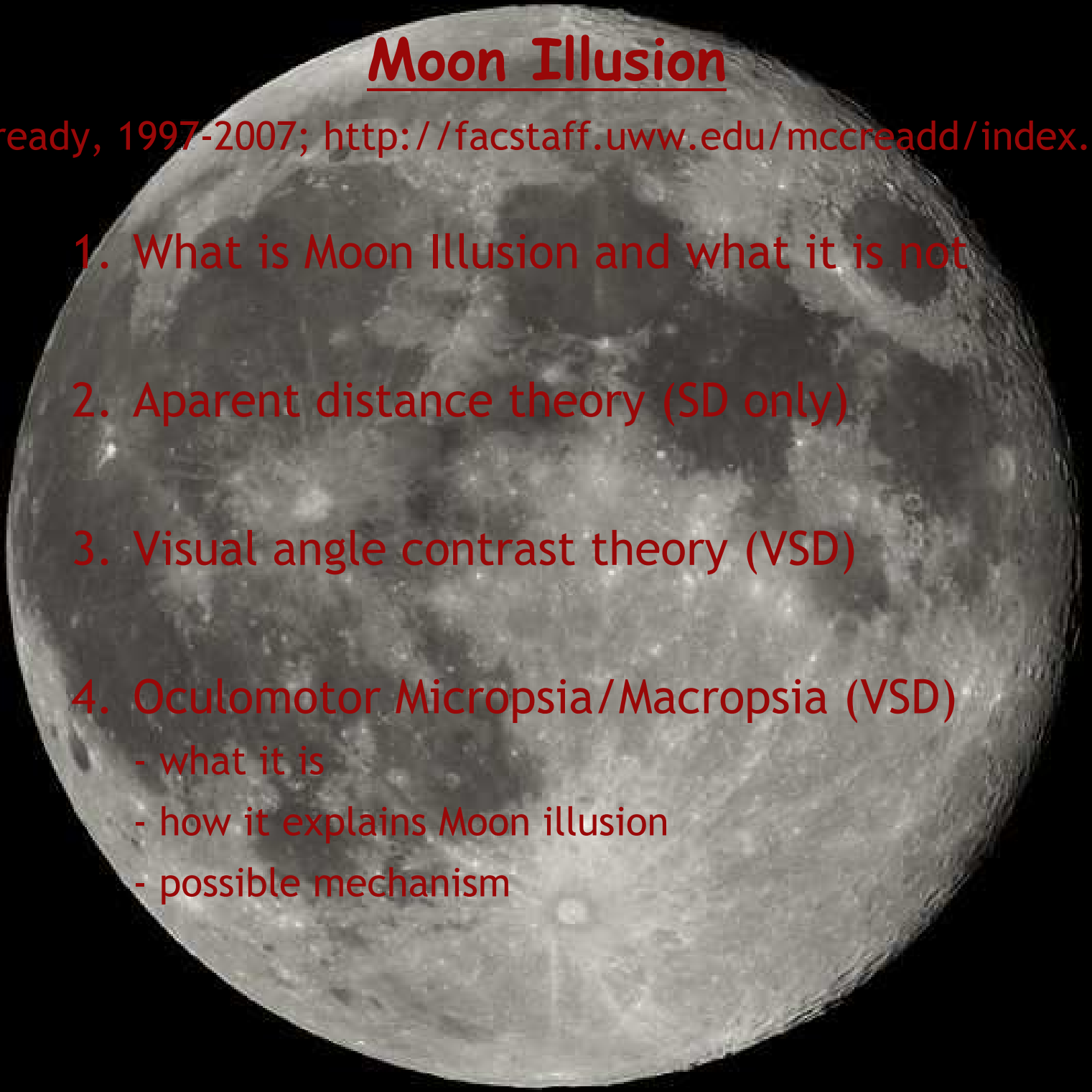
Moon Illusion

(McCready, 1997-2007; http://facstaff.uww.edu/mccreadd/index.html)

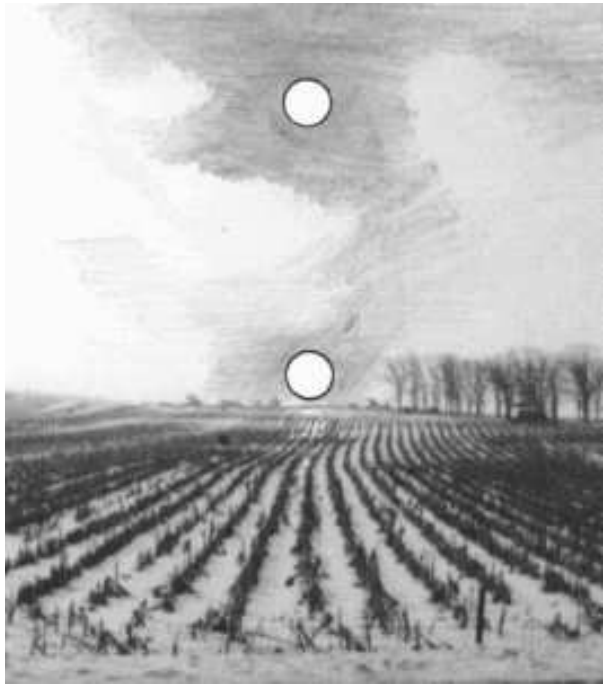


1. What is Moon Illusion and what it is not
2. Aparent distance theory (SD only)
3. Visual angle contrast theory (VSD)
4. Oculomotor Micropsia/Macropsia (VSD)
   - what it is
   - how it explains Moon illusion
   - possible mechanism

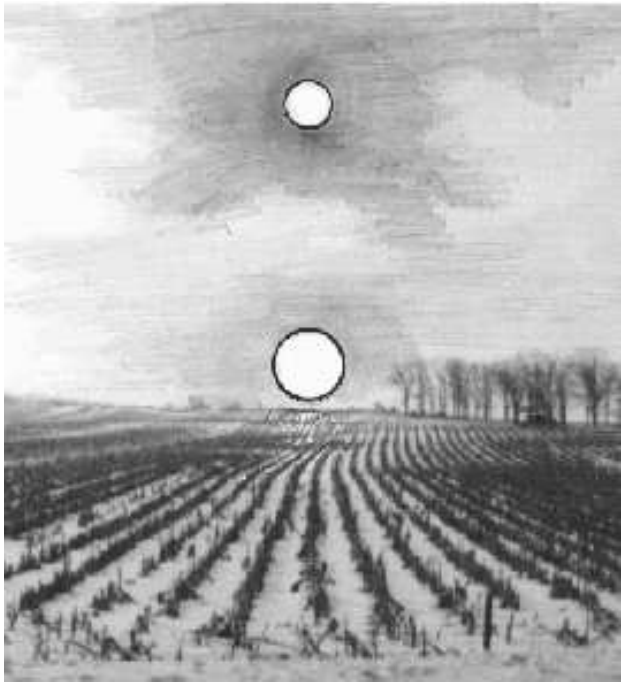
What is Moon Illusion, what it isn't

- Moon: $R = 1737$ km, $d = 363,104 - 405,696$ km;
  ($\dot{d} \sim 3.8$ cm/yr; $\dot{d}/d \sim 97$ km s^{-1} Mpc^{-1})
- angular size on the sky: $\sim 0.52^o$ (indep. on alt. above horizont)
  (Ibn al-Haytham, known as Alhazen, 11th century)
- optical image on the retina: ~ 0.15 mm

photo

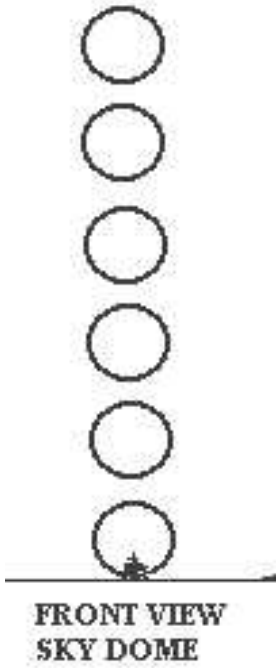


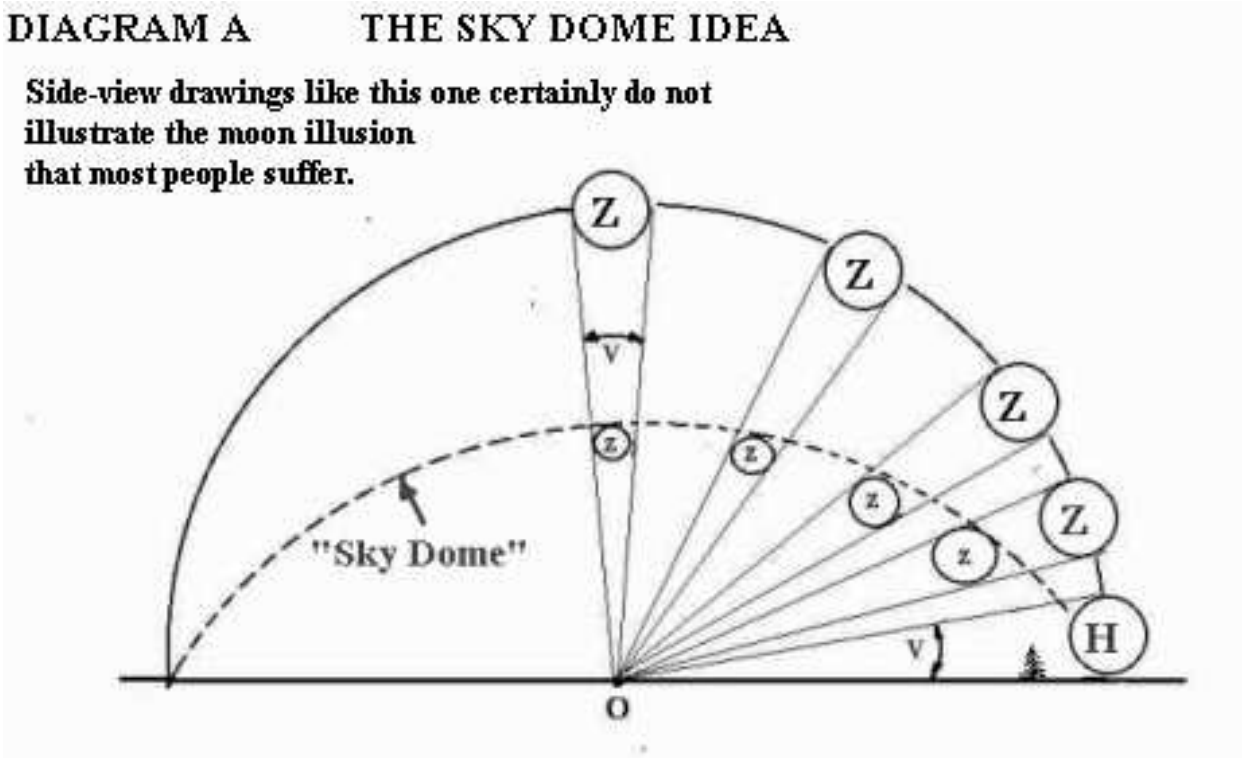
percieved (horizon Moon $1.5\times$ larger)



Aparent Distance Theory

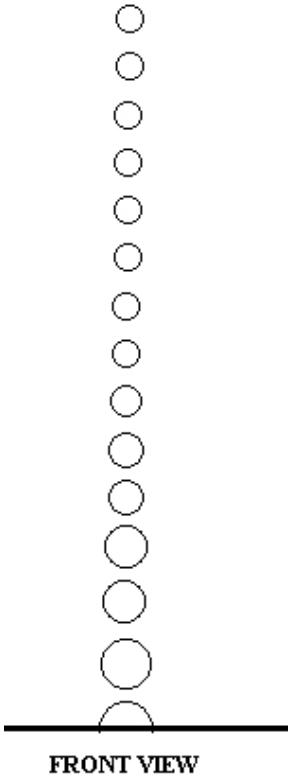
- SD-illusion (linear size - distance)
- ignores (or rejects) visual angle illusion
- can explain MI only for $\sim 5\%$ people who percieve the horizon Moon to be further away than the zenith one
- side-view misleading - zenith Moon circles smaller (angularly)

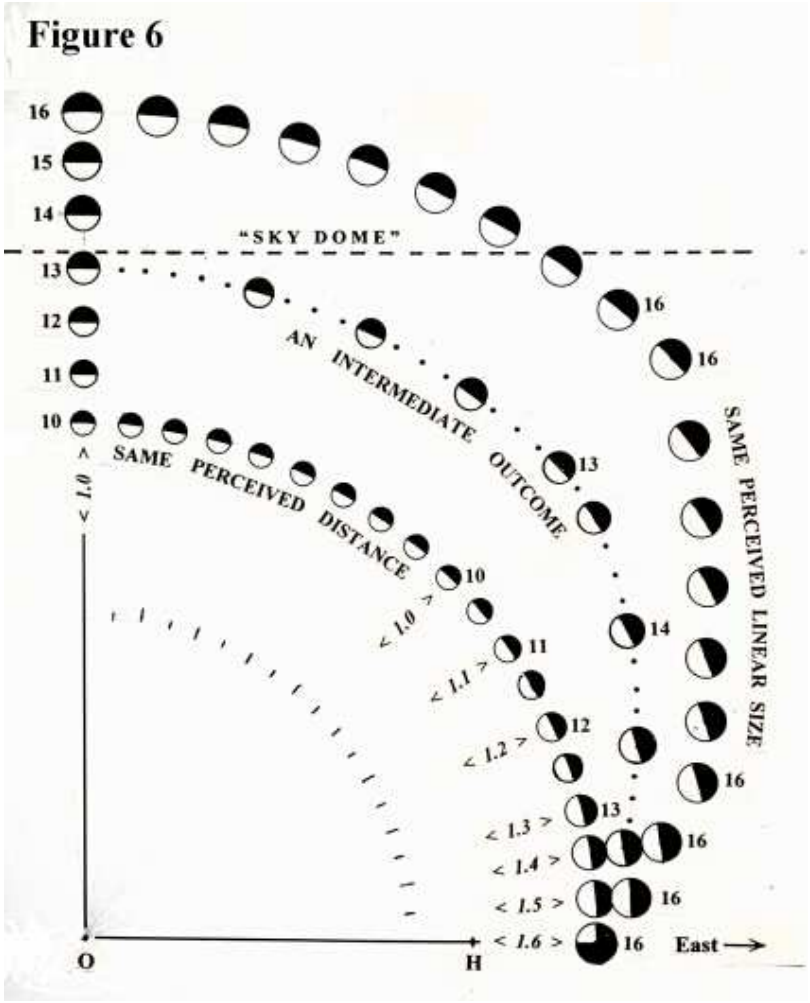




Size-distance paradox

- meassured percieved distance and percieved visual angle
- 3 most common outcomes: the same percieved distance, the same percieved linear size, the intermediate case

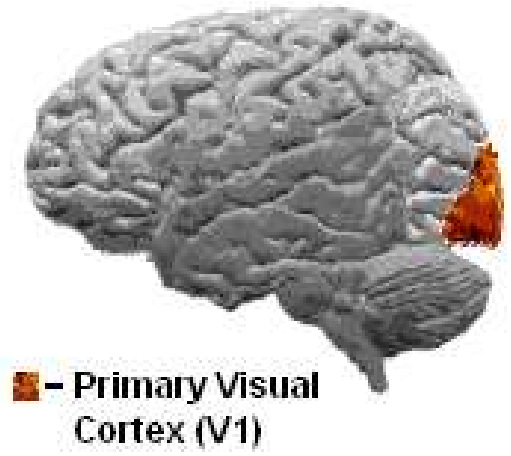


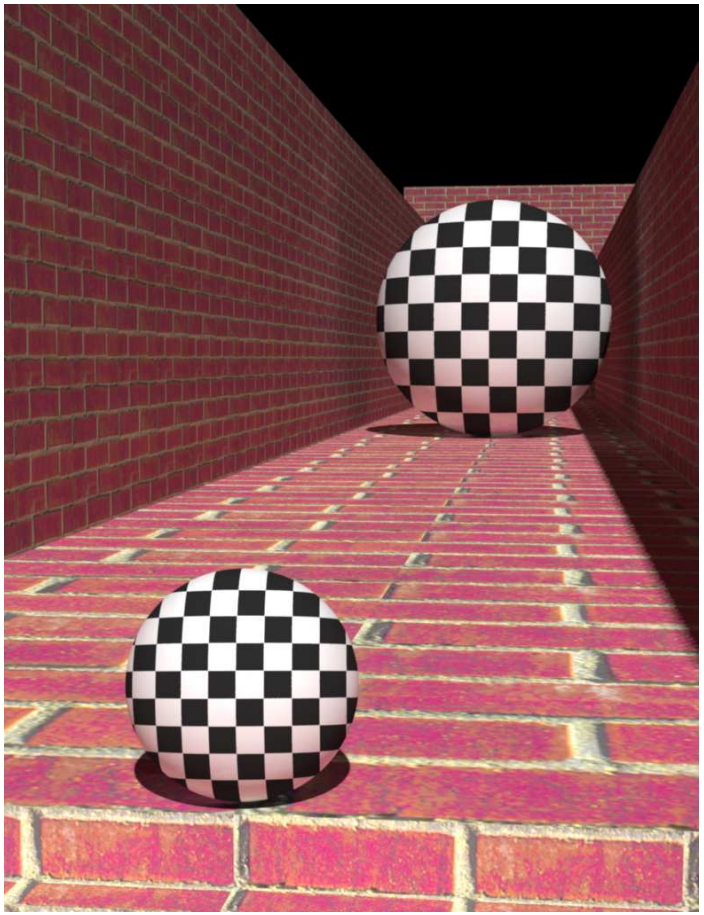


Neurological evidence for the visual angle illusion

(Murray, Boyaci & Kersten, 2006)

- top right ball activates larger area (by 17%) in primary visual cortex V1 (fMRI) $\Rightarrow$ larger percieved angular size
  - ▷ *very precise correspondence between a given location in V1 and the subjective visual field (even blind spots mapped)*
  - ▷ 2×140 *mil neural networks doing some kind of Fourier transform*

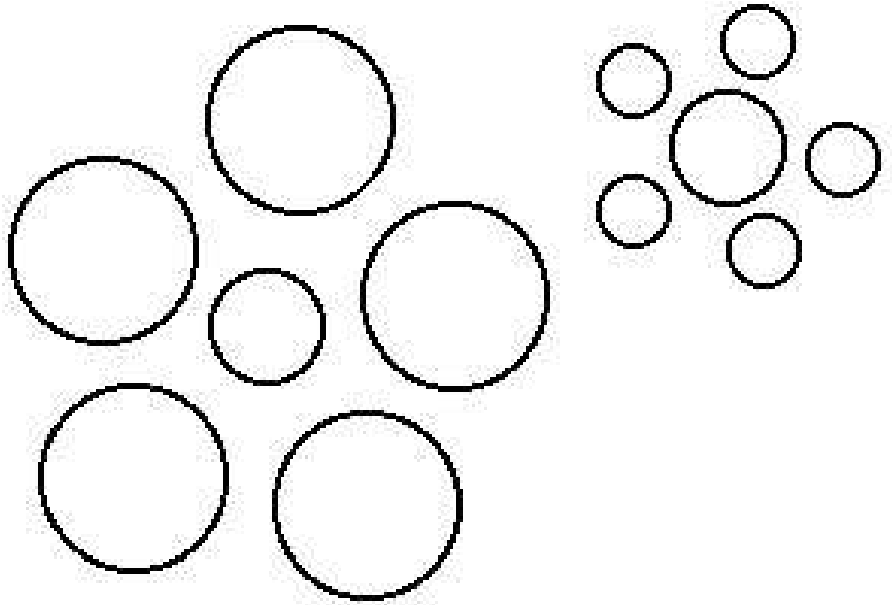




Visual angle contrast theory

- vista near horizon includes visible elements that subtend angles smaller than Moon's 0.5^o, but the visible elements close to zenith Moon's vista usually subtend larger angles
- may explain a small portion of the Moon illusion

- problems:
  - ▷ *MI persists if viewed on the feature-less plain, on the ocean, and even by airline pilots flying above clouds*
  - ▷ *MI disappears (or is reduced) when one bends down and looks at the Moon upside down (Washburn, 1894)*



Oculomotor Micropsia/Macropsia

- while looking at a fixed object which subtends a constant visual angle, if one focuses and converges one's eyes to a distance closer than the object, the visual angle of that object looks smaller than it did. (Wheatstone, 1852)
- perhaps the largest visual angle illusion, occurs in everyday viewing whenever convergence of eyes or the eye accommodation change
- seems to be controlled by "distance-cue" (neurological brain activity) rather than by oculomotor (muscle that moves eye)
- maximum value - factor of 2

Oculomotor macropsia & Moon illusion

- horizon moon: many distance-cue patterns that make one's eye adjust for "very far" $\longrightarrow$ oculomotor macropsia: objects (including Moon) look to have larger angular sizes
- zenith moon: few distance-cues that indicate a great depth $\longrightarrow$ eyes tend to adjust to a resting focus ($1 - 2$ m) $\longrightarrow$ it creates slightly imperfect vision, but people usually not aware of it; many people become slightly near-sighted in relative darkness (night myopia)
- different eye adjustement for horizon/zenith moon measured (Enright, 1975-89; Roscoe, 1979-89)

Seeming contradictions and Cue conflicts

- horizon moon: brain tells to eyes to adjust for **far**, but the moon looks for many people to be **closer** (than zenith moon). How is this possible?
- several different sets of distance cues compete with each other:
- **equidistance tendency** (Gogel, 1965): assumption that the moon is at the same distance (both at horizon and zenith)
- **linear size constancy** (Piaget, 1954): tendency for an object to look the same linear size from one moment to the next when other things change. An aspect of **identity constancy**.
- **relative percieved visual angle distance-cues:** linear perspective and texture gradient

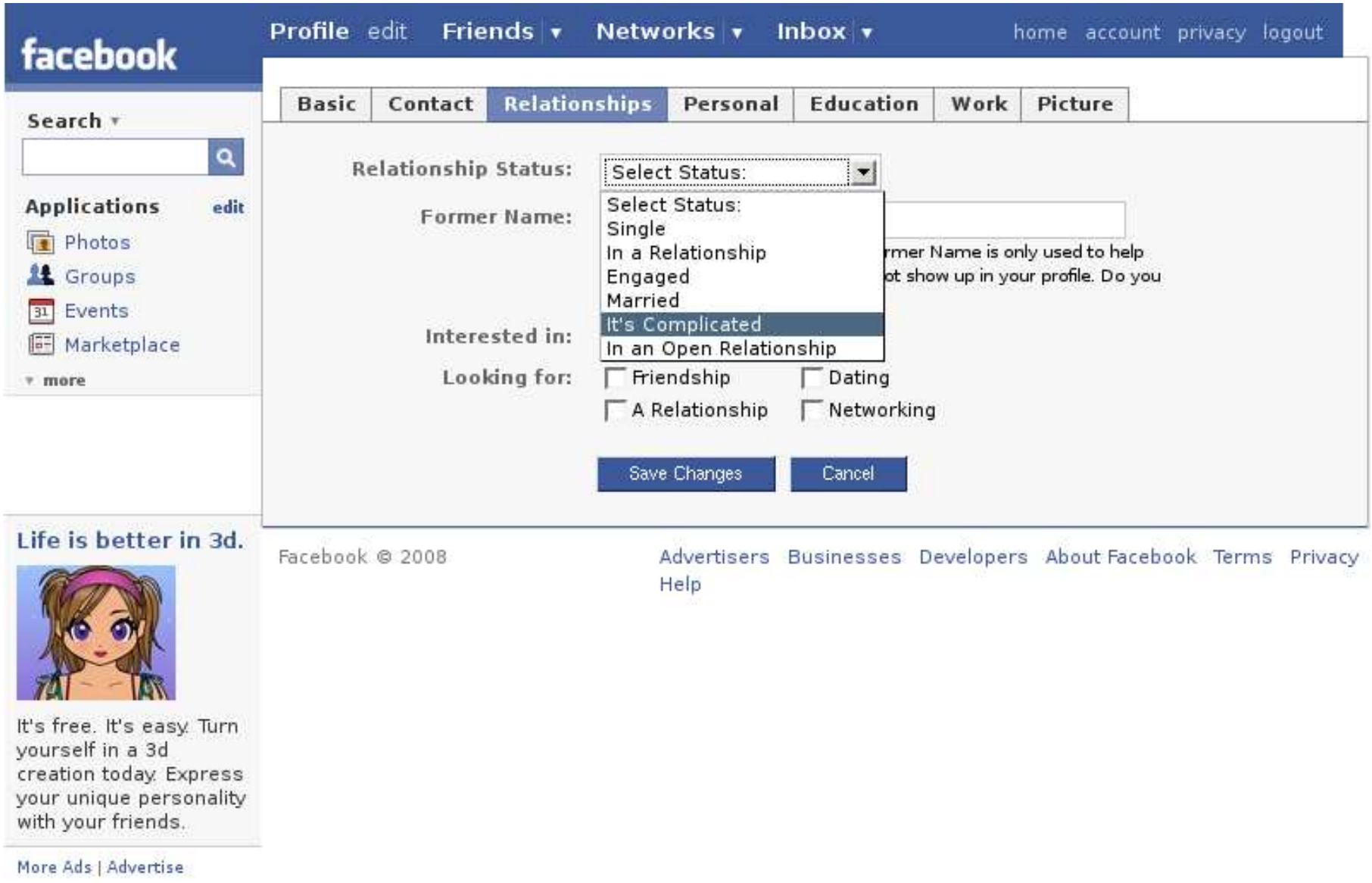
Explanation of Oculomotor micropsia/macropsia

- no explanation has been yet widely accepted
- several theories explaining oculomotor micropsia (small optical distance) - all based on the fact the eyes lie about 10cm in front of the center of the head (or its rotational axis)
- orienting reflex: turning head in direction of some object; the turning angle is smaller that the angle at which the object is seen

$$\frac{V'}{V} = \frac{D}{D+T}$$

- macropsia (for large optical distance) may be related (by-product of micropsia), or it may be different adaptation (software zoom)

Conclusions



References

McCready, 1999-2007, The moon illusion explained, http://facstaff.uww.edu/mccreadd/index.html

Murray, S.O., Boyaci, H, & Kersten, D. (2006) The representation of perceived angular size in human primary visual cortex. Nature Neuroscience, 9, 429-434 (01 Mar 2006).

Enright, J. T. (1975). The Moon illusion examined from a new point of view. Proceedings of the American Philosophical Society, 119, 87-107.

Enright, J. T. (1989b). Manipulating stereopsis and vergence in an outdoor setting : Moon, sky and horizon. Vision Research, 29, 1815-1824.

Gogel, W. C. & Eby, D. W. (1997). Measures of perceived linear size, sagittal motion, and visual angle from optical expansions and contractions. Perception & Psychophysics, 59, 783-806.

Piaget, J. (1954). The construction of reality in the child. New York:Basic Books.

Roscoe, S. N. (1979). When day is done and shadows fall, we miss the airport most of all, Human Factors, 21, 721-731.

Roscoe, S. N. (1989). The zoom-lens hypothesis. Chapter 3 in M. Hershenson (Ed.) The Moon Illusion. Hillsdale, NJ: L. Earlbaum.

Ross, H., and Plug, C. (2002). The mystery of the moon illusion. Oxford: Oxford University Press.

Washburn, M. (1894) The perception of distance in the inverted landscape. Mind, n.s. 3, 438-440.

Wheatstone, C. (1852). Contributions to the physiology of vision, Part 2. Philosophical Transactions of the Royal Society, 1852, part 2, 1-17