

NTS: $P(s_c | \bar{V}) > P(s_g | \bar{V})$
 [deaccented "has" is a cue for competitor]

$$\Leftrightarrow \tau_c q_{\bar{V}} > \tau_g p_{\bar{V}}$$

$$\Leftrightarrow \frac{q_{\bar{V}}}{p_{\bar{V}}} > \frac{\tau_g}{\tau_c}$$

any bias towards competitor must be counterbalanced by the evidence $q_{\bar{V}}/p_{\bar{V}} > 1$.

[we could naturally expect this to be the case] even if $\tau_g \neq \tau_c$ because of $[q_{\bar{V}} > p_{\bar{V}}]$

So assume:
 $\tau_g = \tau_c + \epsilon_r$
 $q_{\bar{V}} = p_{\bar{V}} + \epsilon_{\bar{V}}$ with $0 \leq \epsilon_r < \epsilon_{\bar{V}}$

Then:

$$\frac{p_{\bar{V}} + \epsilon_{\bar{V}}}{p_{\bar{V}}} > \frac{\tau_c + \epsilon_r}{\tau_c}$$

$$\Leftrightarrow (p_{\bar{V}} + \epsilon_{\bar{V}}) \cdot \tau_c > p_{\bar{V}} (\tau_c + \epsilon_r)$$

$$\Leftrightarrow p_{\bar{V}} \tau_c + \epsilon_{\bar{V}} \tau_c > p_{\bar{V}} \tau_c + p_{\bar{V}} \epsilon_r$$

$$\Leftrightarrow \epsilon_{\bar{V}} \tau_c > p_{\bar{V}} \epsilon_r$$

$$\Leftrightarrow \frac{\epsilon_{\bar{V}}}{\epsilon_r} > \frac{p_{\bar{V}}}{\tau_c}$$

true if $\epsilon_r < \epsilon_{\bar{V}}$ & $p_{\bar{V}} < \tau_c$
 both are natural assumptions
 also assumed here: $q_{\bar{V}} > p_{\bar{V}}$ & $\tau_g \geq \tau_c$ ✓

maybe assume that: $\tau_g = \tau_c + \epsilon_r$
 with $0 \leq \epsilon_r$ small & $p_{\bar{V}} + \epsilon_{\bar{V}} = q_{\bar{V}}$
 with $0 \leq \epsilon_r < \epsilon_{\bar{V}}$.

NTS: $P(s_g | V) > P(s_c | \bar{V})$
 [proof exists (?) for flat prior $\tau_g = \tau_c$
 and identical string likelihood $p_{\bar{V}} = q_{\bar{V}}$]

$$\Leftrightarrow \frac{\tau_g p_V}{\tau_g p_V + \tau_c q_V} > \frac{\tau_c q_{\bar{V}}}{\tau_g p_{\bar{V}} + \tau_c q_{\bar{V}}}$$

$$\Leftrightarrow \frac{\tau_g p_V}{\tau_g p_V + \tau_c q_V} > \frac{\tau_c (1 - q_V - q_{\bar{V}})}{\tau_g (1 - p_V - p_{\bar{V}}) + \tau_c (1 - q_V - q_{\bar{V}})}$$

$$\Leftrightarrow \dots > \frac{\tau_c - \tau_c q_V - \tau_c q_{\bar{V}}}{\tau_g - \tau_g p_V - \tau_g p_{\bar{V}} + \tau_c - \tau_c q_V - \tau_c q_{\bar{V}}}$$

$$\Leftrightarrow \tau_g p_V (\tau_g - \tau_g p_V - \tau_g p_{\bar{V}} + \tau_c - \tau_c q_V - \tau_c q_{\bar{V}}) > (\tau_c - \tau_c q_V - \tau_c q_{\bar{V}}) \cdot (\tau_g p_V + \tau_c q_V)$$

$$\Leftrightarrow \tau_g^2 p_V - \tau_g^2 p_V^2 - \tau_g^2 p_V p_{\bar{V}} + \tau_g \tau_c p_V - \tau_g \tau_c p_V q_V - \tau_g \tau_c p_V q_{\bar{V}} > \tau_g \tau_c p_V + \tau_g \tau_c q_V - \tau_g \tau_c p_V q_V - \tau_c^2 q_V^2 - \tau_g \tau_c p_V q_{\bar{V}} - \tau_c^2 q_V q_{\bar{V}}$$

$$\Leftrightarrow \tau_g^2 p_V - \tau_g^2 p_V^2 - \tau_g^2 p_V p_{\bar{V}} > \tau_g \tau_c p_V - \tau_c^2 q_V^2 - \tau_c^2 q_V q_{\bar{V}}$$

$$\Leftrightarrow (\tau_g^2 - \tau_g \tau_c) p_V - \tau_g^2 p_V^2 - \tau_g^2 p_V p_{\bar{V}} > -\tau_c^2 q_V^2 - \tau_c^2 q_V q_{\bar{V}}$$

$$\Leftrightarrow (\tau_g^2 - \tau_g \tau_c + \tau_g \epsilon_r) p_V - \tau_g^2 p_V^2 - \tau_g^2 p_V p_{\bar{V}} > -(\tau_g^2 - 2\tau_g \epsilon_r + \epsilon_r^2) (q_V^2 - q_V q_{\bar{V}})$$

$$\Leftrightarrow \tau_g \epsilon_r p_V - \tau_g^2 p_V^2 - \tau_g^2 p_V p_{\bar{V}} > \dots$$

okay, it is clear that any prior bias for s_g will pull closer towards s_g ; shows that, by mere likelihood, the same result is expected; so set: $\epsilon_r = 0$

$$\frac{p_V}{p_V + q_V} > \frac{q_{\bar{V}}}{p_{\bar{V}} + q_{\bar{V}}}$$

$$\Leftrightarrow p_V p_{\bar{V}} + p_V q_{\bar{V}} > p_V q_V + q_V q_{\bar{V}}$$

$$\Leftrightarrow p_V p_{\bar{V}} > q_V q_{\bar{V}}$$

$$\Leftrightarrow \frac{p_{\bar{V}}}{q_V} > \frac{q_{\bar{V}}}{p_V}$$

$$(p_{\bar{V}} + \epsilon_p) p_{\bar{V}} > q_V (q_V + \epsilon_q)$$

$$p_{\bar{V}}^2 + \epsilon_p p_{\bar{V}} > q_V^2 + \epsilon_q q_V$$

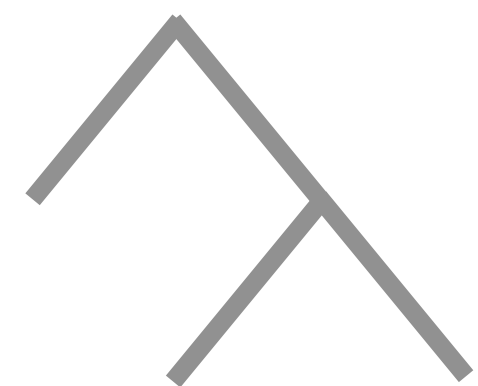
$$p_{\bar{V}}^2 + \epsilon_p p_{\bar{V}} > q_V^2 + \epsilon_q q_V + \epsilon_p q_V$$

assume:
 $q_{\bar{V}} = q_V + \epsilon_q$ $\epsilon_q > \epsilon_p$
 $p_V = p_{\bar{V}} + \epsilon_p$
 [producing V when adequate is less likely than producing \bar{V} when adequate] $p_V < q_{\bar{V}}$
 [producing V when inadequate is less likely than producing \bar{V} when inadequate] $p_{\bar{V}} > q_V$

Computational Pragmatics

Introduction to the Rational Speech Act framework

Session 4



/lɪŋˈɡwɪstɪks/

$$[[\text{Joe}]] = \lambda e . \lambda w . \text{Joe}(e, w)$$

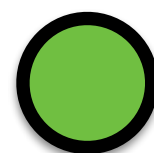
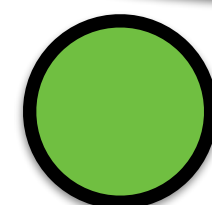
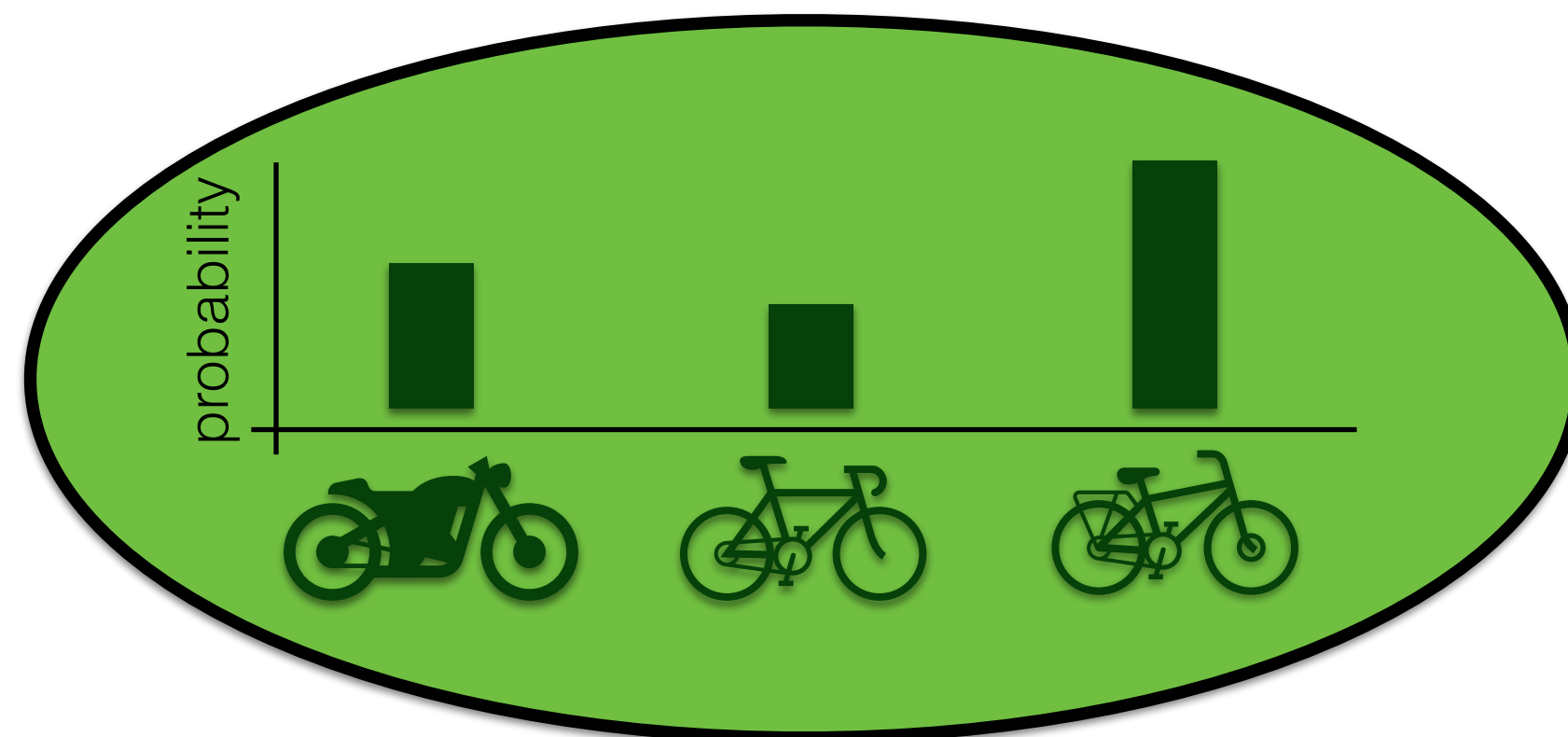
KNOWLEDGE OF LANGUAGE



GENERAL WORLD KNOWLEDGE



ACTUAL CONTEXT OF CONVERSATION

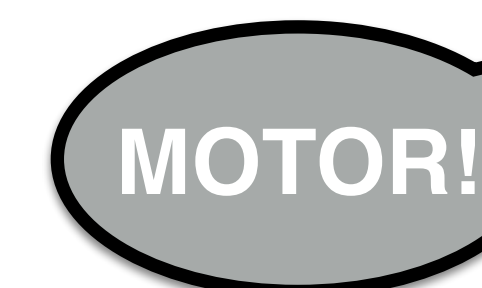


PRAGMATIC INTERPRETER



ACTUAL SPEAKER

MODEL OF SPEAKER BEHAVIOR



**ALTERNATIVE UTTERANCES
& INTERPRETATIONS**

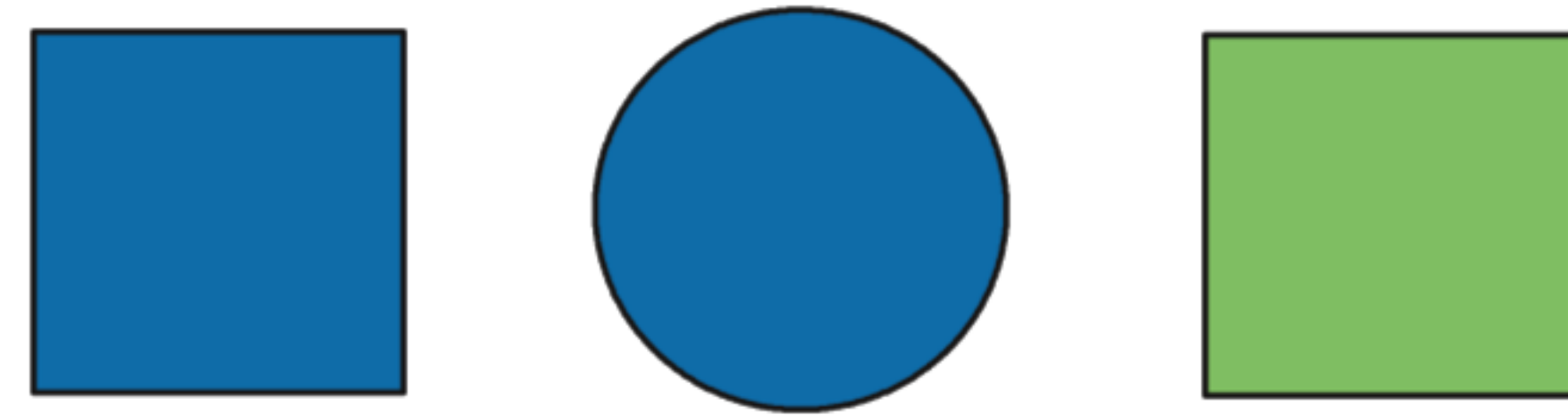


Reference Games

referential communication

context

set of objects/referents

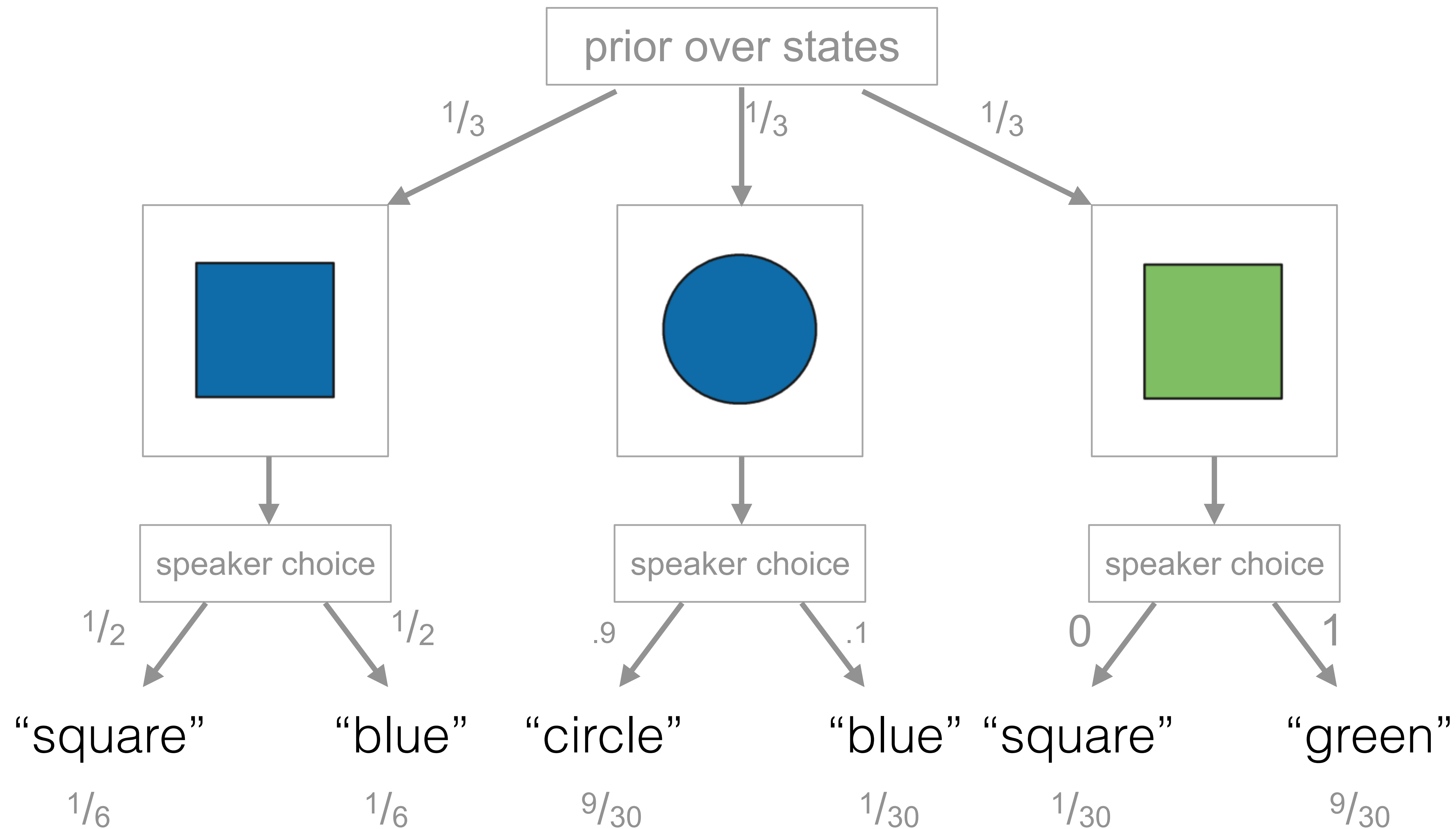


utterances

single properties of objects

$$U = \{ \text{"square"}, \text{"circle"}, \text{"green"}, \text{"blue"} \}$$


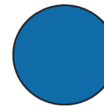

which object do you think a speaker meant when she selects “blue”?



RSA for reference games (example)






literal interpreter

			
“square”	.5	0	.5
“circle”	0	1	0
“green”	0	0	1
“blue”	.5	.5	0





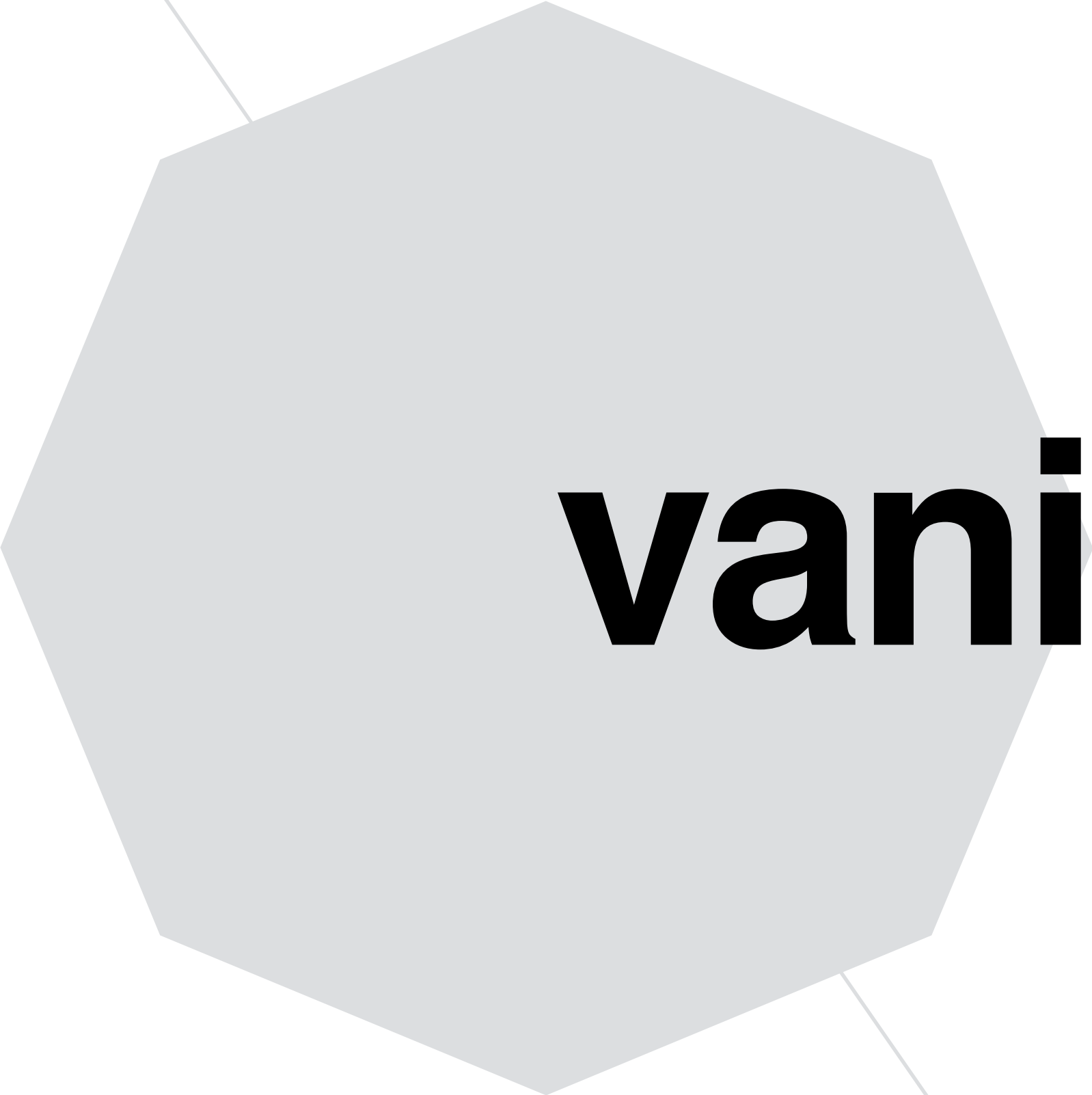
rational speaker

	“square”	“circle”	“green”	“blue”
	.5	0	0	.5
	0	.89	0	.11
	.11	0	.89	0



rational interpreter

			
“square”	.82	0	.18
“circle”	0	1	0
“green”	0	0	1
“blue”	.82	.18	0



vanilla RSA

Rational Speech Act model



L₀

LITERAL INTERPRETATION

STRATEGIC DEPTH 0



$$P_{lit}(s | u) = P(s | \llbracket u \rrbracket)$$



S₁

GRICEAN SPEAKER

STRATEGIC DEPTH 1



$$P_S(u | s) \propto \exp \left(\alpha \left(\log P_{lit}(s | u) - C(u) \right) \right)$$



L₁

GRICEAN INTERPRETATION

STRATEGIC DEPTH 2



$$P_L(s | u) \propto P(s) P_S(u | s)$$

Pragmatic listener

Pragmatic speaker

Pragmatic speaker

Pragmatic speaker

Literal listener