

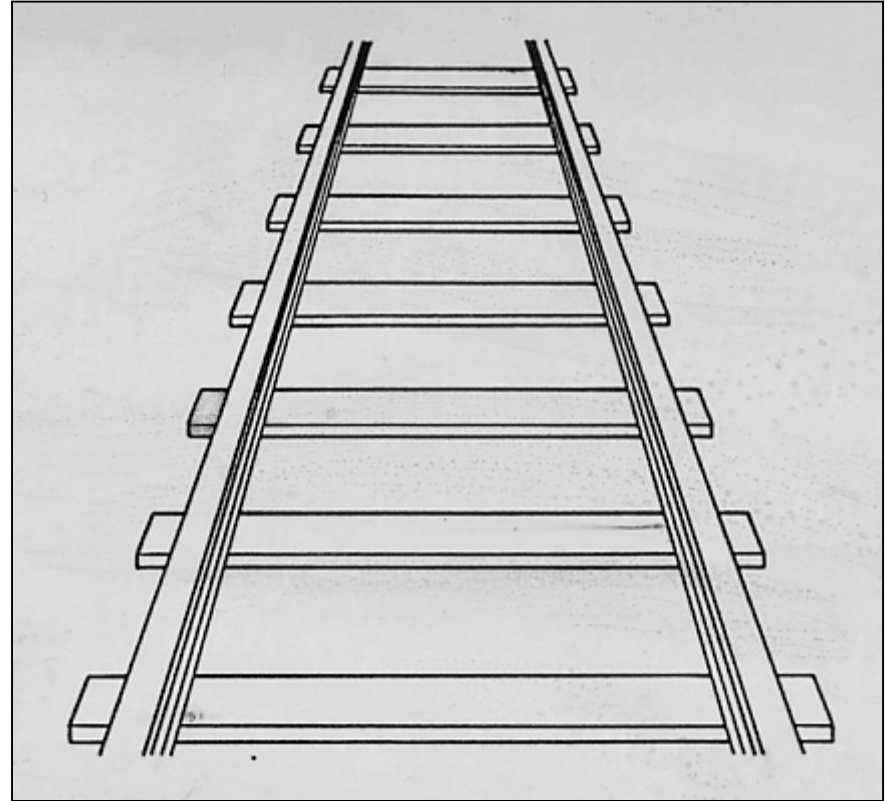
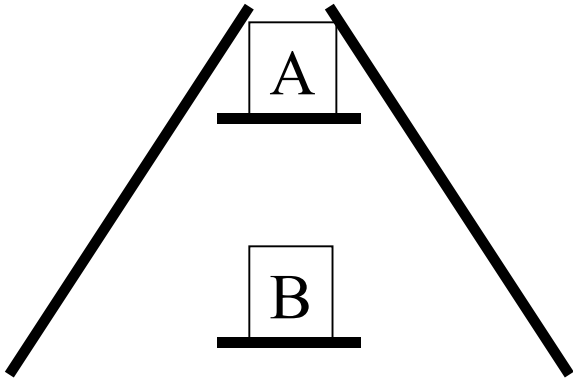
Bottom-up and Top-down Perception

- Bottom-up perception
 - Physical characteristics of stimulus drive perception
 - Realism
- Top-down perception
 - Knowledge, expectations, or thoughts influence perception
 - Constructivism: we structure the world
 - “Perception is not determined simply by stimulus patterns; rather it is a dynamic searching for the best interpretation of the available data.” (Gregory, 1966)

Perceptual Illusions

- Why study illusions?
 - Illusions reveal constraints/biases on perception
 - Constraints are perceptual assumptions that we make
 - Usually correct but occasionally wrong
 - When wrong, illusion results
 - Illusions come from helpful processes
 - Without constraints, no perception at all!
 - Explore human contribution to perception by dissociating real world from our perception of it
- Case Studies
 - Railroad tracks illusion
 - Apparent Motion
 - Stereo depth perception

The Railroad Tracks Illusion



Assumption: the scene is taken from a 3-D world

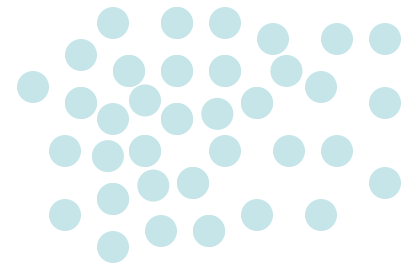
Apparent Motion

- Motion Perception

- Importance for perceptual organization
- Dedicated brain areas

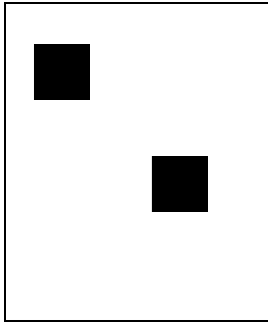
- Apparent Motion

- Motion from sequentially presented still frames
- Assume objects in one frame are the same as those in the other frame, just moved
- Challenge: How to determine which objects correspond to each other across frames

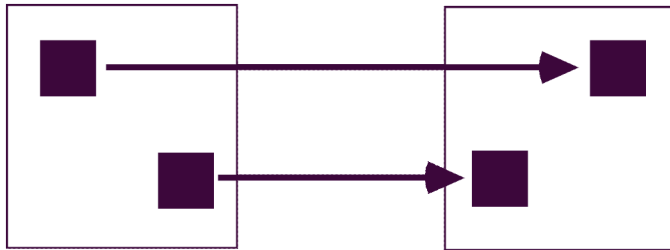
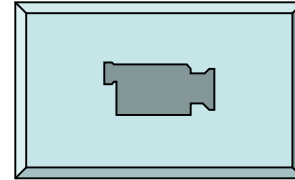
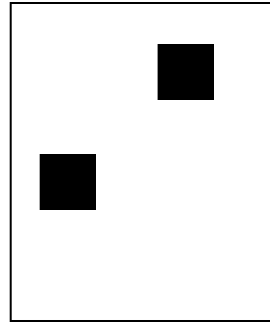


One-to-one Mapping Constraint

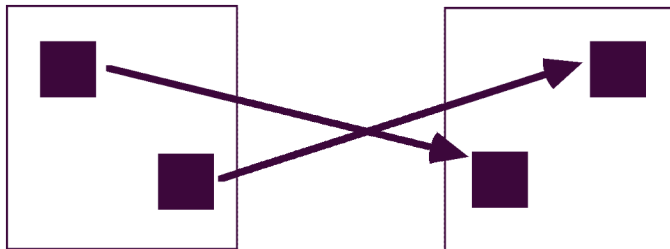
Frame 1



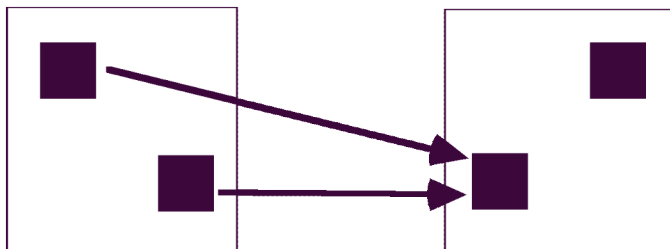
Frame 2



Yes, horizontal motion



Yes, vertical motion

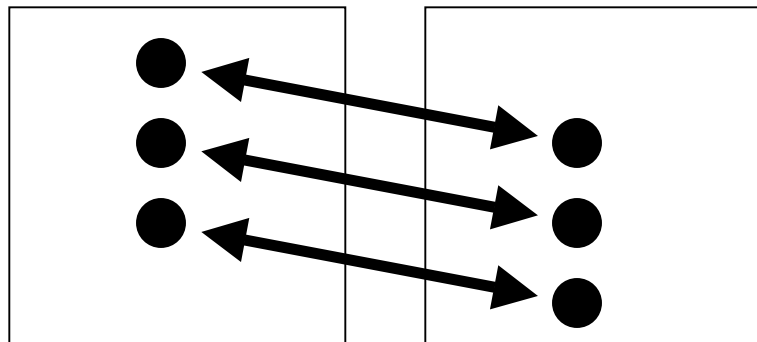
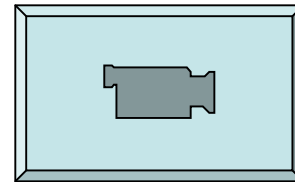
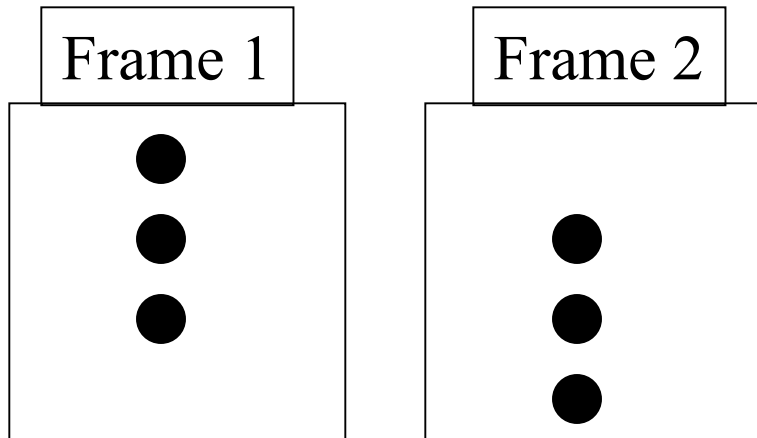


No, violates 1-to-1 mapping

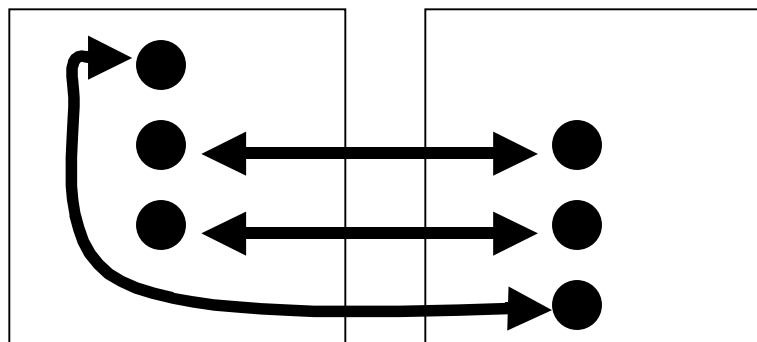
Constraints on Motion Perception

- Proximity
 - Parts A and B tend to be the same object if they are close
- Shape similarity
 - Parts A and B tend to be the same object if they are similar in their shape
- Color and size similarity
- One-to-one mapping constraint
 - Two parts at Time T should not correspond to one part at Time T+1
 - Global coherence: Correspondences all influence each other

Ternus Effect

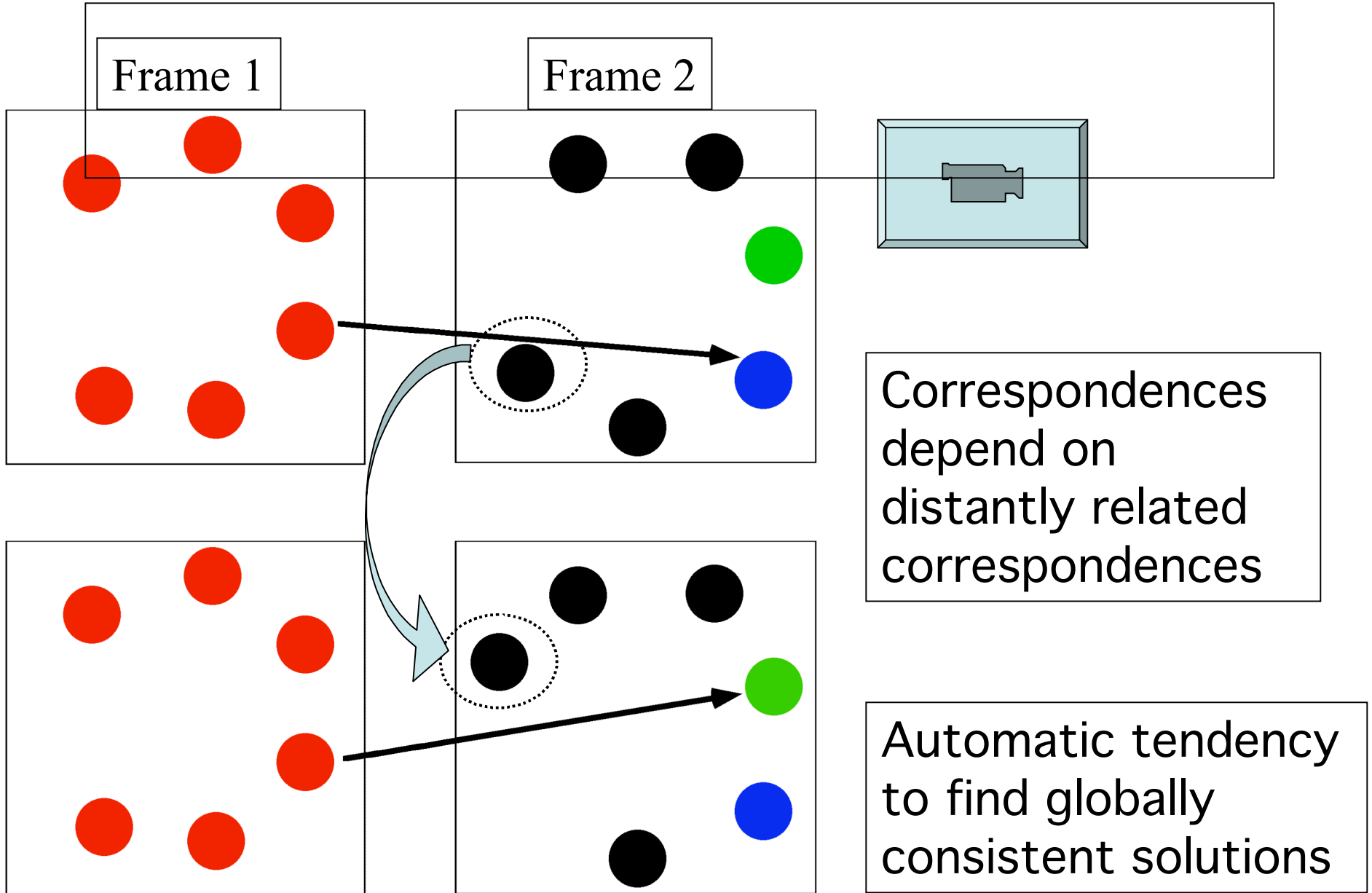


Globally coherent correspondences (Long pause)

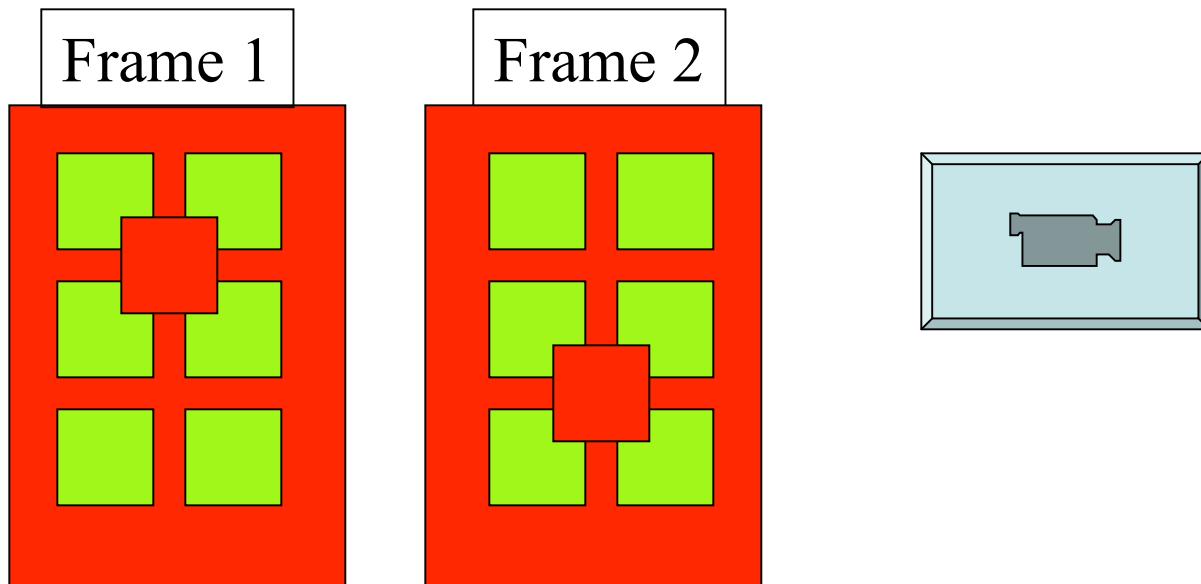


Locally determined correspondences (Short pause)

Globally Coherent Motion



Illusory Motion of Illusory Contours



Illusory square moves, so the generation of illusory contours occurs before the generation of apparent motion.

If contours were generated only after motion is perceived, then people would see a pac-man (which requires no illusory contours) rotating.

Constraint Satisfaction Network for Apparent Motion Perception

Nodes

Represent correspondences between elements across frames

Activity represents strength of correspondence

Neural network does not learn

Connections between units are hard-wired

Activation/inhibition spreads according to constraints:

Shape, color, size, location similarity: if corresponding elements are similar, then activity increases

Motion similarity: Excitation between two nodes if similar directions of motion are implied by them

Consistency

Consistent nodes excite one another

Inconsistent nodes inhibit one another

Consistent = one-to-one mapping

Inconsistent = two-to-one mapping

Match

Bias for each cell to have a correspondence

Constraint Satisfaction Network for Apparent Motion Perception (Dawson, 1991; Ullman, 1979)

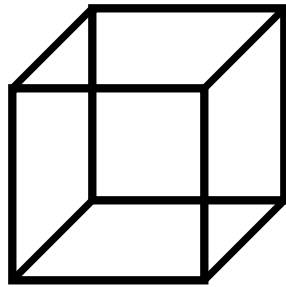
Processing in model

Time = number of cycles of activation passing

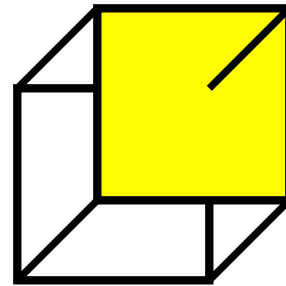
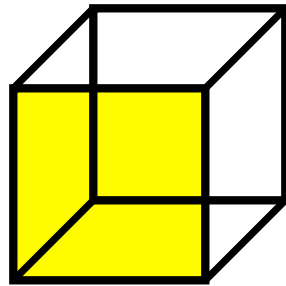
Soft-constraints (neural networks need not be tabula rasas)

Activation passing leads to increased harmony over time

Harmony = consistency between nodes



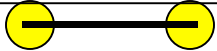
The necker cube is an ambiguous object



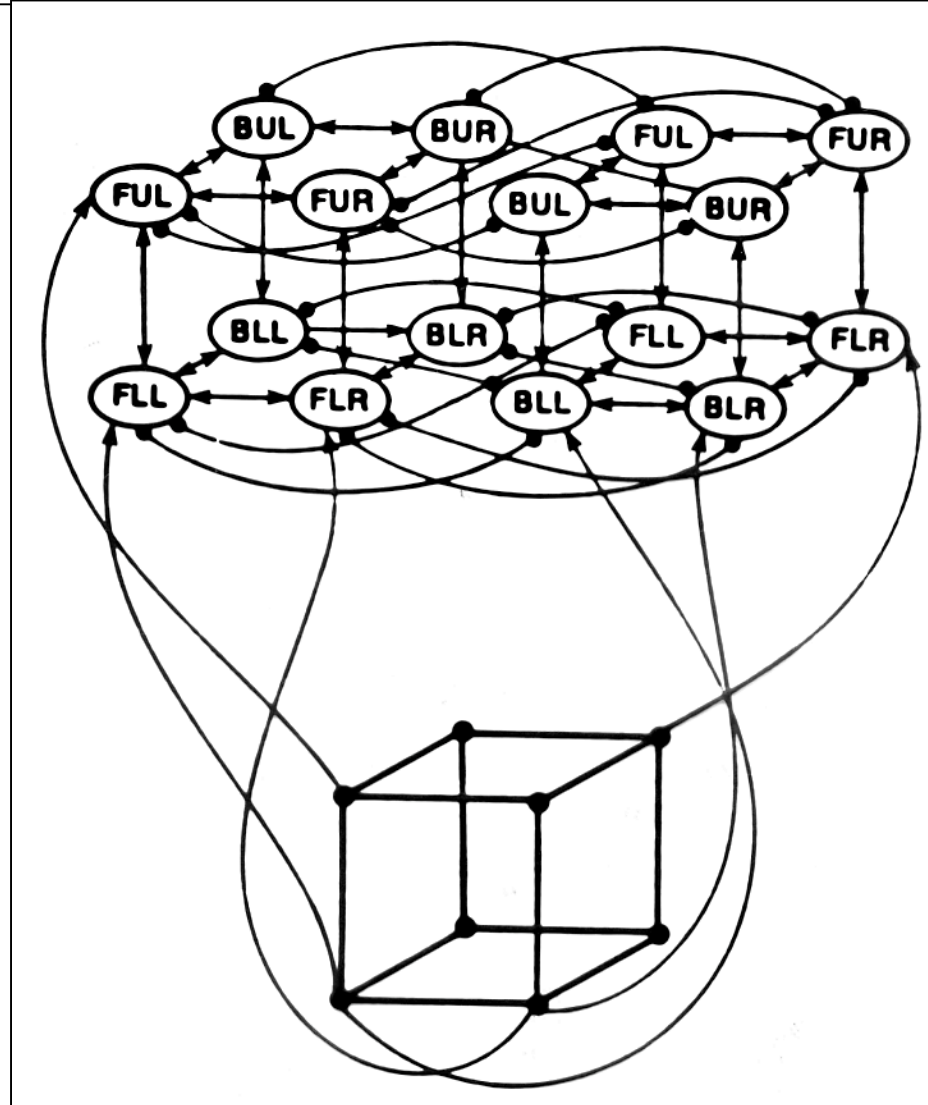
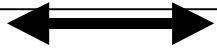
Each interpretation is internally consistent and harmonious
Networks settle into one of two consistent interpretations

Constraint Satisfaction Network for Necker Cube Perception

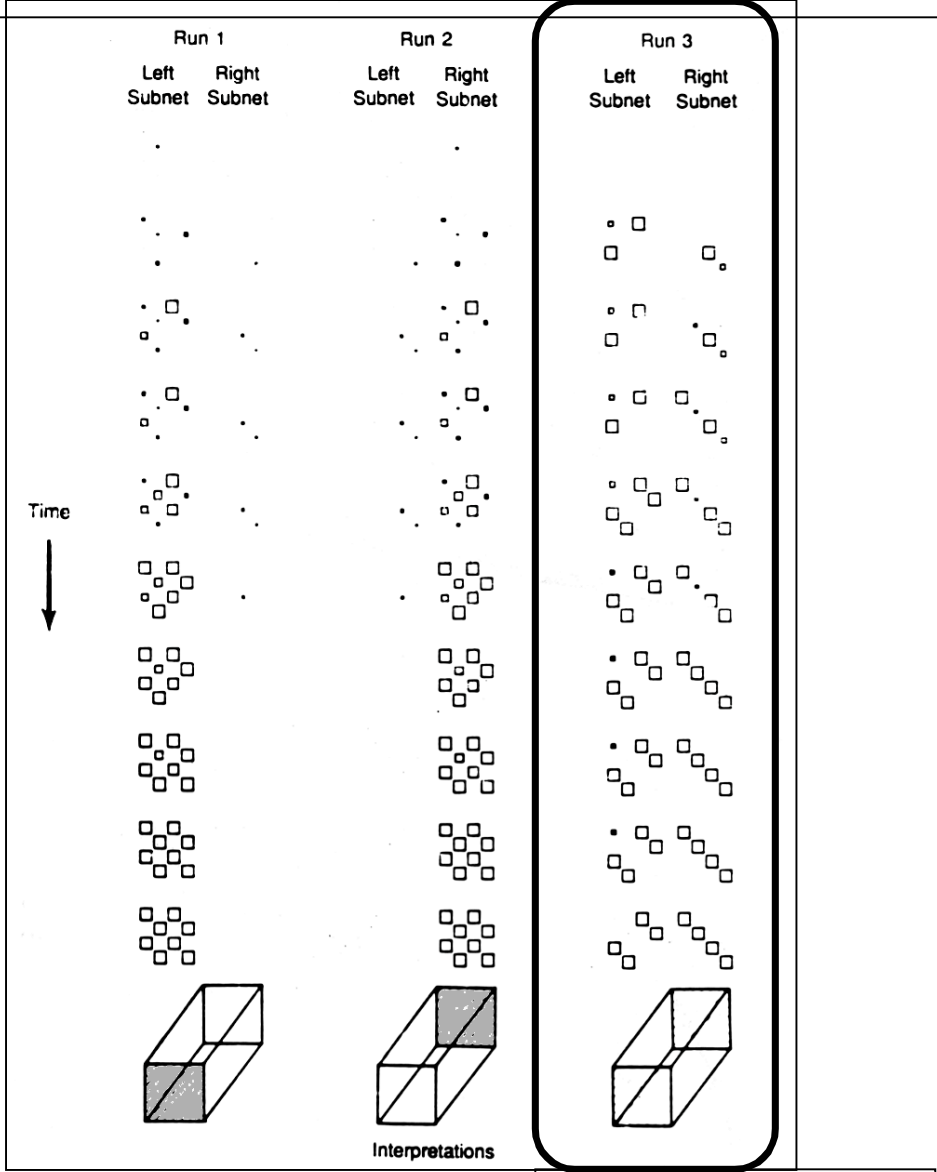
Inhibitory



Excitatory



Constraint Satisfaction Network for Necker Cube Perception



Unlikely

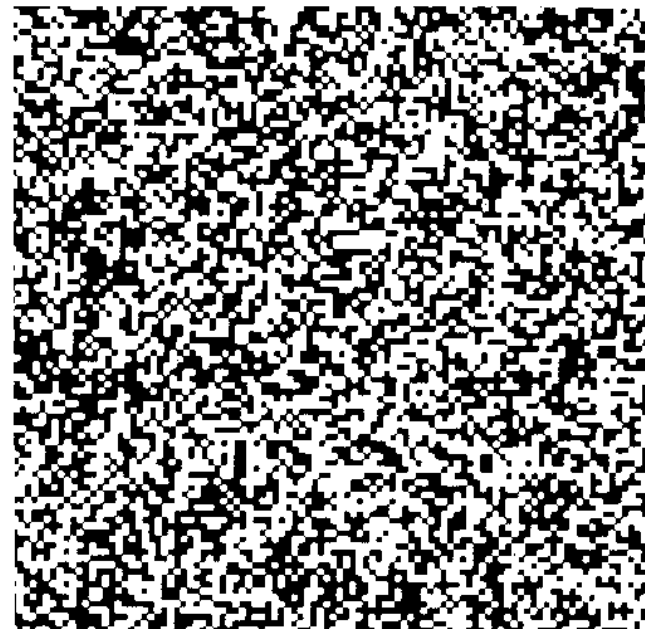
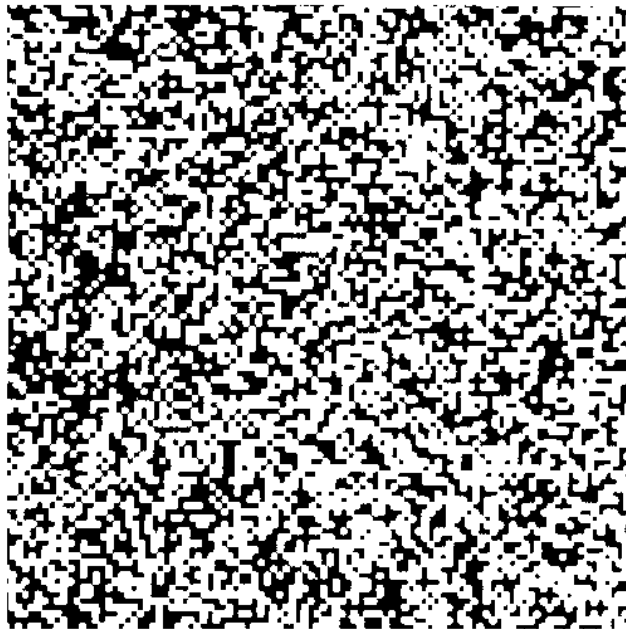
Applications of the Apparent Motion Network

- **Similarity matters**
 - Similar objects are more likely to correspond to each other
- **Network finds consistent correspondences**
- **Hysteresis**
 - Once a stable percept is found, it resists change
 - Adding randomness helps appropriate restructuring
- **Predicts distribution of responses**
 - Make model stochastic by adding randomness to nodes
 - Even with randomness, stable percepts are found
- **Applicability to other areas**
 - Stereo depth perception (Marr & Poggio, 1979)
 - Analogical reasoning (Goldstone, 1994; Holyoak & Thagard, 1989)

The Correspondence Problem in Depth Perception

- Stereopsis as a major depth cue
 - Left and right eyes see different images
 - Differences in positions of objects in two eyes tells us about their depth
 - Correspondence problem: What element in the left eye corresponds to what element in the right eye?
- Analogy to apparent motion
 - Frame 1: Frame 2 :: Left eye image : Right eye image
 - For both apparent motion and stereopsis, for two images elements to correspond means that they come from the same real-world object
 - Constraints: location similarity, shape similarity, 1-to-1 mapping, smoothness

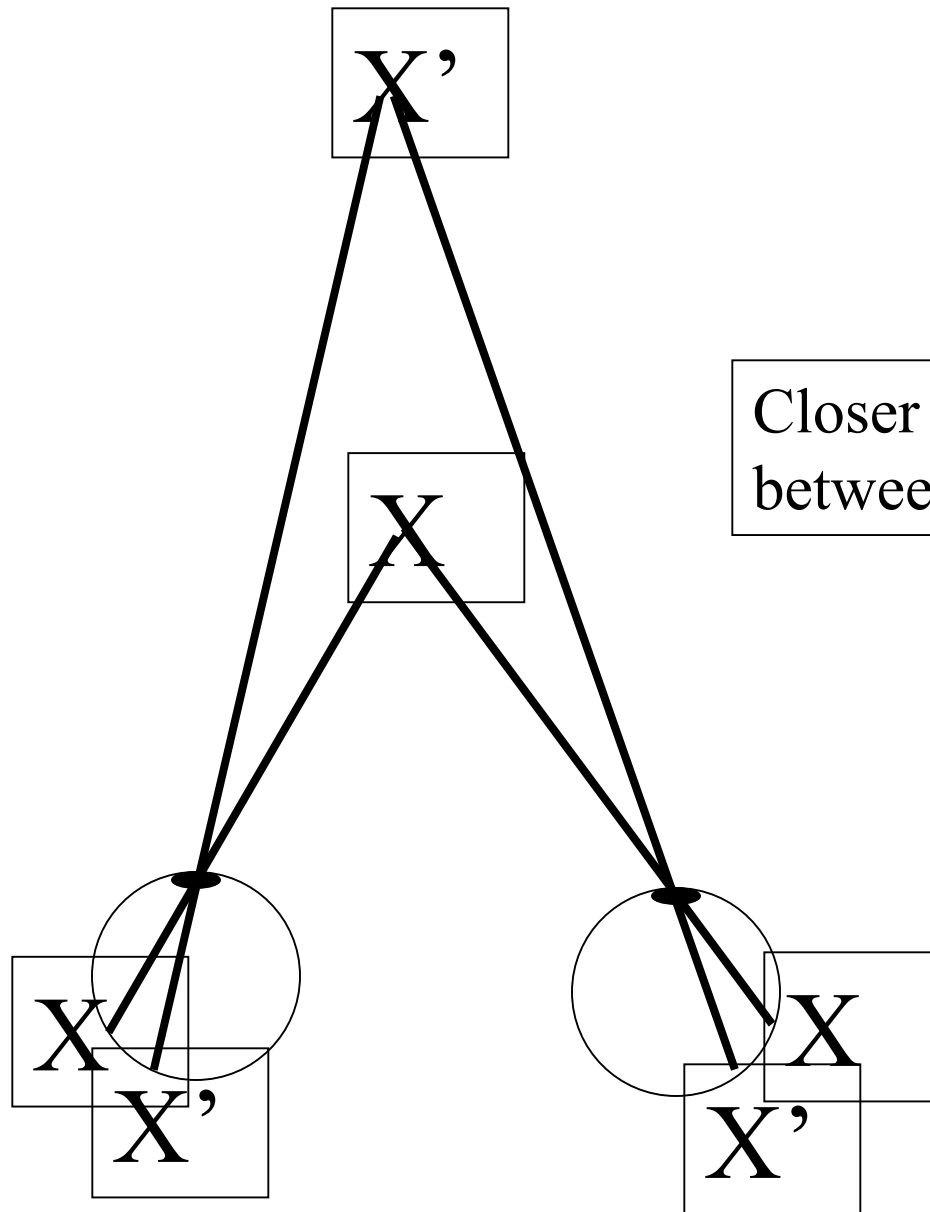
Random-dot stereograms (Julesz, 1971)



1	0	1	0	1	0	0	1	0	1
1	0	0	1	0	1	0	1	0	0
0	0	1	1	0	1	1	0	1	0
0	1	0	A	A	B	B	X	0	1
1	1	1	B	A	B	A	Y	0	1
0	0	1	A	A	B	A	Y	1	0
1	1	1	B	B	A	B	X	0	1
1	0	0	1	1	0	1	1	0	1
1	1	0	0	1	1	0	1	1	1
0	1	0	0	0	1	1	1	1	0

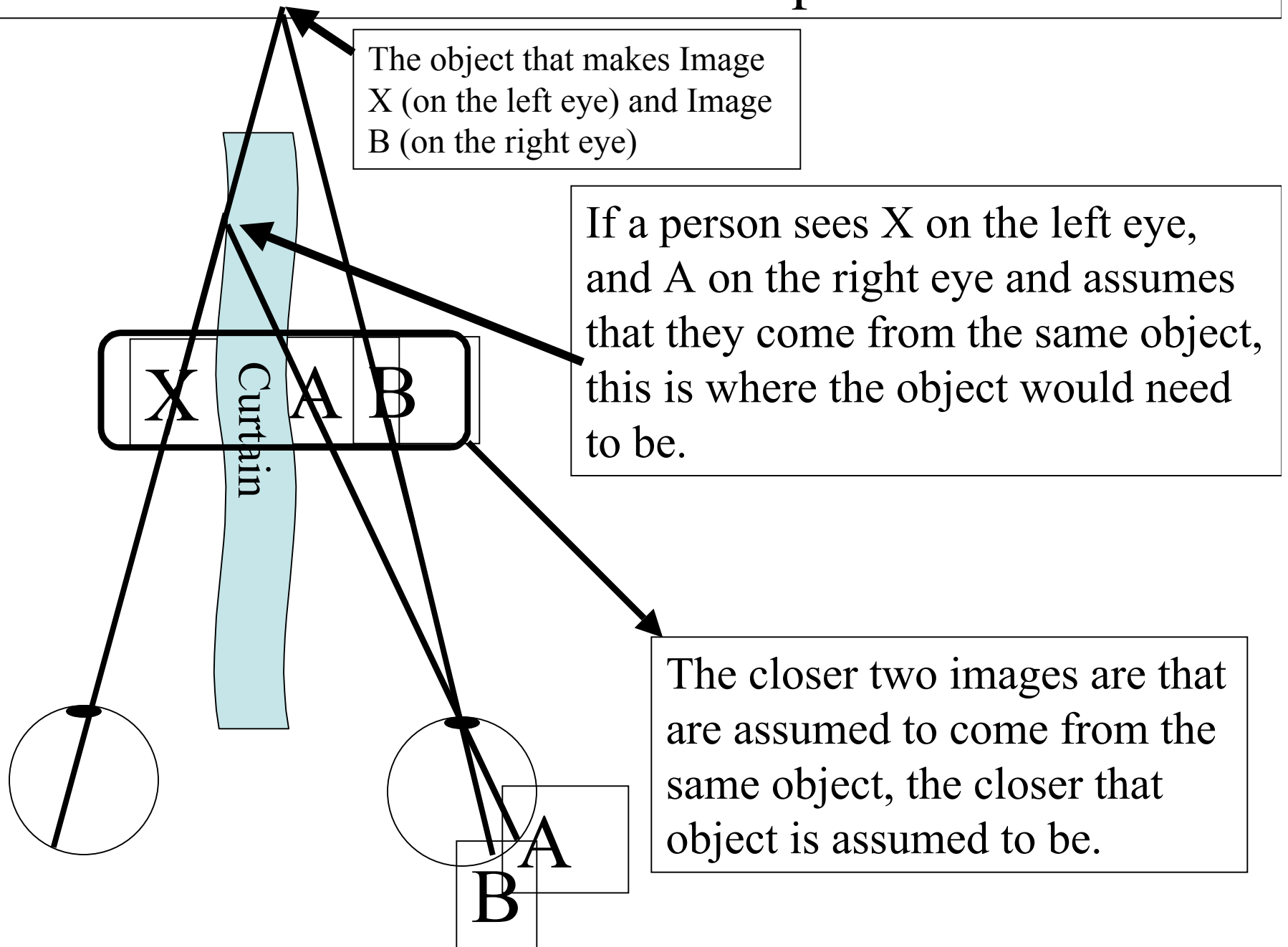
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1	0	0	1	0	1	0	1	0	0
0	0	1	1	0	1	1	0	1	0
0	1	0	Y	A	A	B	B	0	1
1	1	1	X	B	A	B	A	0	1
0	0	1	X	A	A	B	A	1	0
1	1	1	Y	B	B	A	B	0	1
1	0	0	1	1	0	1	1	0	1
1	1	0	0	1	1	0	1	1	1
0	1	0	0	0	1	1	1	1	0

Retinal Disparities



Closer object = greater disparity
between retinal images

Illusions in Stereopsis



Marr & Poggio (1976)

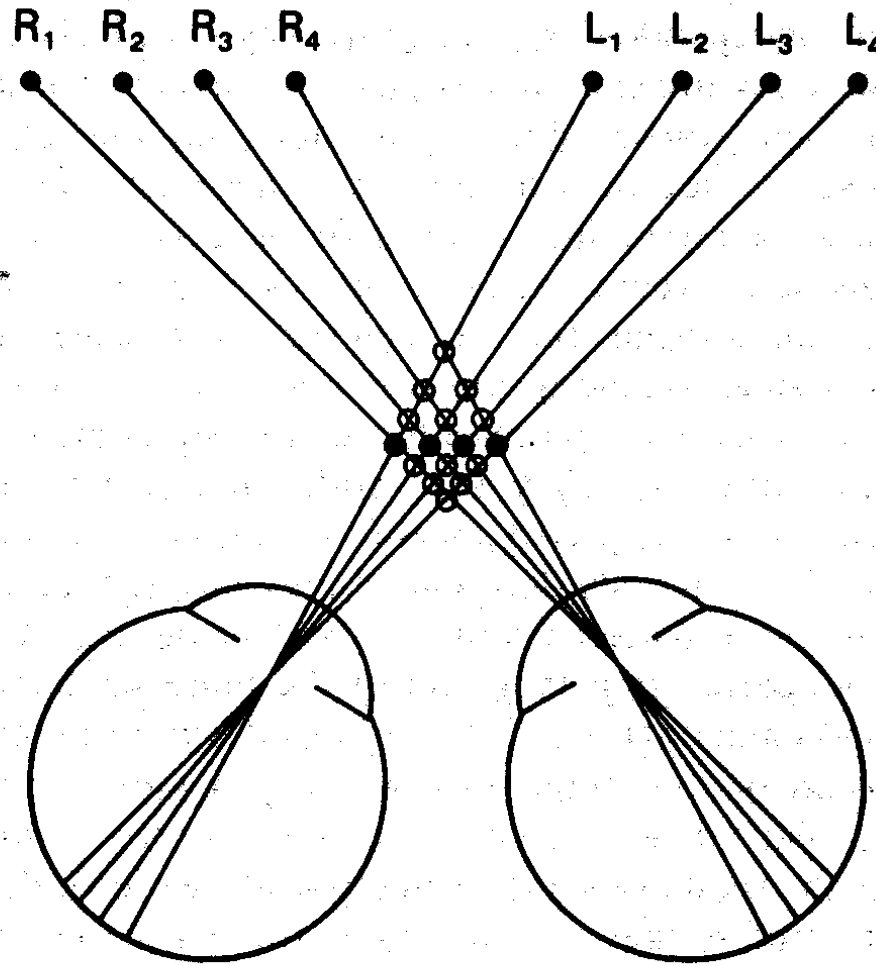
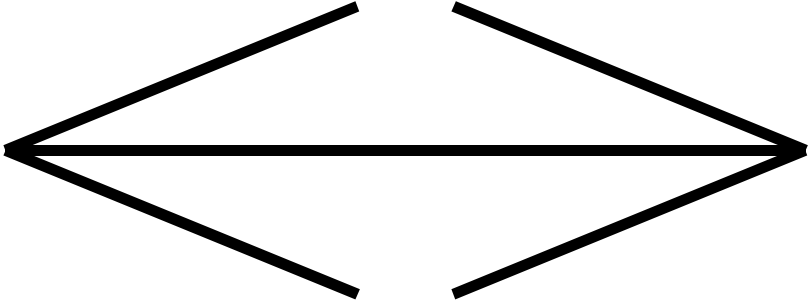


FIG. 2.21. Two eyes viewing a simplified stereogram in which each eye sees just 4 dots. Each of the left eye's dots (L₁ to L₄) could match any of the right eye's dots (R₁ to R₄), so that the number of possible matches, shown with filled and open circles, is very large. The visual system chooses the matches which are shown with filled circles. (Adapted from Marr & Poggio, 1976, and reproduced from Bruce & Green, 1985, with permission.)

The Mueller-Lyer Illusion



Cognitive Impenetrability