Coordination
協調賽局

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Lecture 10, EE-BGT

Why is Coordination Important?

- Which Equilibrium to Select Among Many?
  - This requires Coordination!
- Examples of Coordination in Daily Life:
  - Language
  - Trading in Markets (Liquidity)
  - Industry Concentration

Why is Coordination Important?

- Equilibrium Selection in Game Theory

1. Desirable Features Approach:
   - Payoff-Dominance, Risk Dominance, etc.
2. Convergence via Adaptation/Learning
   - Weibull (1995), Fudenberg and Levine (1998)
3. Empirical Approach: Infer Principles by
   - Putting people in experiments and observe actual behavior/outcome

Why is Coordination Important?

- Possible "Selection Principles":
  - Precedent, focal, culture understanding, etc.
- Why are observations useful?
- Schelling (1960, p.164):
  - "One cannot, without empirical evidence, deduce what understandings can be perceived in a nonzero-sum game of maneuver
  - any more than one can prove,
  - by purely formal deduction, that a particular joke is bound to be funny."

Why is Coordination Important?

- Can't Communication Solve This?
  - Not always... (See Battle of Sexes below)
- Sometimes communication is not feasible:
  - Avoiding Traffic Jams
  - Speed Limits (useful because they reduce speed "variance", and hence, enhance coordination!)
- Miscommunication can have big inefficiency!

Examples of Coordination Impact

- The standard width of US railroad tracks is 4 feet and 8.5 inch Because English wagons were about 5 feet (width of two horses)
  - Space Shuttle rockets are smaller than ideal since they need to be shipped back by train...
- Industries are concentrated in small areas
  - Silicon Valley, Hollywood, Hsinchu Science Park
- Urban Gentrification
  - I want to live where others (like me) live

Examples of Coordination Impact

- Drive on the Left (or Right) side of the road
  - Right: Asia, Europe (Same continent!)
  - Left: Japan, UK, Hong Kong (Islands!)
  - Sweden switched to Right (on Sunday morning)

- What about America? Right, to avoid
  - hitting others with the whip on your right hand
- Bolivians switch to Left in mountainous area
  - Cannot see outer cliffside from driver seat (left)
- Pittsburgh left: left-turners go first/avoid line

3 Types of Coordination Games

- Matching Games
  - Pure Coordination Game; Assignment Game
- Games with Asymmetric Payoffs
  - Battle of Sexes, Market Entry Game
- Games with Asymmetric Equilibria
  - Stag Hunt, Weak-Link Game
- Applications: Market Adoption and Culture

Examples of Coordination Impact

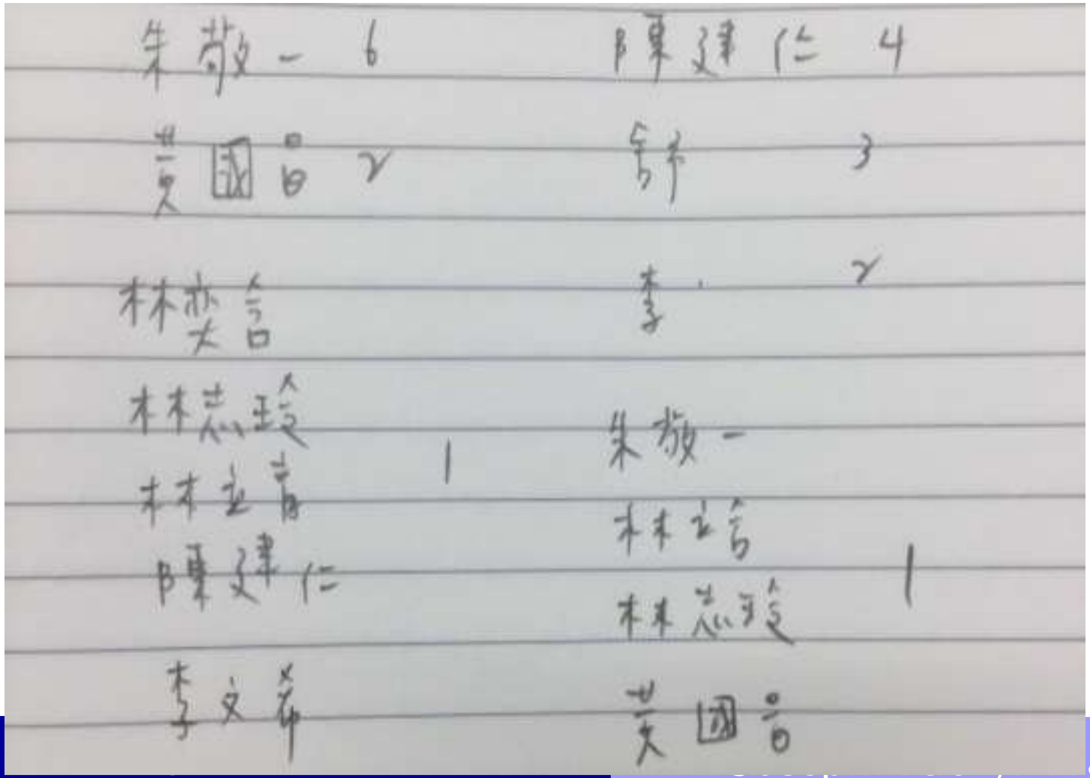
- Categorizing Products
  - Where should you find Narnia? Family or Action?
  - Can you find your favorite grocery at a new store?
- Common Language: Internet promotes English
  - Some Koreans even get surgery to loosen their tongues, hoping to improve their pronunciation
- Key: Agreeing on something is better than not; but some coordinated choices are better.

Matching Game: GAMES magazine (1989)

- Pick one celebrity (out of 9) for President, another for Vice-President:
  - Oprah Winfrey, Pete Rose,
  - Bruce Springsteen, Lee Iaccoca,
  - Ann landers, Bill Cosby,
  - Sly Stallone, Pee-Wee Herman,
  - Shirley MacLaine
- One person is randomly awarded prize among those who picked most popular one

Matching Game: GAMES magazine (1989)

- Taiwanese example:
  - 戴資穎、陳偉殷、黃國昌、朱敬一、陳建仁、林立青、李來希、舒淇、林志玲、林奕含
- Prize?
- Results...



Matching Game: GAMES magazine (1989)

- US Results:

1. Bill Cosby (1489): successful TV show
2. Lee Iacocca (1155): possible US candidate
3. Pee-Wee Herman (656): successful TV show
4. Oprah Winfrey (437): successful TV show

...

9. Shirley MacLaine (196): self-proclaimed reincarnate

Pure Coordination Game

	A	B
A	1, 1	0, 0
B	0, 0	1, 1

- Both get 1 if pick the same;
- Both get 0 if not
- Two pure NE,
- One mixed NE
- Which one will be played empirically?

Pure Coordination Game

- Mehta, Starmer and Sugden (AER 1994)
- Picking Condition (P): Just pick a strategy
- Coordinating Condition (C):
  - Win $1 if your partner picks the same as you
- Difference between P and C = How focal
- Choices: Years, Flowers, Dates, Numbers, Colors, Boy's name, Gender, etc.

Pure Coordination Game

Category	Group P (n=88)		Group C (n=90)	
	Response	%	Response	%
Years	1971	8.0	1990	61.1
Flowers	Rose	35.2	Rose	66.7
Dates	Dec. 25	5.7	Dec. 25	44.4
Numbers	7	11.4	1	40.0
Colors	Blue	38.6	Red	58.9
Boy's Name	John	9.1	John	50.0
Gender	Him	53.4	Him	84.4

Pure Coordination Game: Follow-up 1

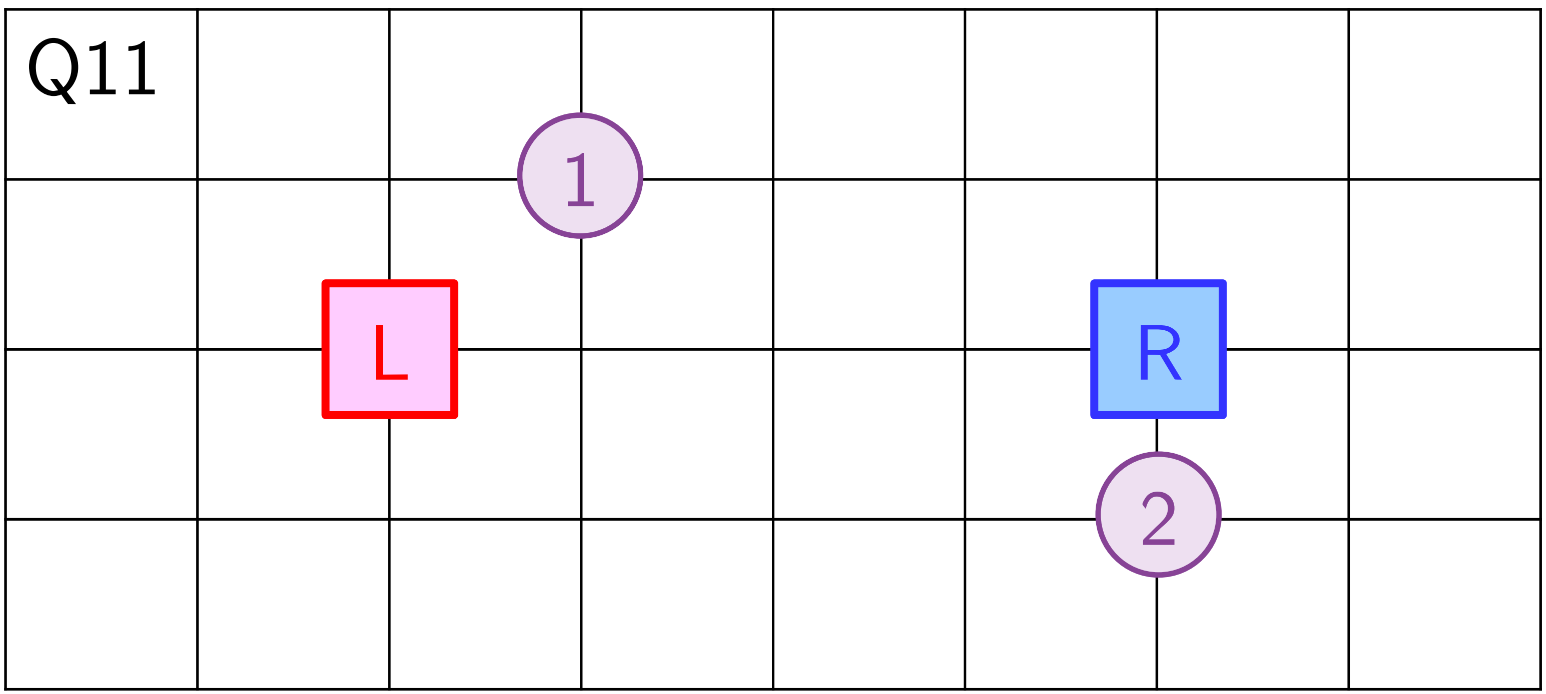
- Bardsley, Mehta, Starmer, Sugden (EJ 2010)
  - Incorporate (Replace?) Bardsley, et al. (wp 2001)
- Add additional condition besides P and C:
  - Guess Condition (G): Guess partner's pick
- 14 Games: One in choice set is distinctive
  - EX: {Bern, Barbodos, Honolulu, Florida}
- Design question: How do you avoid focality of physical location (first/last/top-left)?
  - Have things swim around the computer screen...

Pure Coordination Game: Follow-up 1

- Derivative Salience: P=G=C
  - (See how paper use) Cognitive Hierarchy theory
- Schelling Salience: P=G≠C
  - Team Reasoning: Pick distinctive choice only in C
- Schelling Salience wins here!
  - Distinctive choice = modal choice in C (60%); less often in P and G in 12 games (out of 14)
  - EJ 2010: But still rejected in follow-up study w/ subtle design differences (used to coordinate)

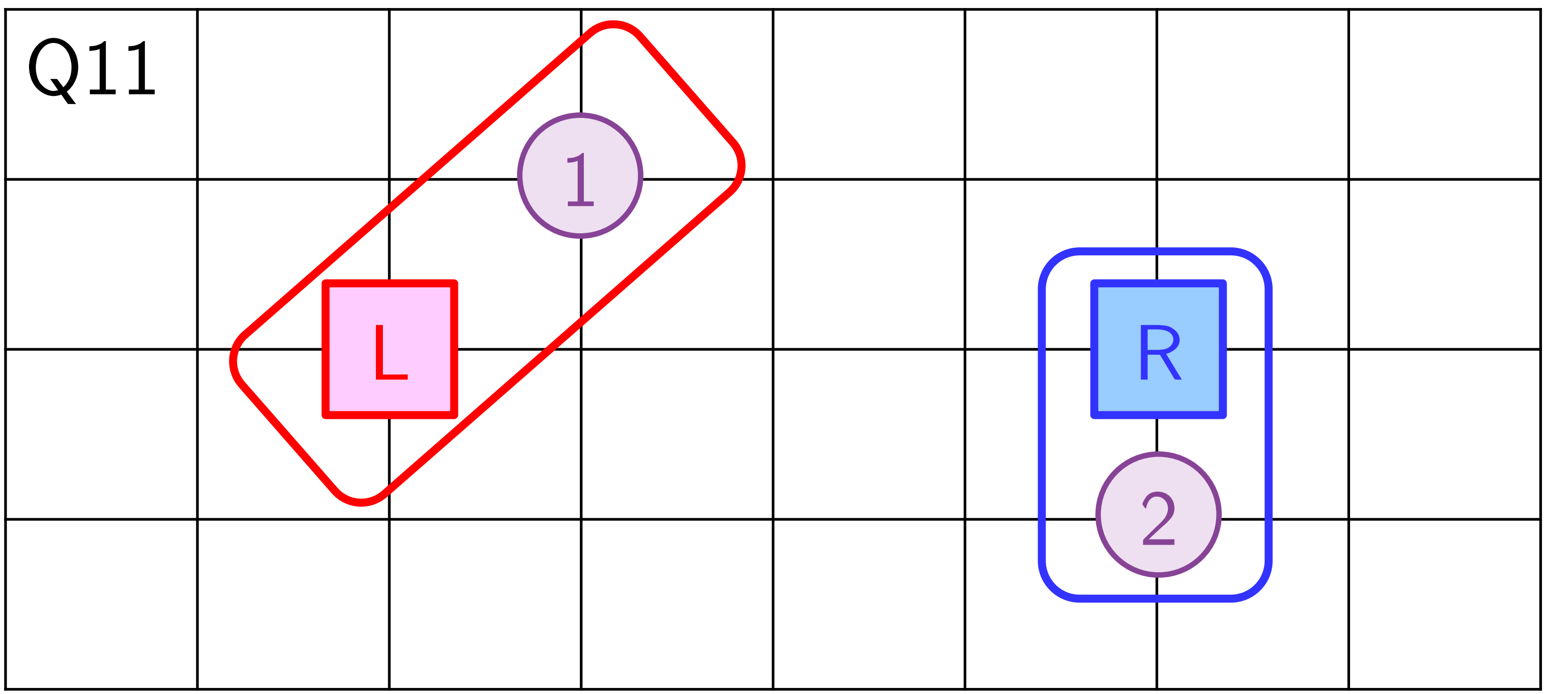
Assignment Game (Follow-up 2)

- Hume (1978/1740) - Ownership conventions: spatial/temporal proximity, cultural, etc.
  - Mehta, Starmer and Sugden (ToD 1994)



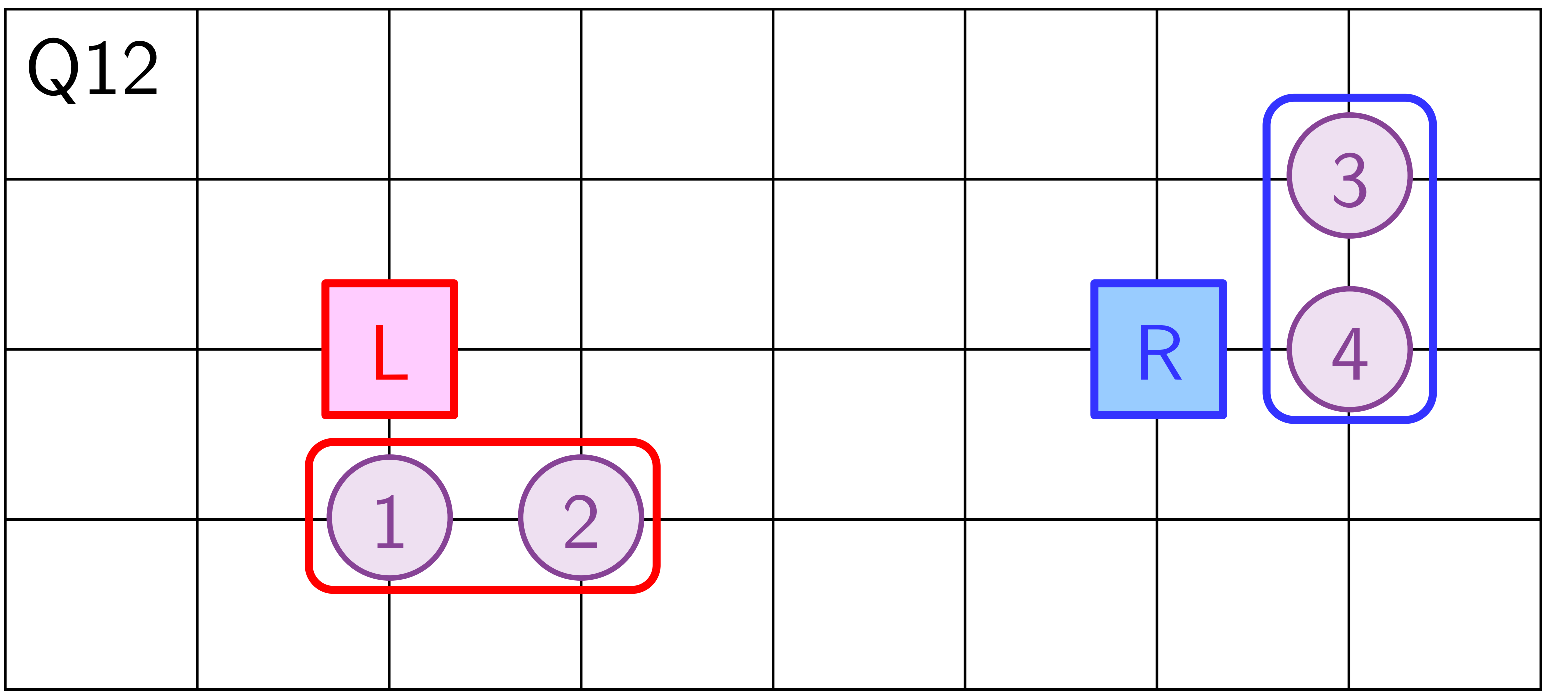
Assignment Game and Visual Selection

- Assign circles to L or R
- Earn $$ if all circles match partner assignment
- Focal Principle 1: Closeness (C)



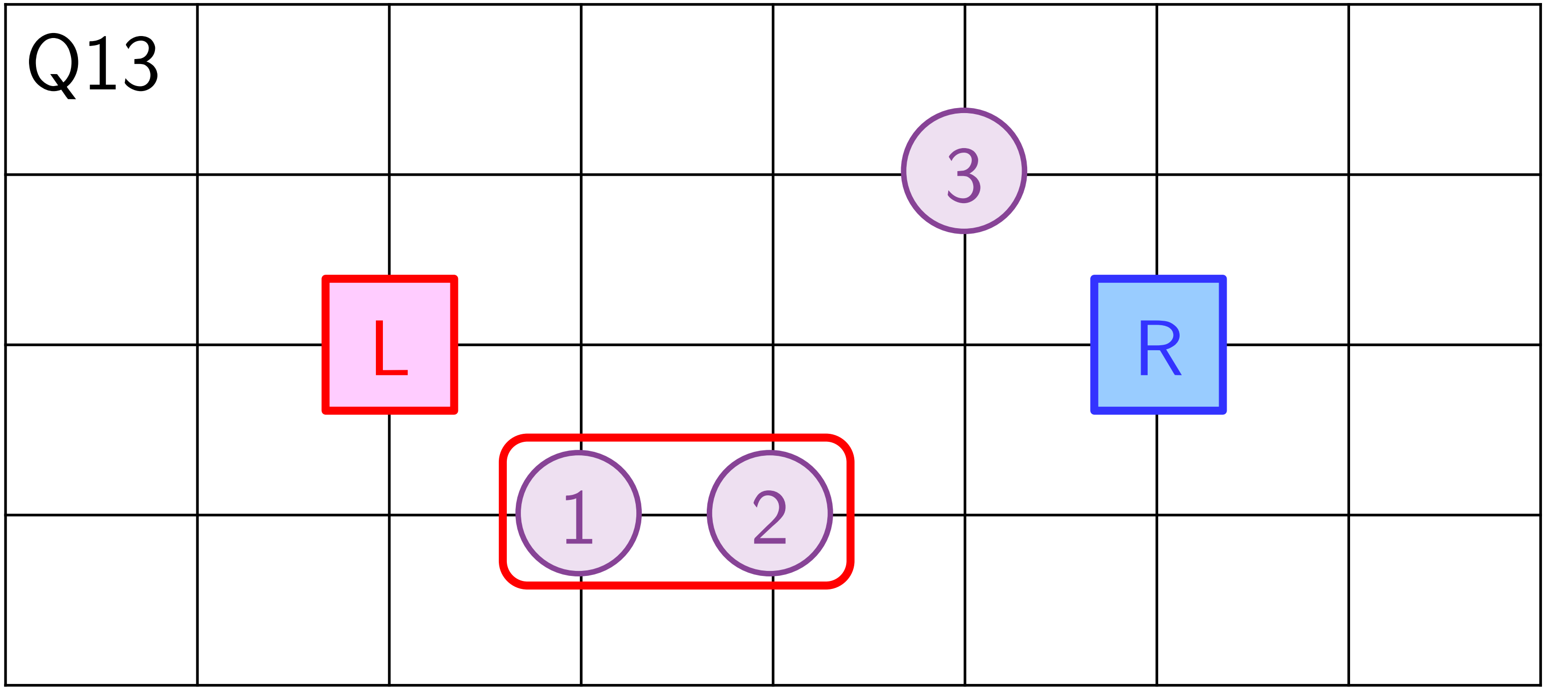
Assignment Game and Visual Selection

- Assign circles to L or R
- Earn $$ if all circles match partner assignment
- Focal Principle 2: Equality (E)



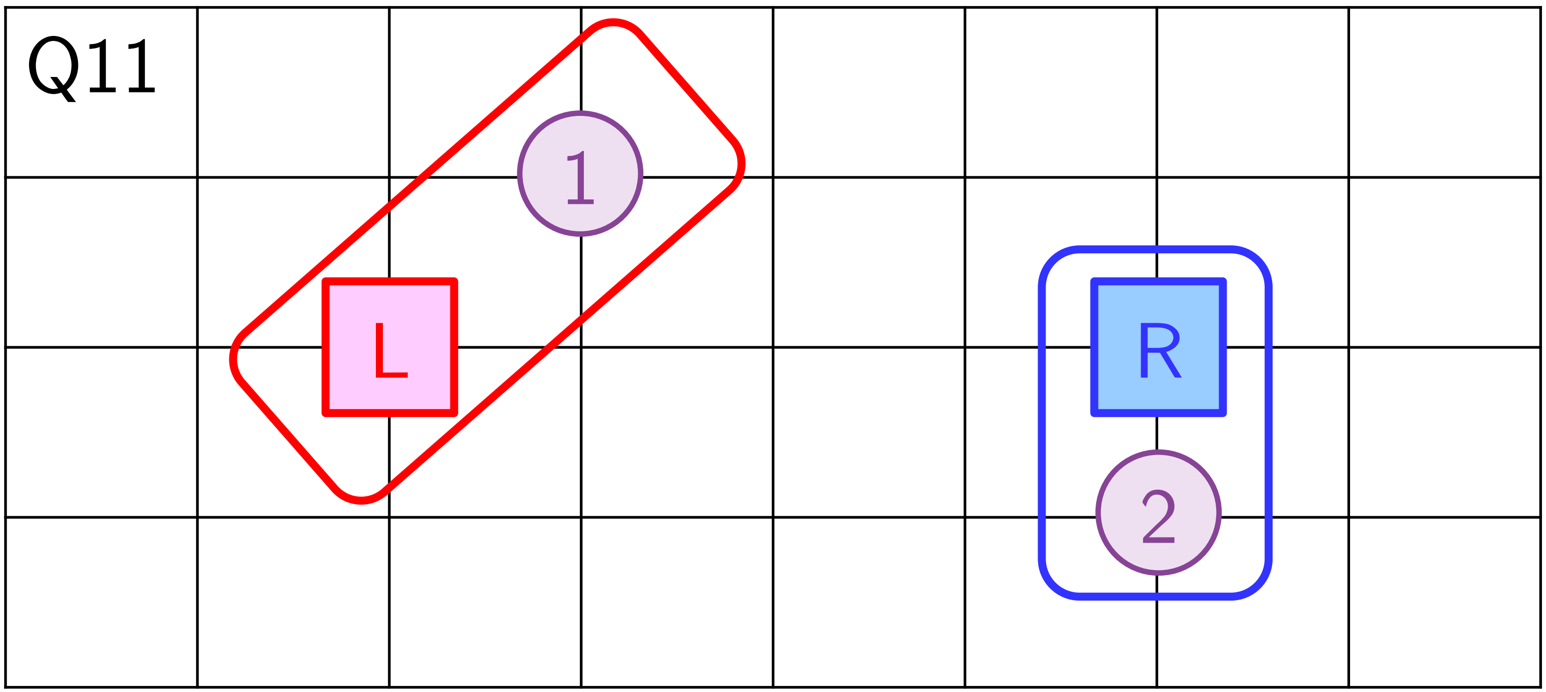
Assignment Game and Visual Selection

- Assign circles to L or R
- Earn $$ if all circles match partner assignment
- Focal Principle 3: Accession (A)



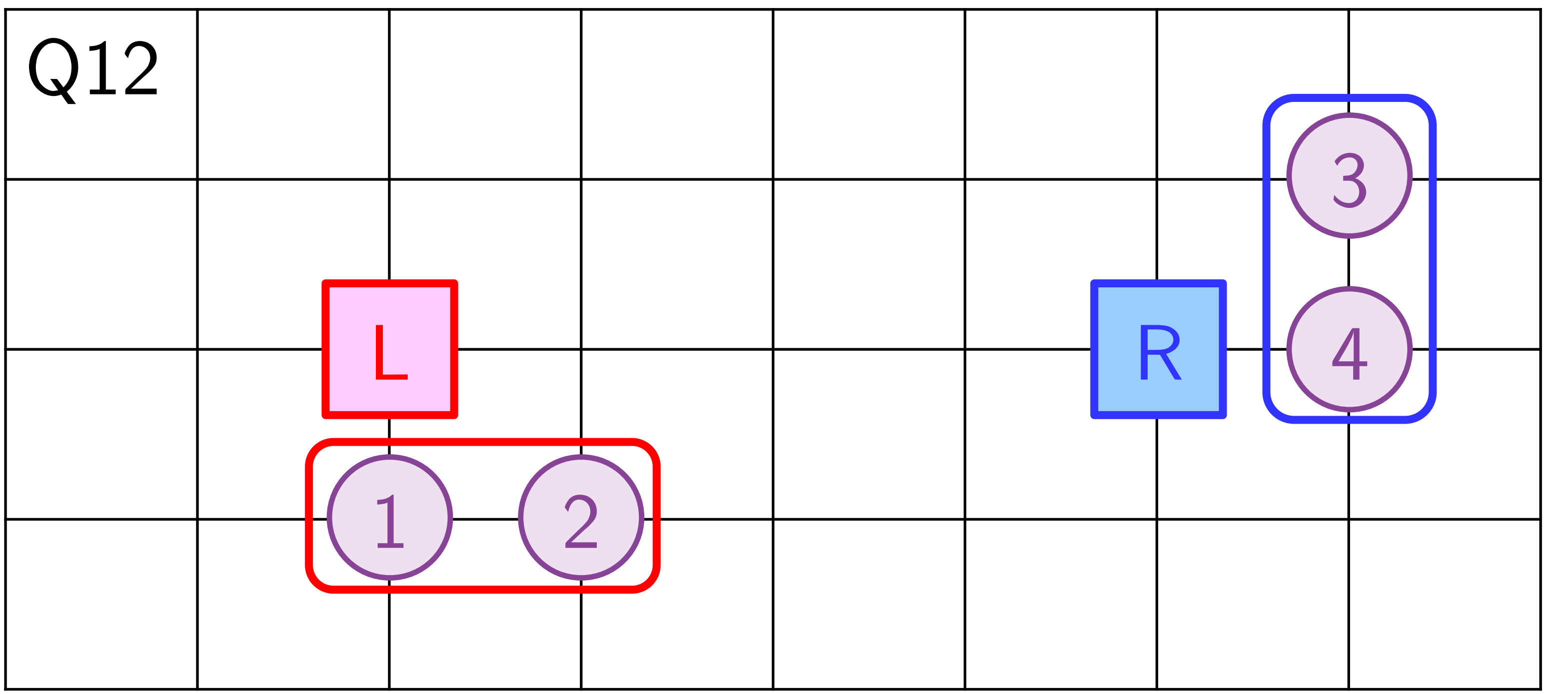
Assignment Game and Visual Selection

- How would you assign the circles?
- What about this? (C = A = E)
  - In fact, 74% chose this!



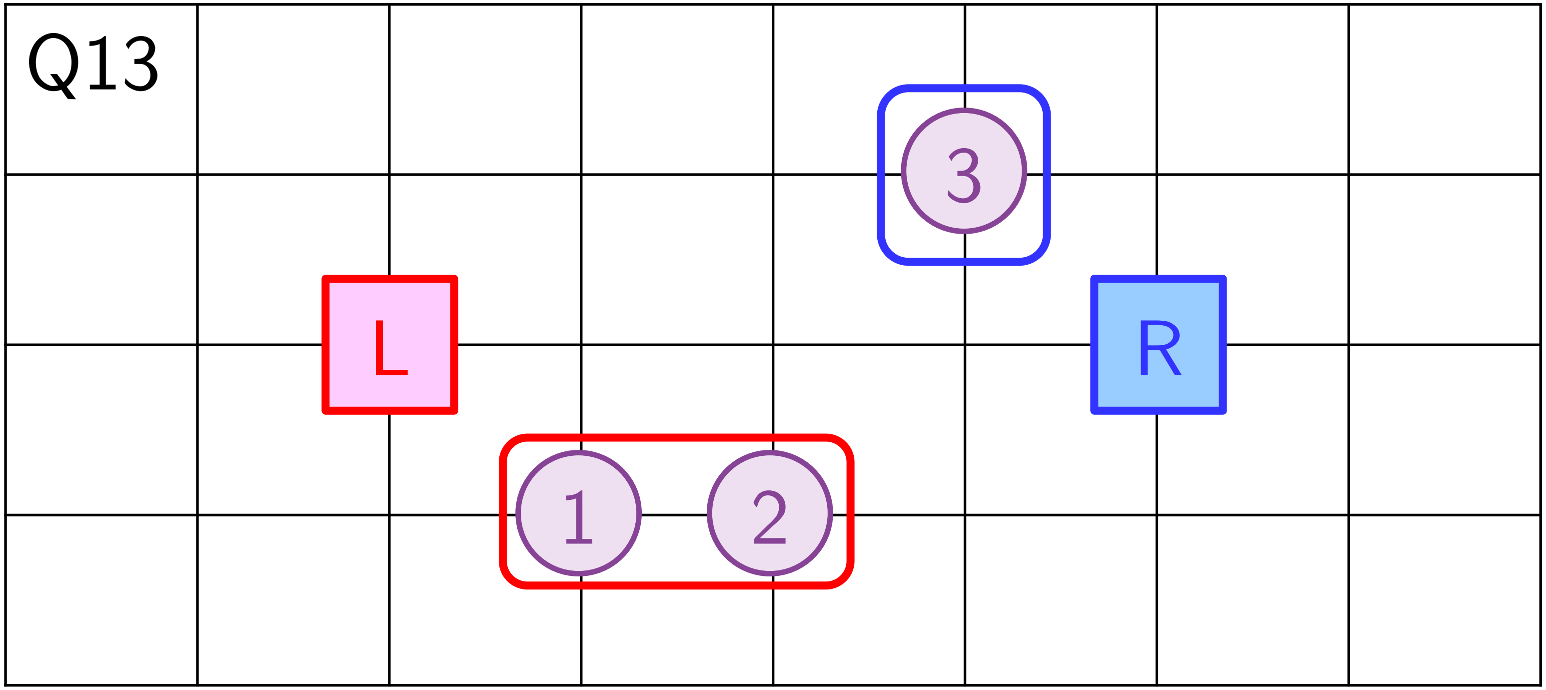
Assignment Game and Visual Selection

  - How would you assign the circles?
- What about this? (C = A = E)
  - In fact, 68% chose this!



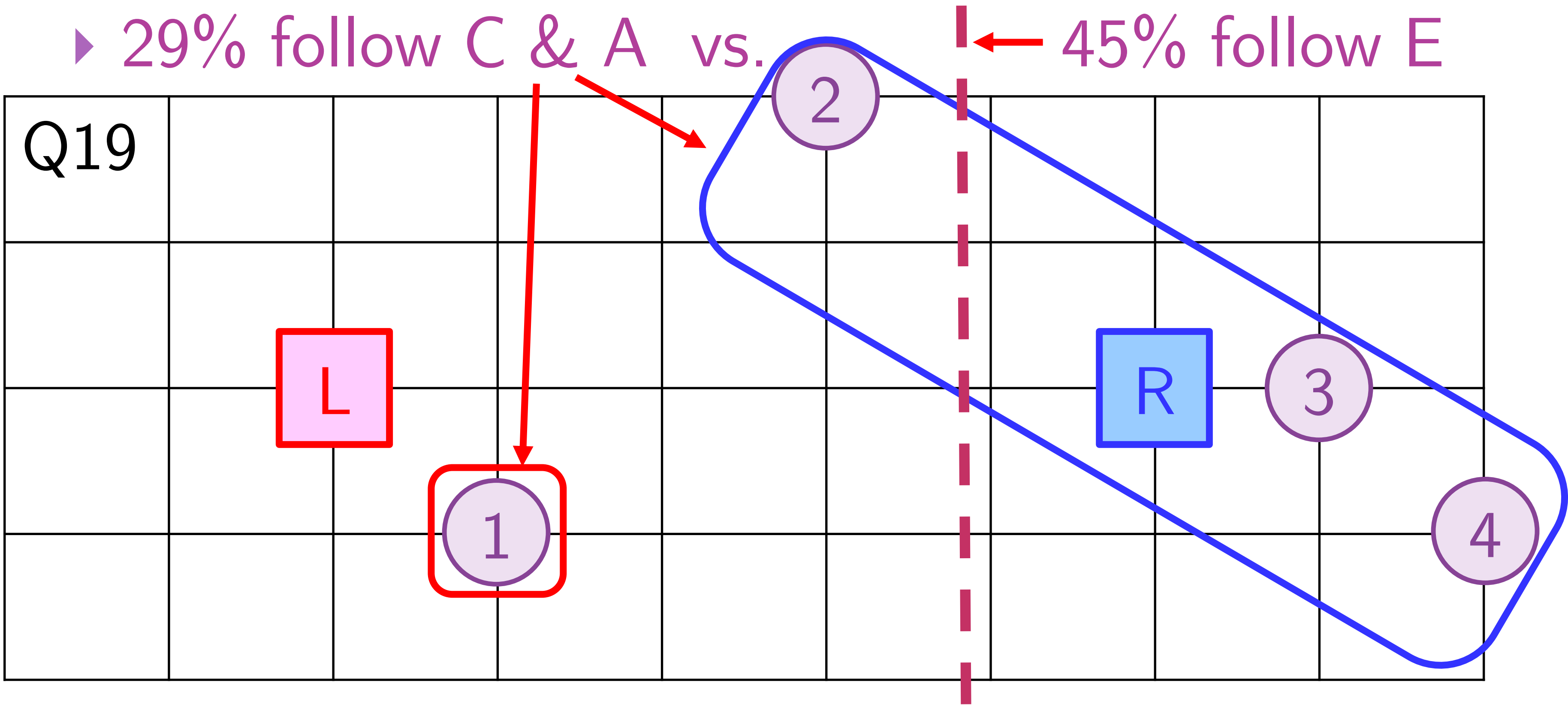
Assignment Game and Visual Selection

- How would you assign the circles?
- What about this? (Accession!)
  - In fact, 70% chose this! (What does C/E say?)



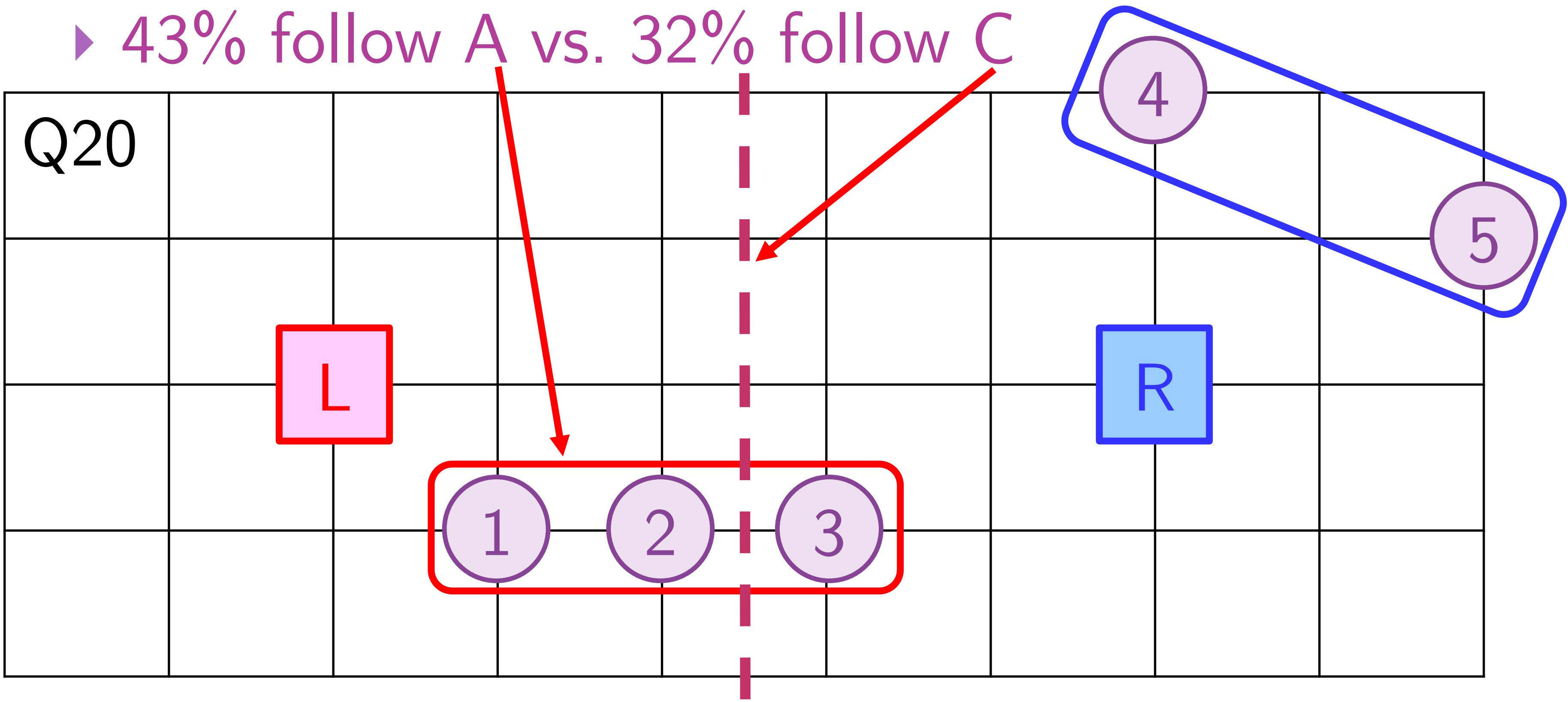
Assignment Game: C & A vs. Equality

- What does Closeness/Accession say?
- What does Equality say about this? ☺
  - 29% follow C & A vs. ← 45% follow E



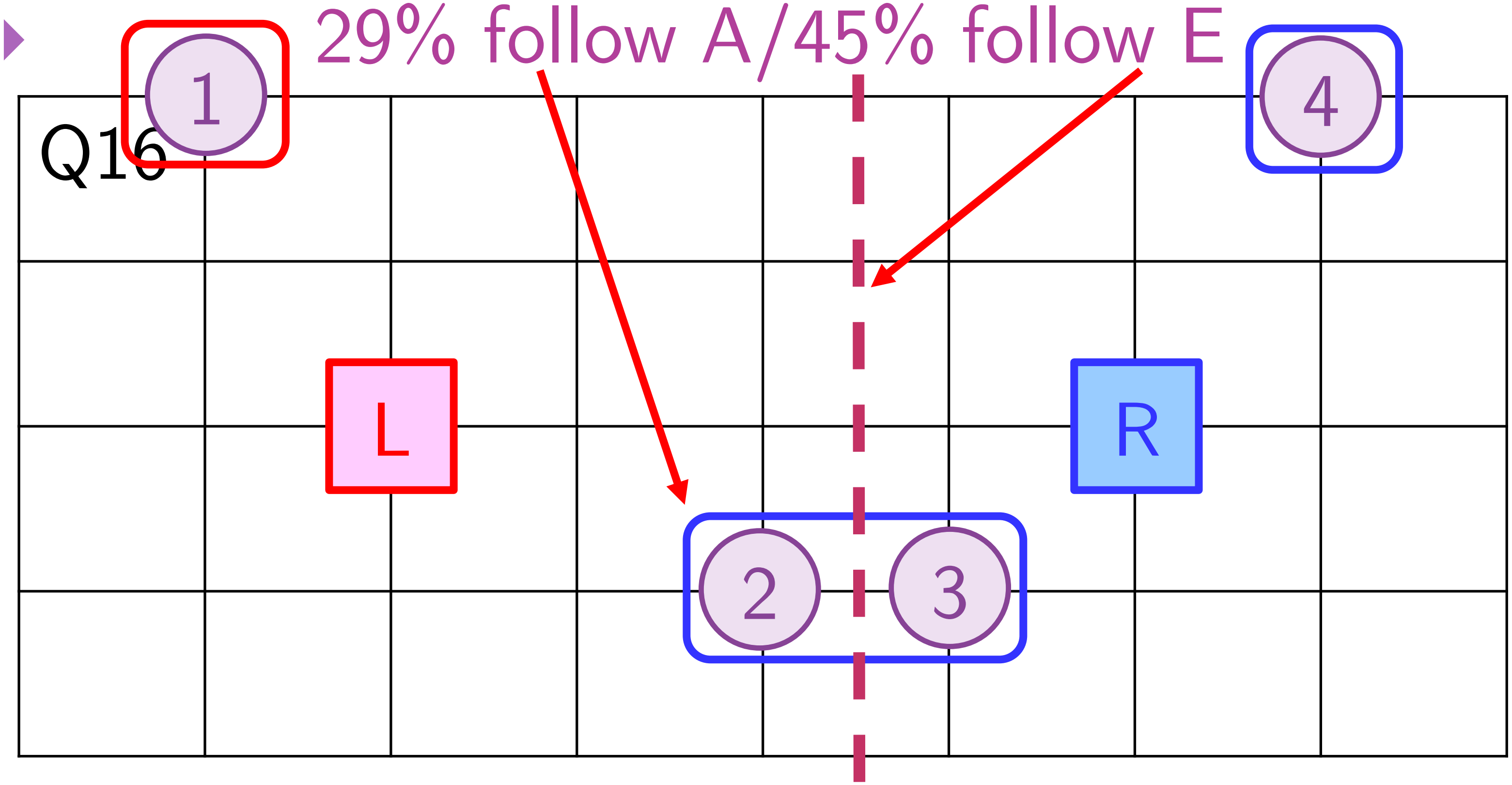
Assignment Game: Accession vs. Closeness

- What does Accession say about this?
- What does Closeness say about this?
  - 43% follow A vs. 32% follow C



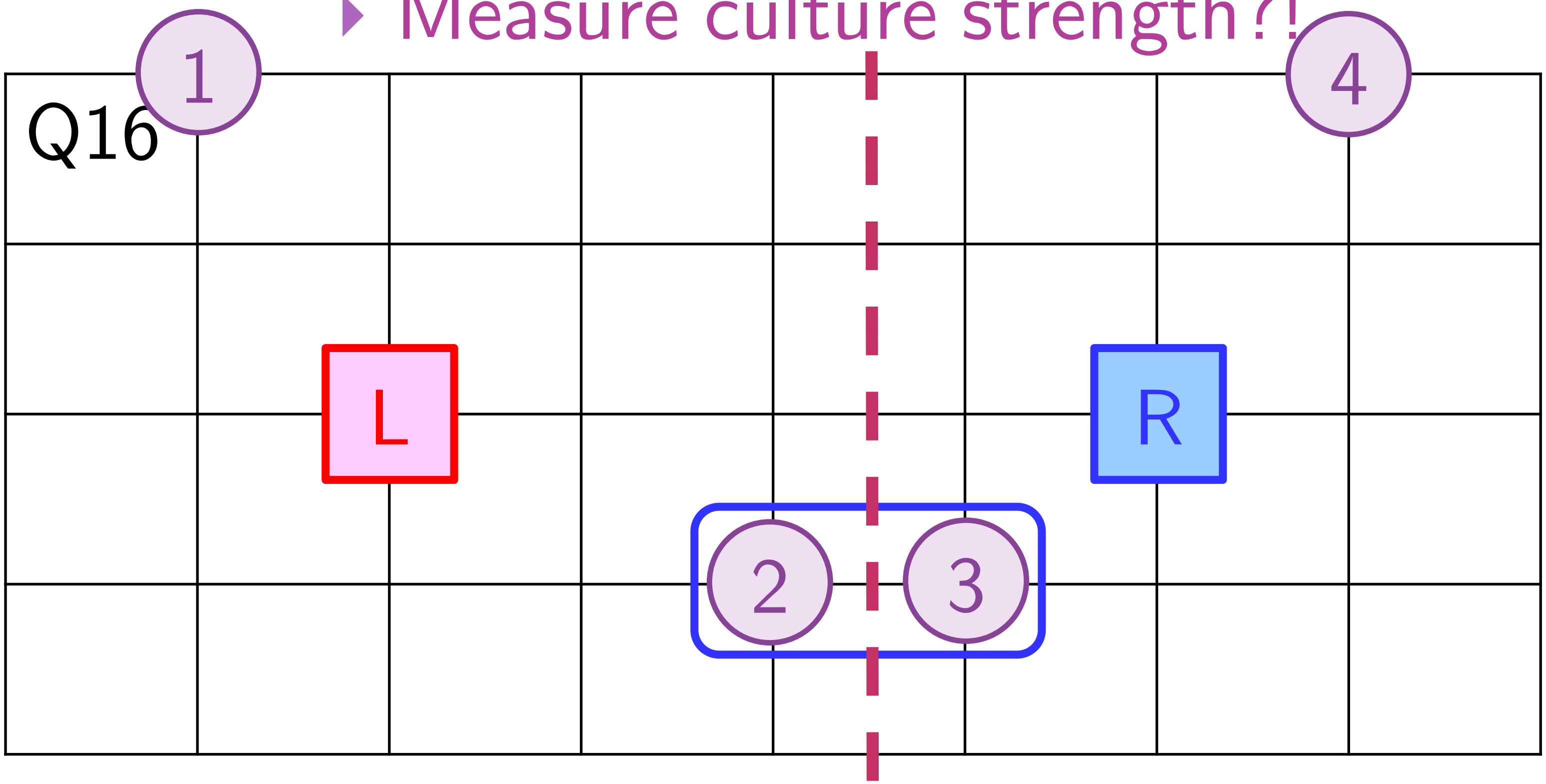
Assignment Game: Accession vs. Equality

- What does Accession say about this?
- What does Equality say about this?
  - 29% follow A/45% follow E



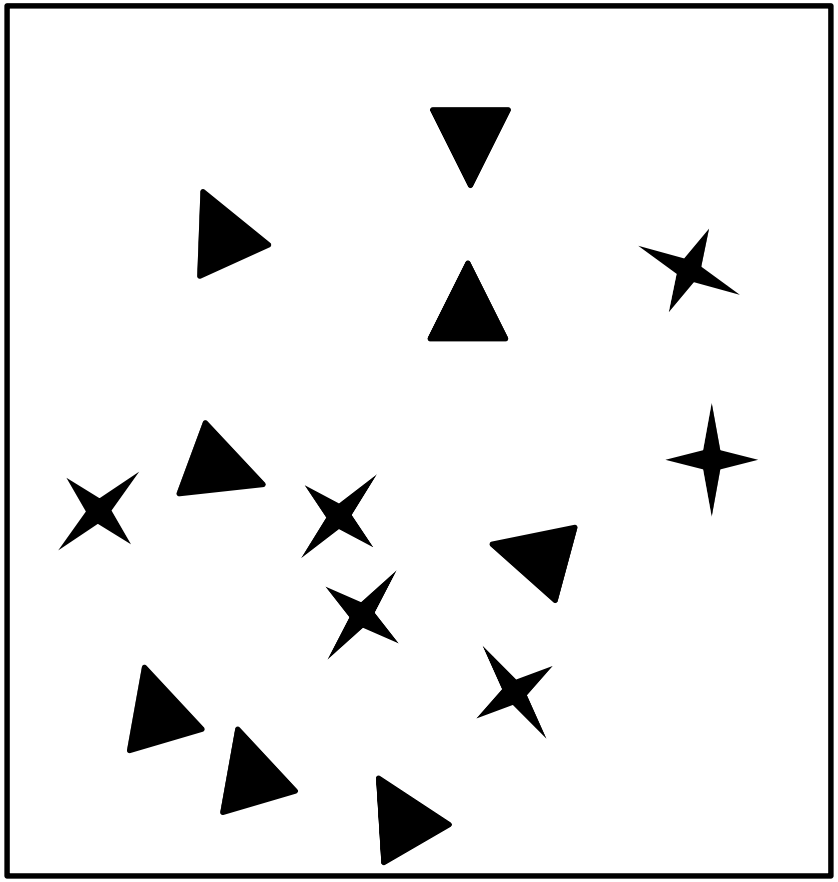
Equality > Accession > Closeness

- First Focal Principle: Equality ☺
- Then Accession (if Equality satisfied/silent)
  - Measure culture strength?!

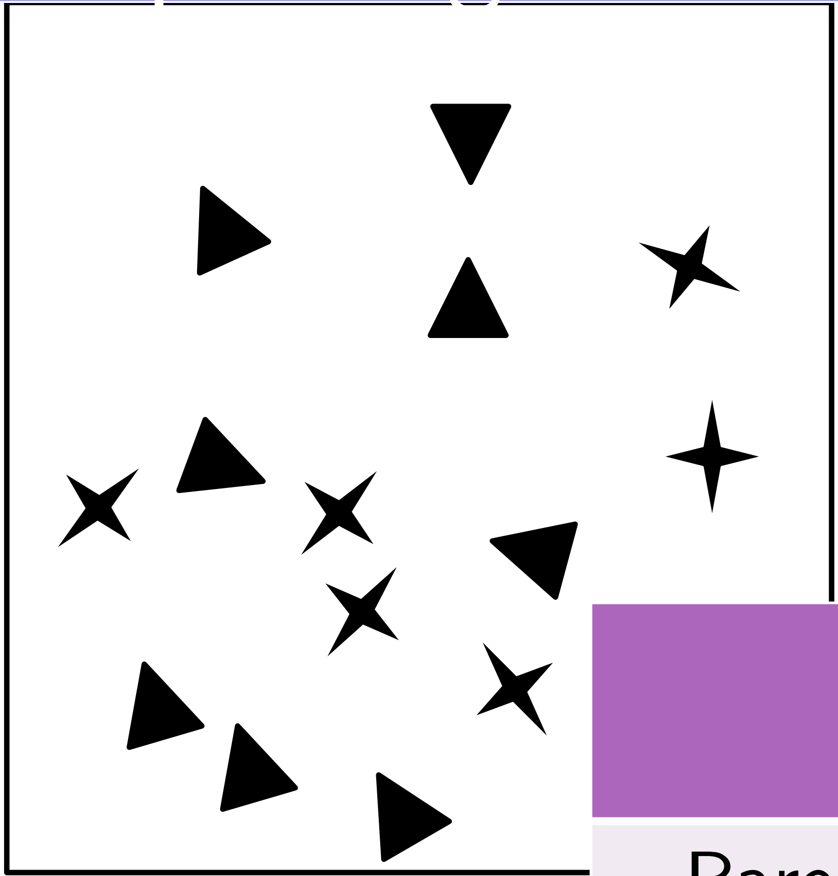


Unpacking Focality

- Bacharach and Bernasconi (GEB 1997)
- Visual matching game
  - Pick one from picture:
- Test rarity preferences
  - 6 vs. 8
- Rare item chosen more frequently
  - As Rarity increases:
  - 6/8, 2/3, 6/18, 1/15



Unpacking Focality: Test Rarity

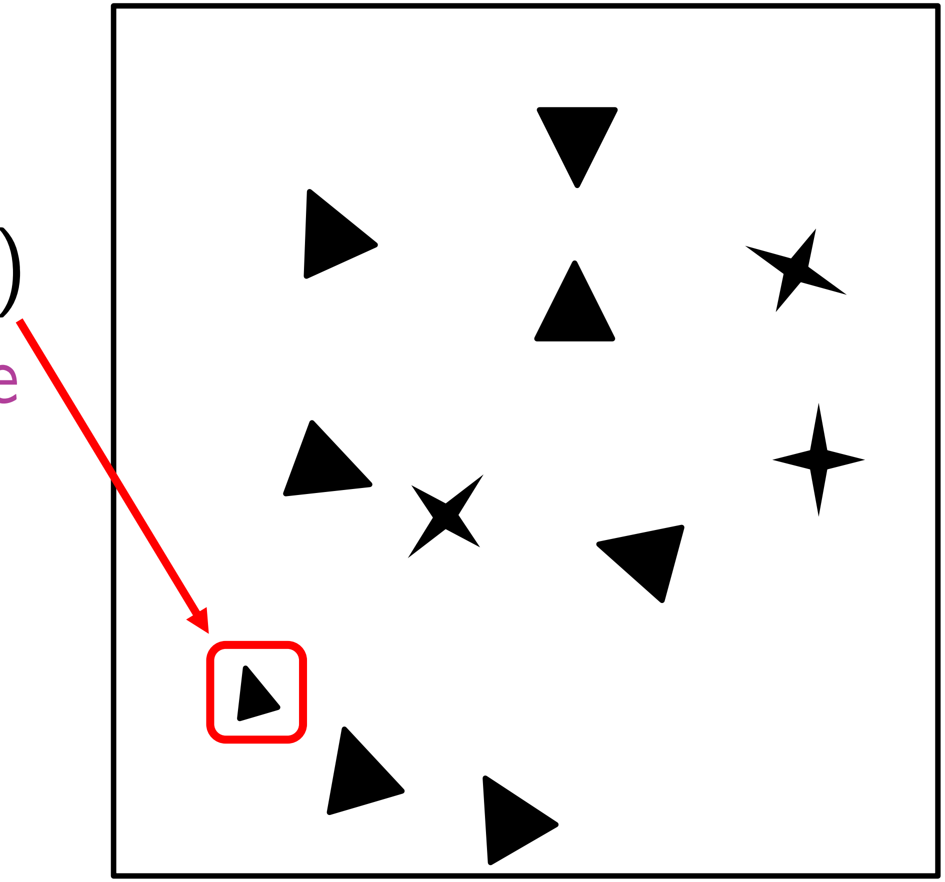


- As Rarity increases
  - Frequency of rare choice increases

	# of Rare/Frequent Items			
	6/8	2/3	6/18	1/15
Rare	65%	76%	77%	94%
Frequent	35%	24%	23%	6%

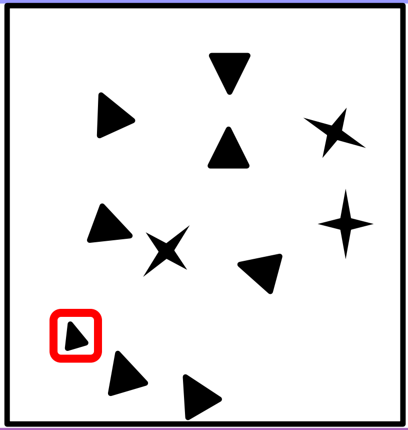
Unpacking Focality: Test Trade-offs

- Rarity (n=3 vs. 8)
  - against
- Oddity (size or color)
  - $p(\mathrm{F})=$ prob. of notice
- Choose Obvious if
  - $p(\mathrm{F})=0.94 >> 1/3$
- Choose Subtle if
  - $p(\mathrm{F})=0.40 > 1/3$



Unpacking Focality: Test Trade-offs

- Violate $p(\mathrm{F}) > 1/r$
  - Mostly chose Obvious Oddity
  - Less than half chose Subtle Oddity



r = # of Rare	Obvious Oddity (r)				Subtle Oddity (r)				
	2	3	4	5	2	3	4	5	6
Rare	14%	19%	9%	7%	77%	55%	45%	69%	55%
Oddity	83%	79%	91%	88%	23%	31%	45%	19%	20%
Other	2%	2%	0%	5%	0%	14%	10%	12%	25%
$p(\mathrm{F})$	0.95	0.91	0.95	0.93	0.55	0.40	0.62	0.25	0.25

Unpacking Focality

- Munro (wp 1999)
- Field study of coordination

Asymmetric Players: Battle of Sexes

	1	2
1	0, 0	200, 600
2	600, 200	0, 0

- 100 lottery tickets =
  - 10% chance to win \$1/\$2
- Pure NE: (1,2) and (2,1)
  - Players prefer equilibrium where they play strategy 2
- Mixed NE:
  - (1/4, 3/4) each
- Which would you pick?

Asymmetric Players: Battle of Sexes

  - Cooper, DeJong, Forsythe & Ross (AER 90')
- BOS: Baseline (MSE mismatch 62.5%)
- BOS-300: Row player has outside option 300
  - Forward induction predicts (2,1)
- BOS-100: Row player has outside option 100
  - Forward induction doesn't apply
- Compare BOS-100 and BOS-300 shows if "any outside option" works...

Battle of Sexes (Last 11 Periods)

Game	Outside	(1,2)	(2,1)	Other	# Obs
BOS	-	37(22%)	31(19%)	97(59%)	165
BOS-300	33	0(0%)	119(90%)	13(10%)	165
BOS-100	3	5(3%)	102(63%)	55(34%)	165
BOS-1W					165
BOS-2W					165
BOS-SEQ					165

Asymmetric Players: Battle of Sexes

- Cooper, DeJong, Forsythe & Ross (AER 90')
- BOS-1W: 1 way communication by Row
- BOS-2W: 2 way communication by both
- BOS-SEQ: Both know that Row went first, but Column doesn't know what Row did
  - Information set same as simultaneous move
  - Would a sequential move act as an coordination device?

Battle of Sexes (Last 11 Periods)

Game	Outside	(1,2)	(2,1)	Other	# Obs
BOS	-	37(22%)	31(19%)	97(59%)	165
BOS-300	33	0(0%)	119(90%)	13(10%)	165
BOS-100	3	5(3%)	102(63%)	55(34%)	165
BOS-1W	-	1(1%)	158(96%)	6(4%)	165
BOS-2W	-	49(30%)	47(28%)	69(42%)	165
BOS-SEQ	-	6(4%)	103(62%)	56(34%)	165

Where Does Meaning Come From?

- Communication can help us coordinate
- But how did the common language for communication emerge in the first place?
- Put people in a situation of no meaning and see how they create it!
- Blume, DeJong, Kim & Sprinkle (AER 98')
  - See also BDKS (GEB 2001) which is better!

Evolution of Meaning: Game 1 (Baseline)

	A	B
T1	0, 0	7, 7
T2	7, 7	0, 0

  - Blume et al. (AER 1998)
- Sender has private type T1 or T2
- Sends message "*" or "#" to receiver
- Receiver chooses A or B (to coordinate type)

Evolution of Meaning

- Blume et al. (AER 1998)
- Game 1: Baseline as above
- Game 1NH: See only history of own match
- Game 2: Receiver can choose C (safe action) that gives (4,4) regardless of T1/T2
  - Theory: Pooling or Separating Equilibrium

Percentage Consistent with Separating

Game \ Period	1	5	10	15	20
1st Session					
Game 1	48	65	74	89	95
2nd Session					
Game 1	49	72	61	89	100
Game 1NH	55	55	28	55	72
Game 2					
Separating	44	88	88	88	94
Pooling	39	05	00	05	05

Evolution of Meaning

- Blume et al. (AER 1998)
- Game 1: Baseline as above
- Game 1NH: See only history of own match
- Game 2: Receiver can choose C (safe action) that gives (4,4) regardless of T1/T2
  - Theory: Pooling or Separating Equilibrium
- Game 3: Coordinate payoffs become (2,7)
  - So sender wants to disguise types to force receiver to choose C (safe action)
  - Allowed to send 2 or 3 messages...

Results of Game 3: 2 vs. 3 messages

# of Messages	1-10	11-20	21-30	31-40	41-50	51-60
2-Separating	43	53	38	39		
2-Pooling	33	34	41	43	2^{nd} Session	
3-Separating	43	38	33	24		
3-Pooling	33	37	42	60		
2-Separating	39	27	23	24	24	23
2-Pooling	39	48	51	60	63	61
3-Separating	23	22	23	25	22	24
3-Pooling	55	61	58	56	57	61
					1^{st} Session	

Example of Asymmetric Payoffs

- Market Entry Game
  - n players decide to enter market with capacity c
  - Payoffs declines as number of entrants increase; < 0 if number $> c$ $(=$ capacity)
- Kahneman (1988): Number close to equil.
  - "To a psychologist, it looks like magic."
- See BI-SAW paper by Chen et al. (2012)...

Market Entry Game Results

Market capacity	1	3	5	7		11	13	15	17	19
MSE	0	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9
1st block	1.3	5.7	9.7	6.7	3.7	14.0	11.3	11.3	16.0	18.0
all data	1.0	3.7	5.1	7.4	8.7	11.2	12.1	14.1	16.5	18.2

- Sundali et al. 95'

Games with Asymmetric Equilibria

	1	2
1	800, 800	800, 0
2	0, 800	1000, 1000

- Stag Hunt
  - Cooper et al. (AER 1990)
- 100 lottery tickets =
  - 10% chance to win \$1/ \$2
- Pure NE:
  - (1,1) & (2,2)
- Which would you pick?

Games with Asymmetric Equilibria

- Cooper et al. (AER 1990)
- CG: Baseline Stag Hunt
- CG-900: Row has outside option 900 each
  - Forward induction predicts (2,2)
- CG-700: Row has outside option 700 each
  - Forward induction won't work
- CG-1W: 1 way communication by Row
- CG-2W: 2 way communication by both

Stage Hunt (Last 11 Periods)

Game	Outside	(1,1)	(2,2)	Other	# Obs
CG	-	160(97%)	0(0%)	5(3%)	165
CG-900	65	2(2%)	77(77%)	21(21%)	165
CG-700	20	119(82%)	0(0%)	26(18%)	165
CG-1W	-	26(16%)	88(53%)	51(31%)	165
CG-2W	-	0(0%)	150(91%)	15(9%)	165

Weak-link Game: Team Production Example

  - Van Huyck, Battalio and Beil (AER 1990)
- Each of you belong to a team
- Each of you can choose effort X=1-4
  - Spade = 4, Heart = 3, Diamond = 2, Club = 1
- Earnings depend on your own effort and the smallest effort of your team
  - Each person has to do his/her job for the whole team project to fly
- Have you every had such a project team?

Weak-link Game: Team Production Example

- Payoff = 60 + 10 * min{X_j} − 10 * (X_i − min{X_j})

Team Project Payoff → 10 * min{X_j}

Cost of Effort X → 10 * (X_i − min{X_j})

Your X	Smallest X in the team			
	4	3	2	1
4	100	80	60	40
3	-	90	70	50
2	-	-	80	60
1	-	-	-	70

Weak-link Game: Team Production Example

- What is your choice when...
  - Group size = 2?
  - Group size = 3?
  - Group size = 20?

- Can some kind of communication help coordinate everyone's effort?

Classroom Experiment: 害群之馬

最弱環節賽局
(Weak-Link Game)

Weak-Link Game (最弱環節賽局)

- Each DM chooses effort X=1-4
  - Spade = 4, Heart = 3, Diamond = 2, Club = 1
- DM (Decision Maker) = a team of two
  - 每組每回合都會有四張撲克牌，分別為黑桃(4)、紅心(3)、方塊(2)、梅花(1)
    - 主持人會跟每組收一張牌
  - 交出來的花色代表你們花多少時間排練
    - 你們的努力程度：黑桃 = 4小時、紅心 = 3小時、方塊 = 2小時、梅花 = 1小時
  - 各組要討論屆時交出哪一張牌...

Payoff Calculation (記分方式)

- Payoff = 3 * min{X_j} – 1 * X_i

Team Project Payoff → 3 * min{X_j}

Cost of Effort X → 1 * X_i

- 「花最少時間排練那一組的排練時數」，每一小時的排練大家都會得到3分。各組自己每花一小時排練，就少1分。

Your X_i (本組時數)	min{X_j} (最低那組時數)			
	4	3	2	1
4	8	5	2	-1
3	-	6	3	0
2	-	-	4	1
1	-	-	-	2

Payoff Calculation (記分方式)

1. How much would you earn if all DM choose X=4?
   - 8!
   - 如果所有各組都花四小時排練，這樣各組會拿幾分？8分!

Your X_i (本組時數)	$\min\{X_j\}$ (最低那組時數)			
	4	3	2	1
4	8	5	2	-1
3	-	6	3	0
2	-	-	4	1
1	-	-	-	2

Payoff Calculation (記分方式)

2. How much would you earn if you choose X=3 while others choose X=4?
   - 6 (< 8, not worth it!)
   - 如果別組都花四小時排練，但你們這組只花三小時排練，這樣你們會拿幾分？你們這麼做值得嗎？6分！小於8分所以不值得！

Your X_i (本組時數)	$\min\{X_j\}$ (最低那組時數)			
	4	3	2	1
4	8	5	2	-1
3	-	6	3	0
2	-	-	4	1
1	-	-	-	2

Payoff Calculation (記分方式)

3. How much would you earn if you choose X=2 while some other DM choose X=1?
   - 1 (< 2, if you also choose X=1!)
   - 如果有某一組只花一小時排練，你們這組如果花兩小時排練，值得嗎？不值得，因為只得1分，但如果也花一小時就會跟他們一樣得到2分!

Your X_i (本組時數)	$\min\{X_j\}$ (最低那組時數)			
	4	3	2	1
4	8	5	2	-1
3	-	6	3	0
2	-	-	4	1
1	-	-	-	2

Weak-Link Game (最弱環節賽局)

- Please decide now and we will see the results...

6. Are you satisfied with the results? How can you encourage cooperation next time?

- 你對結果滿意嗎？如果你希望大家都更好，該怎麼鼓勵大家合作？讓我們再來做一次...

Your X_i (本組時數)	$\min\{X_j\}$ (最低那組時數)			
	4	3	2	1
4	8	5	2	-1
3	-	6	3	0
2	-	-	4	1
1	-	-	-	2

Weak-Link Game (最弱環節賽局)

- In reality, people would see each other's effort and increase effort gradually
- Let's try again by committing hour-by-hour!
  - 現實中你們彼此多半清楚大家的排練情況，而且時數可以逐步加碼。這次我們採一小時、一小時逐步加碼方式進行

本組排練時數	最低那組排練時數			
	4	3	2	1
4	8	5	2	-1
3	-	6	3	0
2	-	-	4	1
1	-	-	-	2