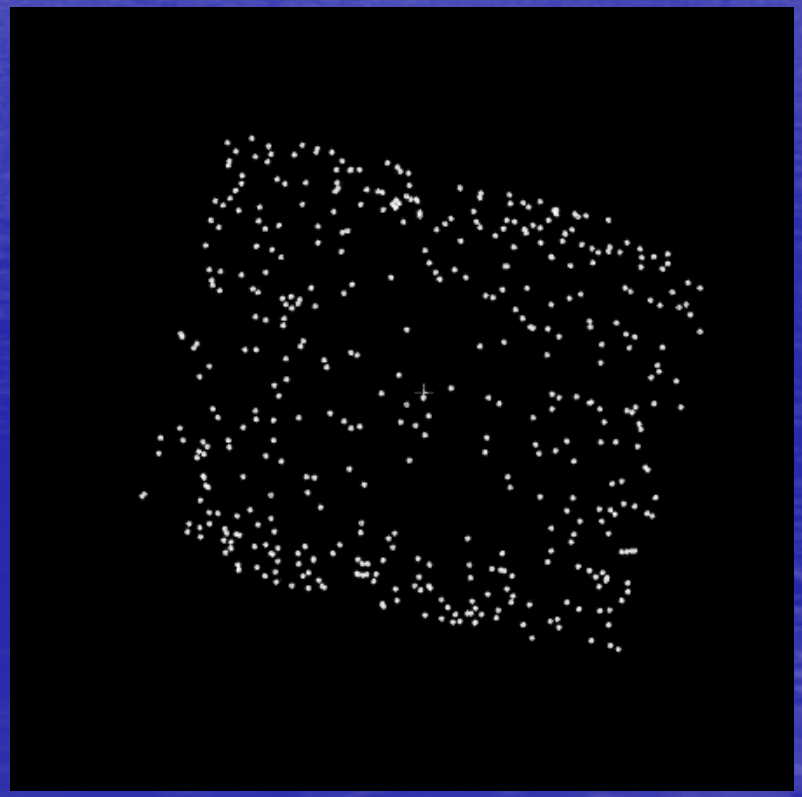




3D Structure from Motion.

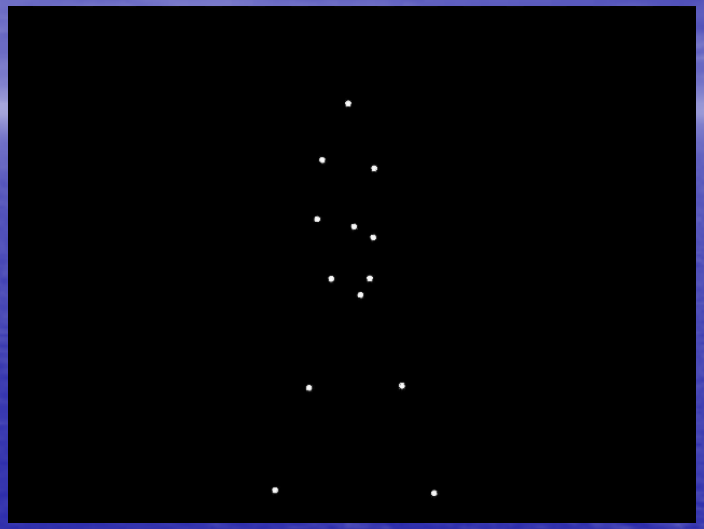
- Mike May can see 3D structure from motion cues.

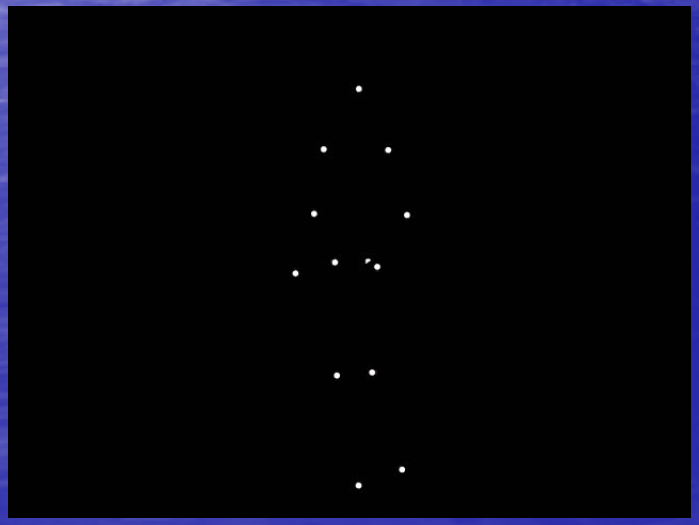


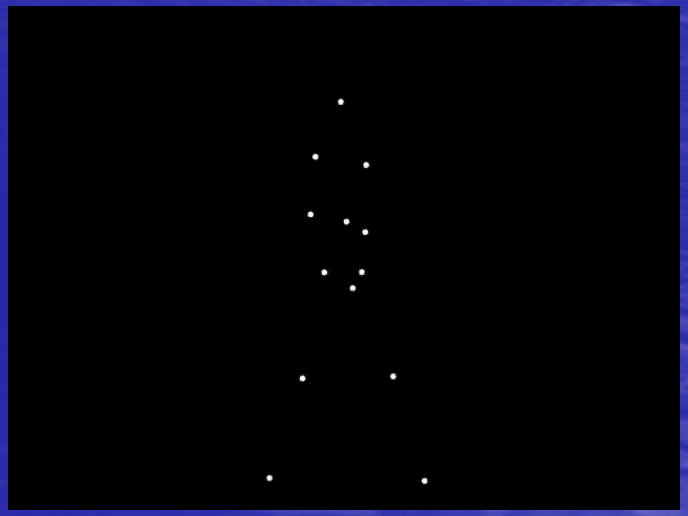


Perceive Biological Motion.

- Mike May can perceive biological motion.







Mike May Summary.

- Low spatial resolution in V1. (Less than predicted by the resolution of the retina).
- Poor ability to process static 3D depth cues and to recognize 3D objects such as faces.
- But good at simple shape tasks (orientation of bars).
- And good at tasks involving motion cues. MT.

Two Probable Explanations.

- (1). *Development.* Infants/Children develop different visual skills at different times.
- They are most sensitive to motion cues – probably Mike May's motion processing system was well developed before he lost his sight (aged 3 ½).
- (2). *Plasticity.* The visual cortex (& all the cortex) shows plasticity – adapting to experience.
- E.g. He could have developed face recognition, but the face area would be underused, and then converted for some other use.

Development of Infant Vision.

- Studies in the last twenty years shows that infant's visual systems are remarkably sophisticated.
- Ability to use size cues may be present within a week of birth.
- Testing: an infant will pay attention to a novel stimulus. It will get bored and look away if the stimulus *is perceived to be familiar.*

Development of Infant Vision.

- Different visual abilities appear at different stages.
- The order and (approximate) timing of these stages is common to all infants.
- E.G. certain depth cues (binocular stereo) will appear between 4 and 12 weeks.
- Differences may be due to the richness of the visual environment or genetic factors.

Infant Development of Vision.

- Example: Infants are able to form perceptual categories between ages 3 to 4 months.
- Distinguish between giraffes, horses, fish, etc.

- Environment: claim that perspective depth cues are only learnt in suitable environments. Reports that some tribes, adapted to jungles, do not develop perspective depth cues.

Development of Visual Abilities

- Some abilities take time to develop.
- Example, the ability to re-create spatial layouts from memory increases from age 5 to age 9.
- Field independence – the ability to separate an image into parts (e.g. detect partially hidden objects) increases from age 10-17 years.

Motion Cues develop very early.

- Infants can use motion cues to detect objects, estimate 3D shape, and recognize objects.
- They do this long before they can reliably perform these tasks from static images.

- Conjecture: motion cues are more reliable. Infants are genetically predisposed to use them.

Motion and Mike May.

- Hypothesis:
- Mike May is good at using motion cues, because this part of his visual system was well developed before his accident. And it did not decay afterwards.

- But, by age 3 he should also be able to use static depth cues and recognize faces.

Plasticity.

- The cortex of humans and monkeys is plastic – experience can alter visual areas.
- Monkey finger's experiment.
- FMRI studies of blind subjects suggest that they use their higher visual areas for non visual processing (visualization).
- Mike May could have lost his ability to detect faces, because his brain face area was adapted for something else. (Use it or lose it).

Other Studies.

- Mike May is probably the best studied patient (Psychophysics and FMRI).
- But other studies give similar results – e.g. inability to perceive 3D depth from static images, poor ability at recognition, ability to see light patterns but inability to detect them.
- Pawan Sinha (MIT). Project Prakash.
- https://brainworldmagazine.com/seeing-is-believing-an-interview-with-neuroscientist-pawan-sinha/

Reactions to Recovered Sight.

- Some reactions are surprising:

1. "It made me kind of angry that people were walking around in this colorful world that I never had access to."
2. "People live so much closer to each other than I had realized...I'm not used to the idea that I can tell so much about them by looking."
3. "A lot of people have got pimples recently".