Extensional versus intensional reasoning: Yet another pragmatic view of the conjunction fallacy

Dani Navarro, Alison McCann, Alexandra Tingey,
Michelle Keshwa, Nicole Baz, and Amy Perfors

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which is more probable?

(a) Linda is a bank teller

(b) Linda is a feminist bank teller

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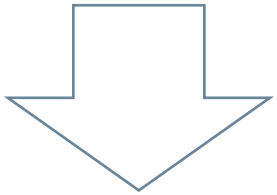
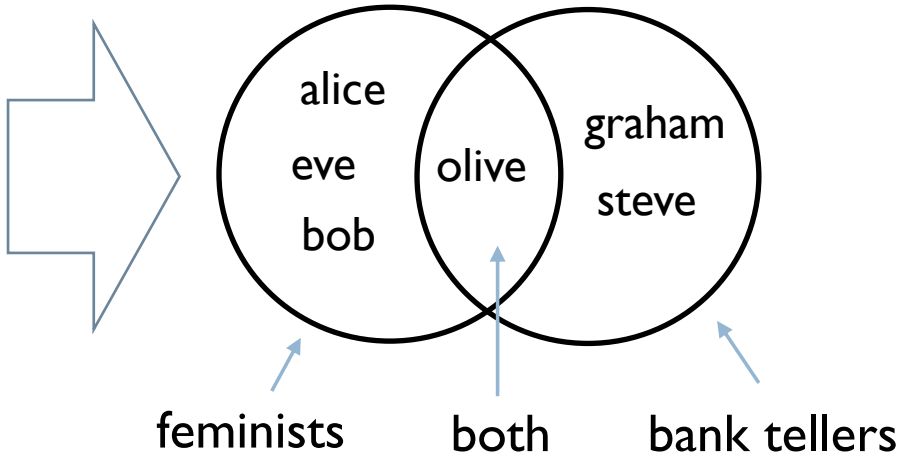


feminist bank teller

When (and why) does this similarity drive our reasoning in the problem?

Extensional reasoning

- What are the attributes of Linda
- Goal is to infer the categories in the world to which Linda belongs
- Conjunctive categories are nested within the marginal & therefore less likely



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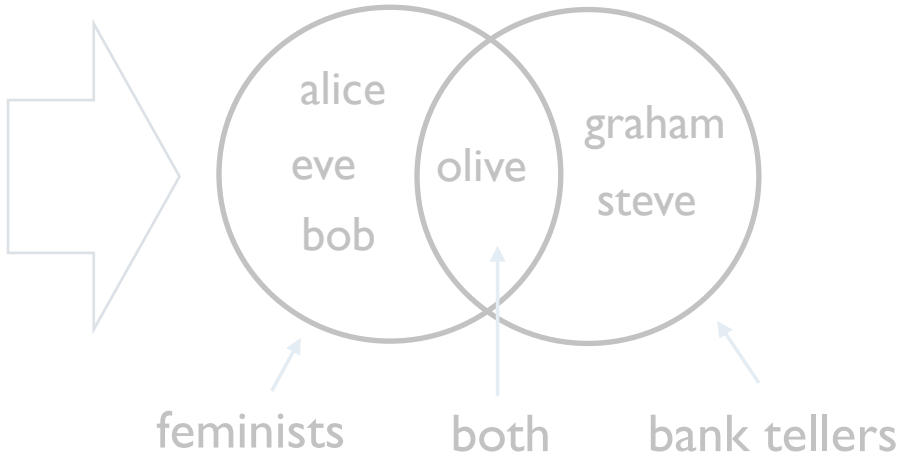

Intensional reasoning

- What does the speaker intend this passage to *mean*?
- What category is the "best" description of Linda?
- Conjunctive inference is not necessarily wrong

feminists ▷ *smart, social justice, risk-seeking, …*

bank tellers ▷ *smart, logical, risk-averse, …*

both ▷ *smart, social justice, logical, risk-neutral, …*

c.f. Hertwig & Gigerenzer (1999)

Grice (1975)

Dani: *Let me tell you about my friend Linda. She's 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.*

Amy: *Ah okay, she's a feminist. Cool.*

Dani: *What? No she's not a feminist. Why would you even think that? That's just weird. You're weird*

Grice (1975)

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Amy: *Ah okay, she's a bank teller. Cool.*

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Predictions?

(1) Representativeness is linked to speaker intent: The conjunction fallacy arises when the correct intensional inference conflicts with the correct extensional inference

Experiments 1-3

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Experiments 1-3

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Experiments 4-6

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Experiments 1-3

(2) Conjunction fallacies partly reflect a pragmatic demand: if we can shift the pragmatics of the task, people should be more willing to reason extensionally rather than intensionally.

Experiments 4-6

(3) We should be able to demonstrate and manipulate a demand effect when people have to reason about purely physical quantities (dice rolls)

Experiments 7-9

Experiments 1-3

On the relationship between conjunction fallacies and speaker intention

Exp 1: "taboo task"

generate a vignette that *implies* *but does not state* that…

N=20, UNSW

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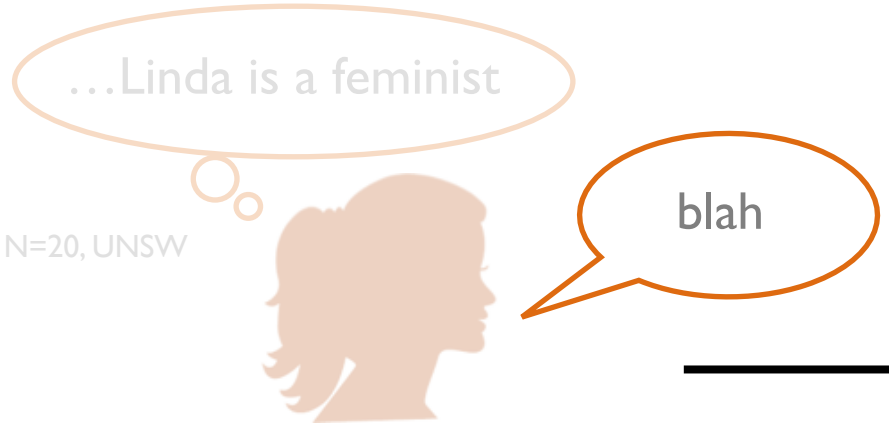
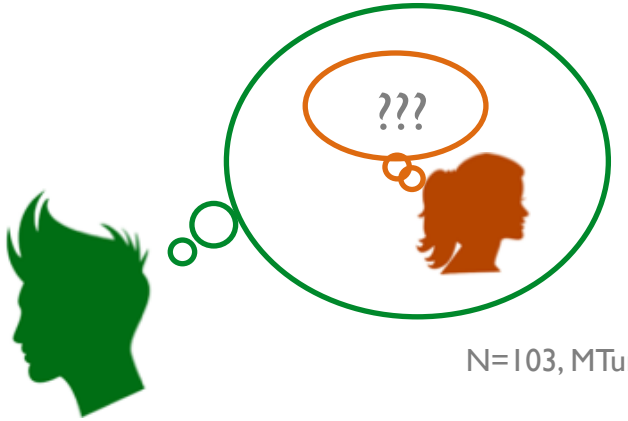


N=20, UNSW

Exp 2: "mind reading task"

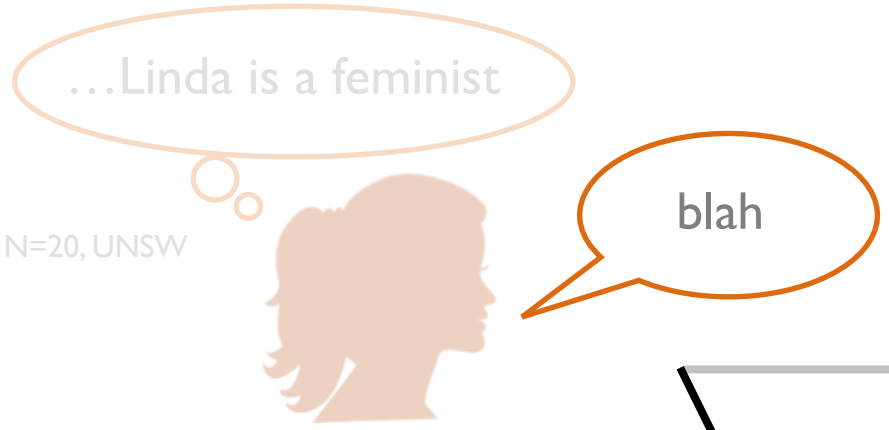
given this vignette, what do you think the author *intended* to communicate?



N=103, MTurk

Exp 1: "taboo task"

generate a vignette that *implies but does not state* that…



N=20, UNSW

Exp 2: "mind reading task"

given this vignette, what do you think the author *intended* to communicate?

N=103, MTurk

Exp 3: "probability judgment task"

given this vignette, what is the probability that Linda is a _____?

N=199, MTurk

Exp 1: Example vignette for "Linda is a feminist"

Linda is 31 and has had a rough upbringing, growing up with an abusive father which restricted her mother and her freedom. This upbringing was what made her decide to major in sociology and psychology within university. She has strong views on politics and other similar matters that affect men and women. She regularly attends rallies and protests on the weekend.

Exp 1: Example vignette for "Paula is a bank teller"

Paula is 30, and loves buying clothes even at her age of 30. She is in contact with money so much that she has been able to calculate the exact change given before the cashier has given it to her. Her skills in counting are ingrained within her brain that she cannot turn it off, due to years dealing with cash

Exp 1: Example vignette for "Brenda is a feminist and a bank teller"

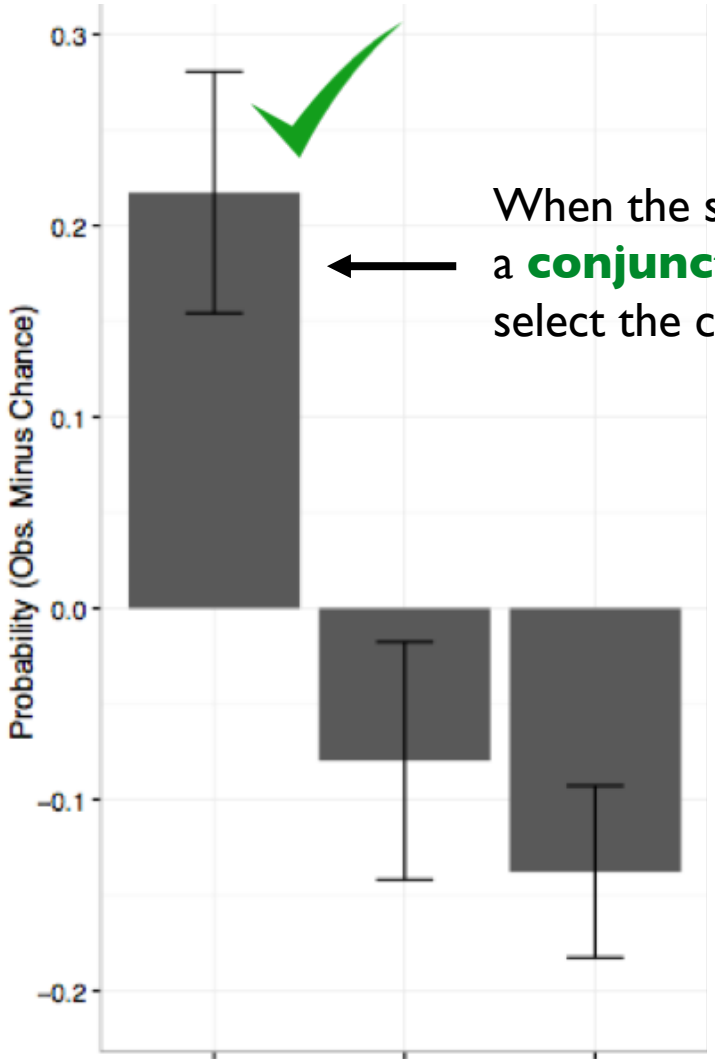
Brenda is 32 years old, methodical, logical, and passionate about her beliefs. She is very good with both people and numbers and is often able to spot errors. She is trusted by her friends to handle the money when planning an overseas trip. She is also a very individual woman and looks up to celebrities such as Emma Watson

Marginal 1	Marginal 2	Conjunction
Feminist	Bank teller	Feminist & bank teller
Engineer	Jazz musician	Engineer & jazz musician
Introvert	Chef	Introvert & chef
Journalist	Anxious person	Journalist & anxious person
Painter	Accountant	Painter & accountant
Extrovert	Statistician	Extrovert & statistician
Pacifist	Boxer	Pacifist & boxer
Butcher	Empath	Butcher & empath
Writer	Mechanic	Writer & mechanic

Experiment 2

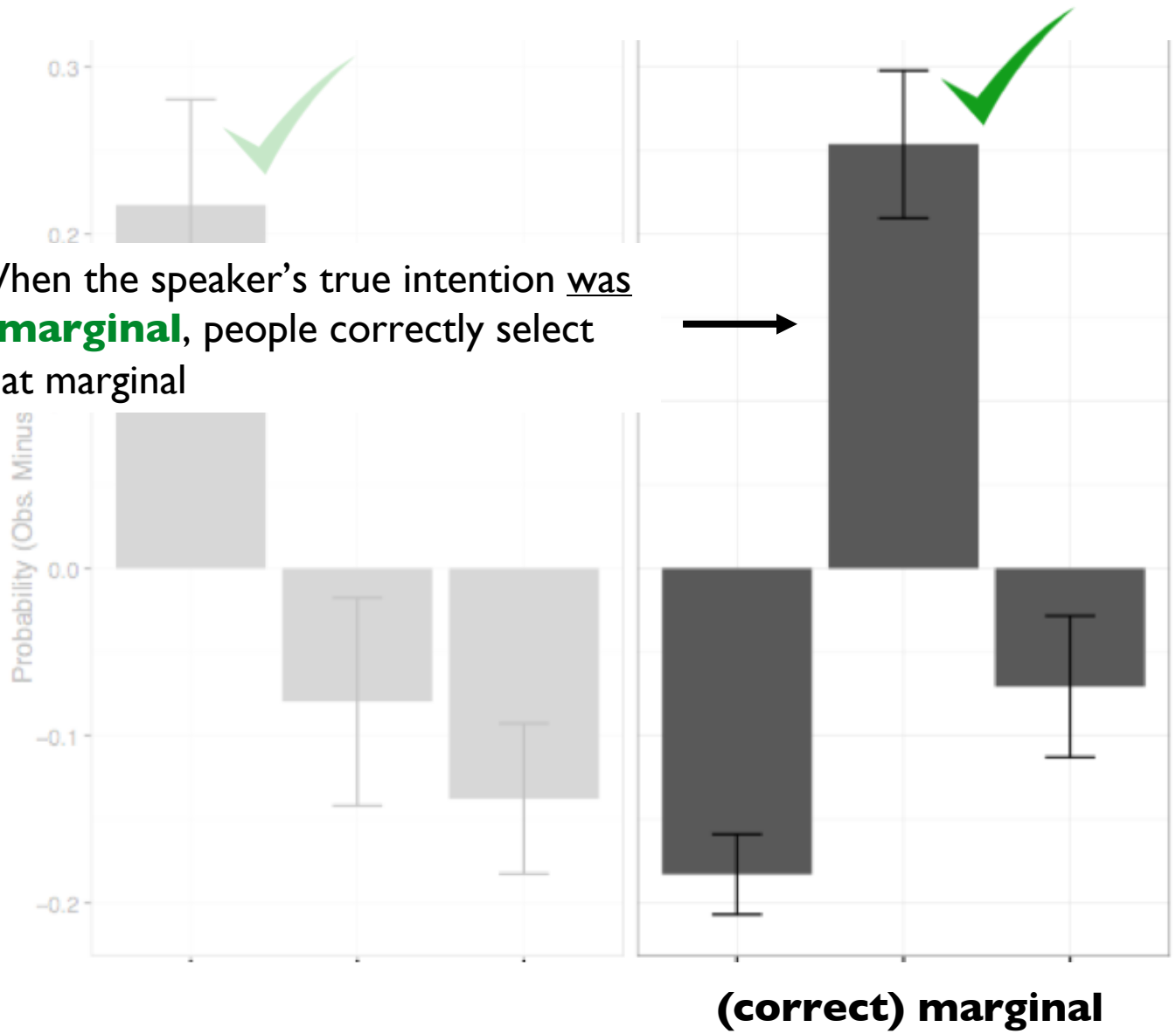
Which of the following do you believe the writer was trying to communicate when they wrote this description:

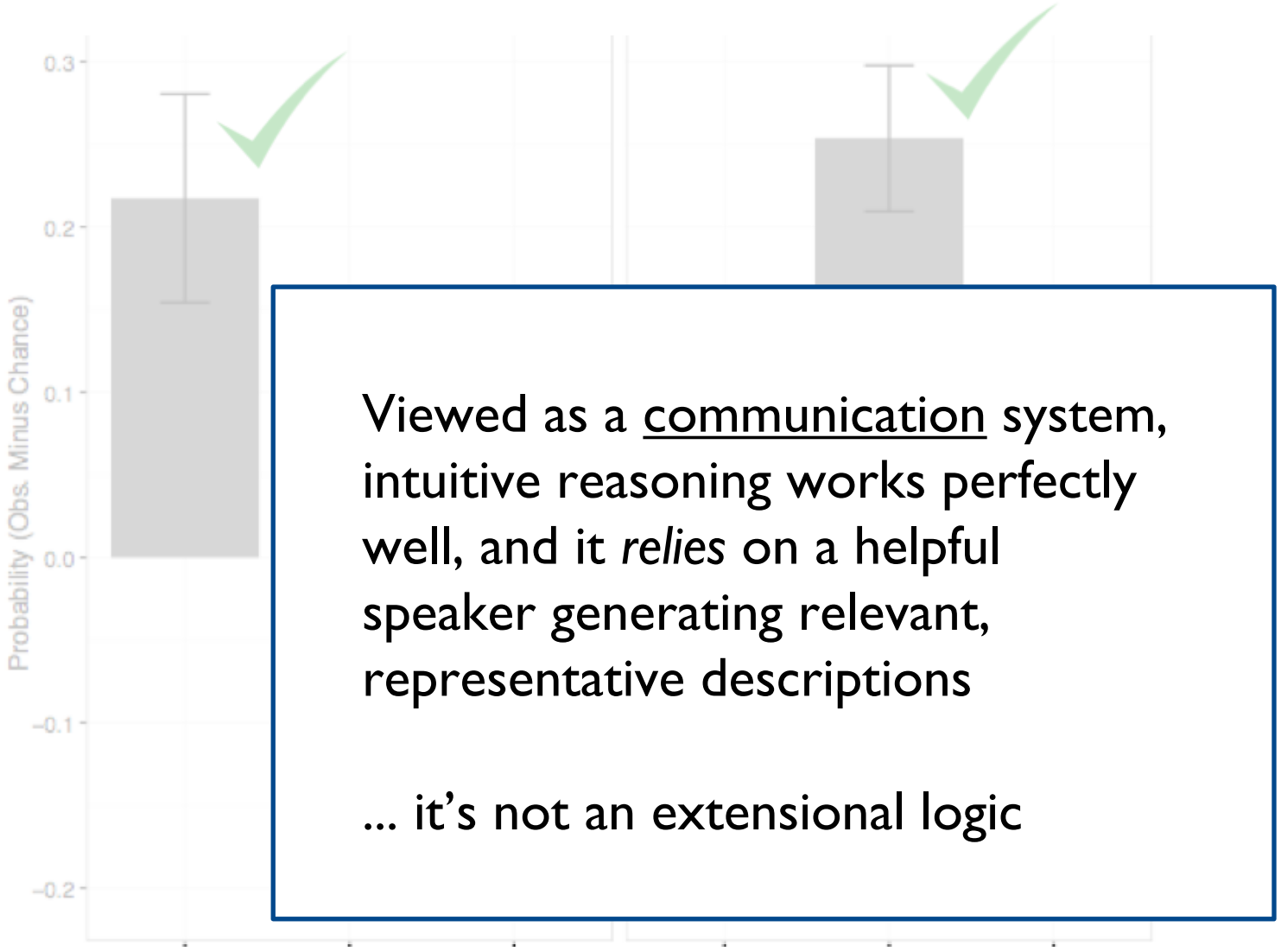
- Linda is a bank teller
- Linda is a feminist
- Linda is both a bank teller and a feminist
- None of the above



When the speaker's true intention was a **conjunction**, people correctly select the conjunction

When the speaker's true intention <u>was</u> a **marginal**, people correctly select that marginal





Viewed as a <u>communication</u> system, intuitive reasoning works perfectly well, and it *relies* on a helpful speaker generating relevant, representative descriptions

... it's not an extensional logic

Experiment 3

How likely is it that Linda belongs to each of the following categories?

- Teacher: _____%
- Feminist: _____%
- Chef: _____%
- Feminist and bank teller: _____%
- Neurosurgeon and pessimist: : _____%

Matched marginal: one of the options matches the speaker's true intent

Experiment 3

How likely is it that Linda belongs to each of the following categories?

- Teacher: _____%
- Bank teller: _____%
- Chef: _____%
- Feminist and bank teller: _____%
- Neurosurgeon and pessimist: : _____%

Mismatched marginal:

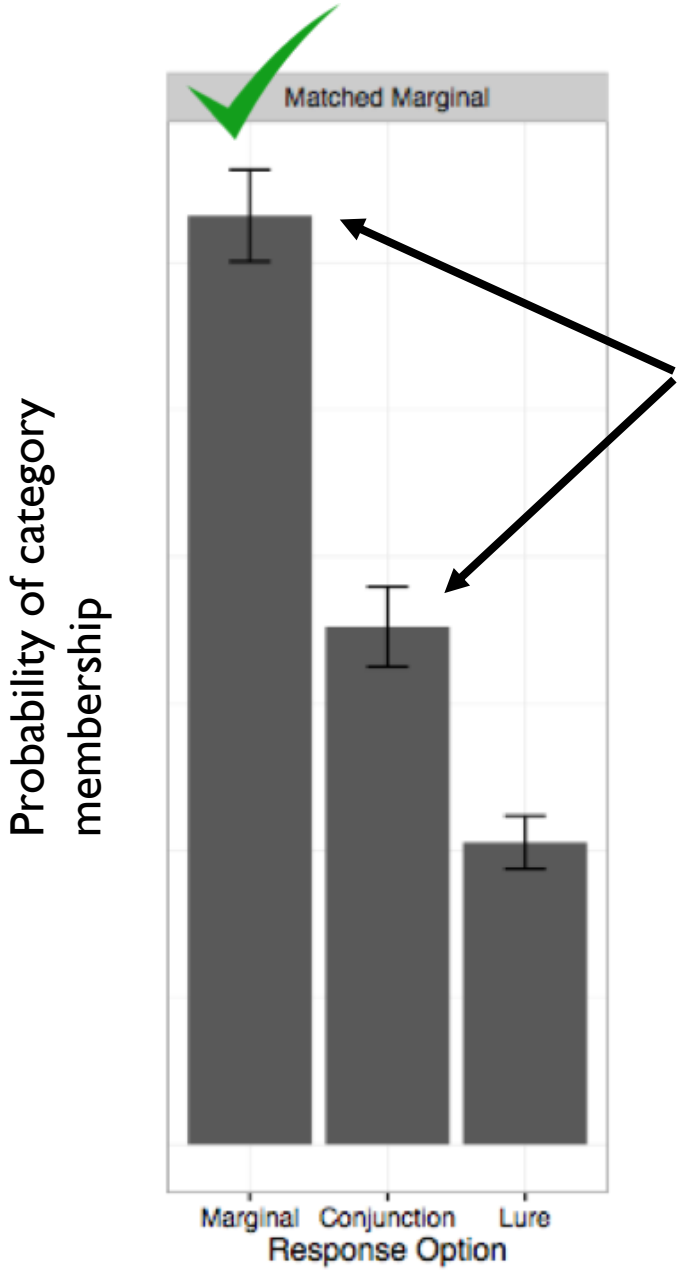
the only way to endorse the correct *intension* (if only partially) is to choose the conjunction

Experiment 3

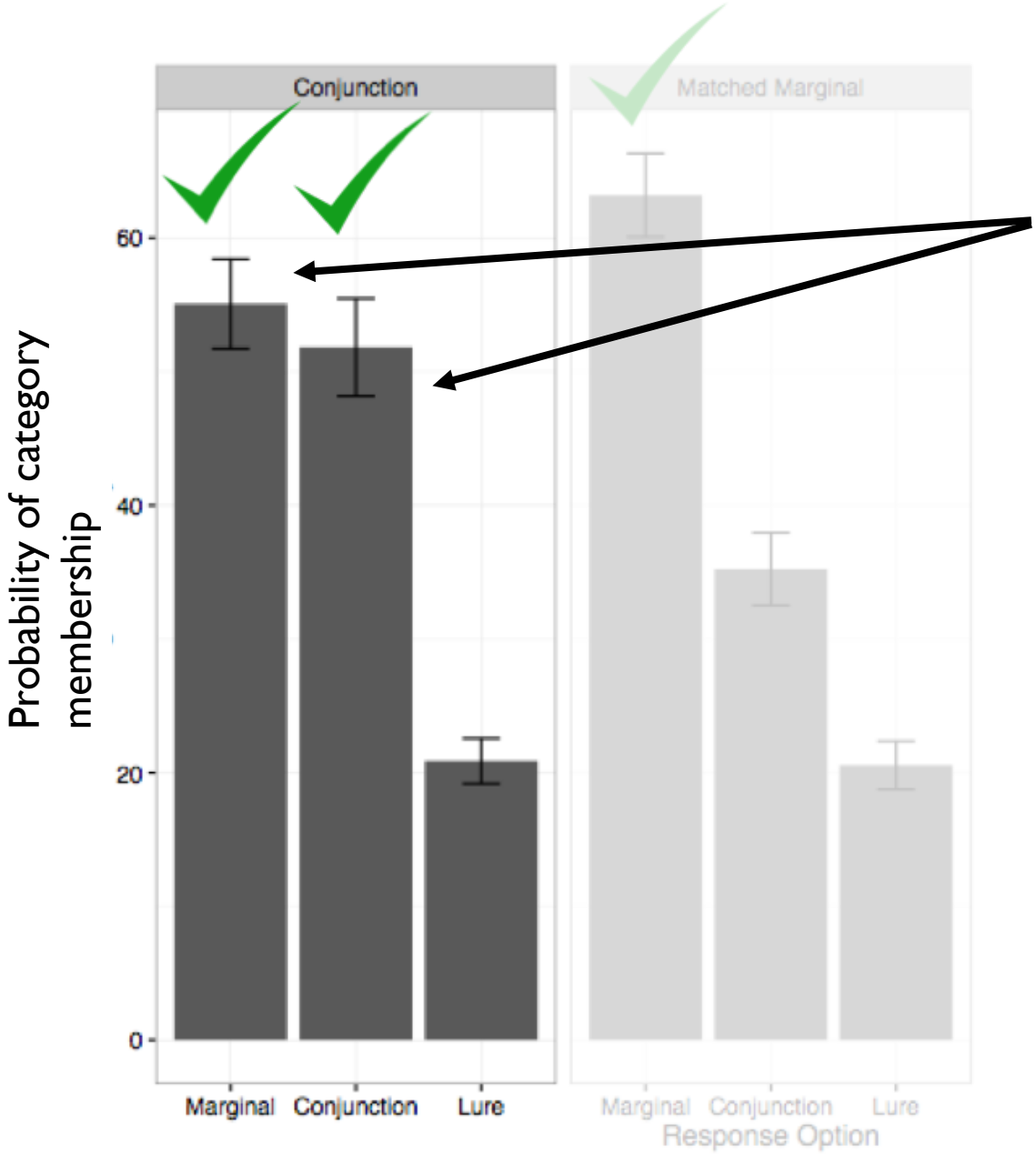
How likely is it that Brenda belongs to each of the following categories?

- Teacher: _____%
- Accountant: _____%
- Activist: : _____%
- Accountant and painter: _____%
- Neurosurgeon and pessimist: : _____%

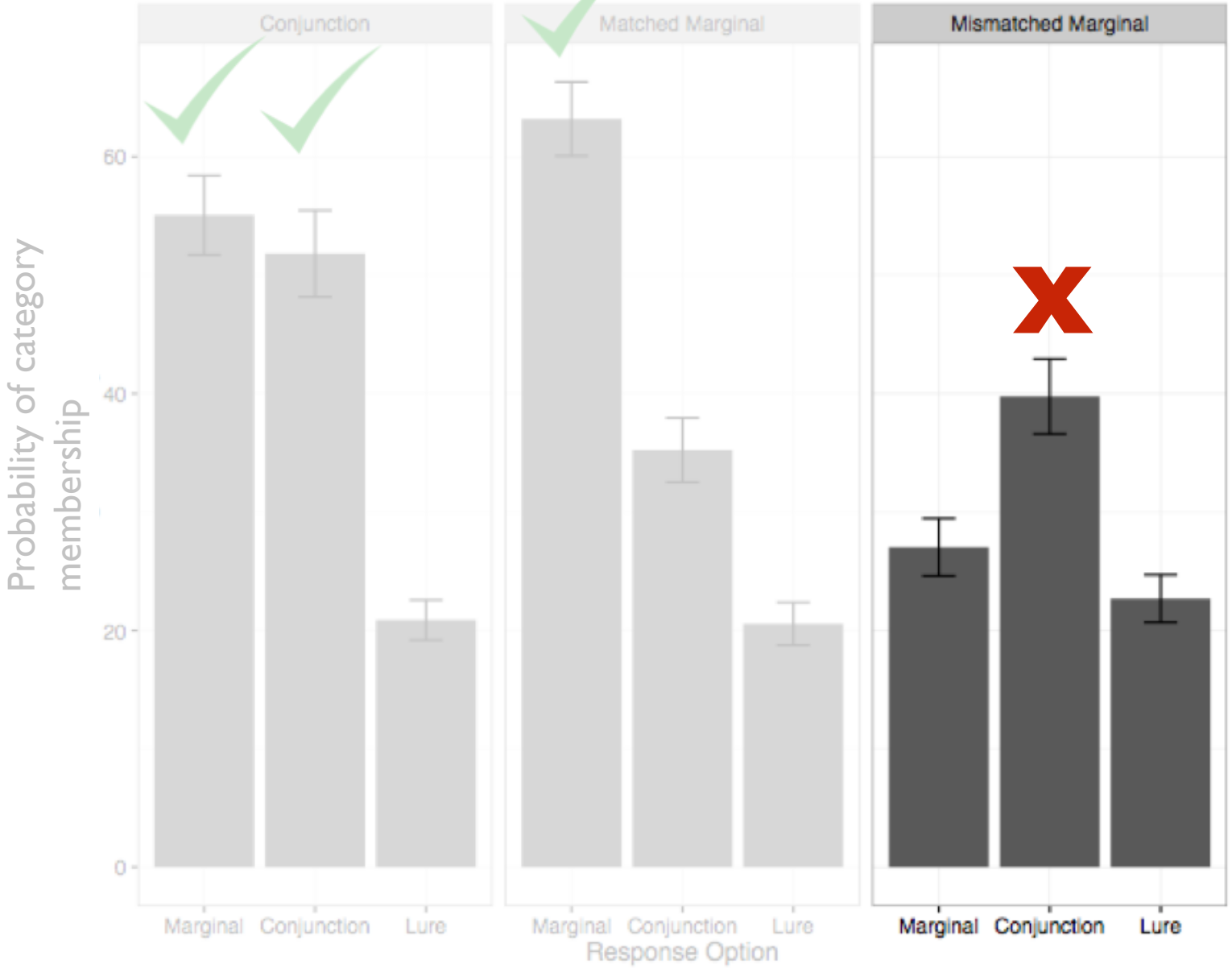
conjunction condition: the true intention is the conjunction



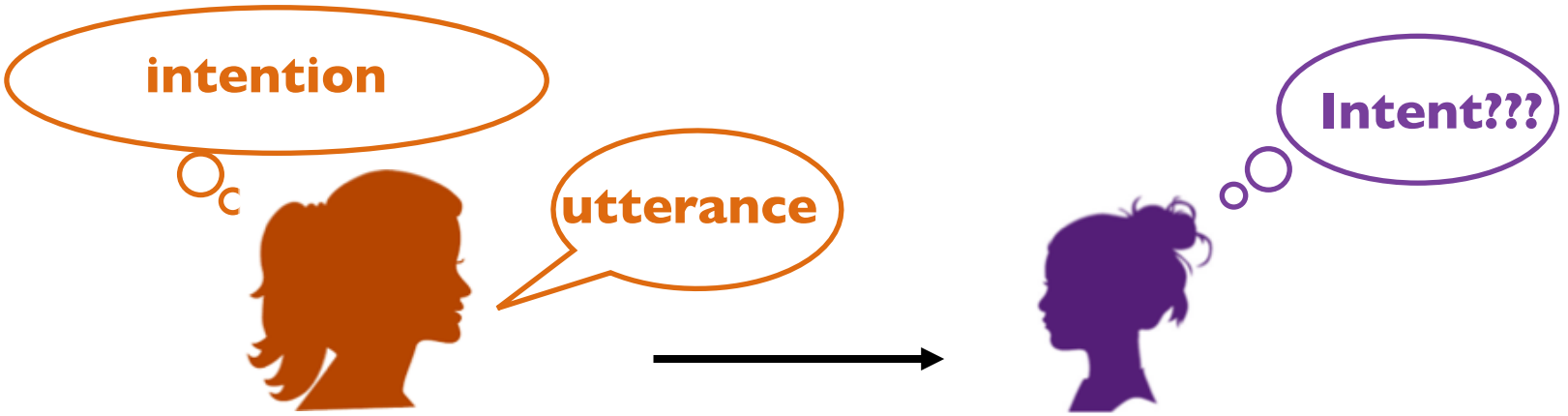
Matched marginal doesn't produce conjunction fallacy



Nor does the conjunction

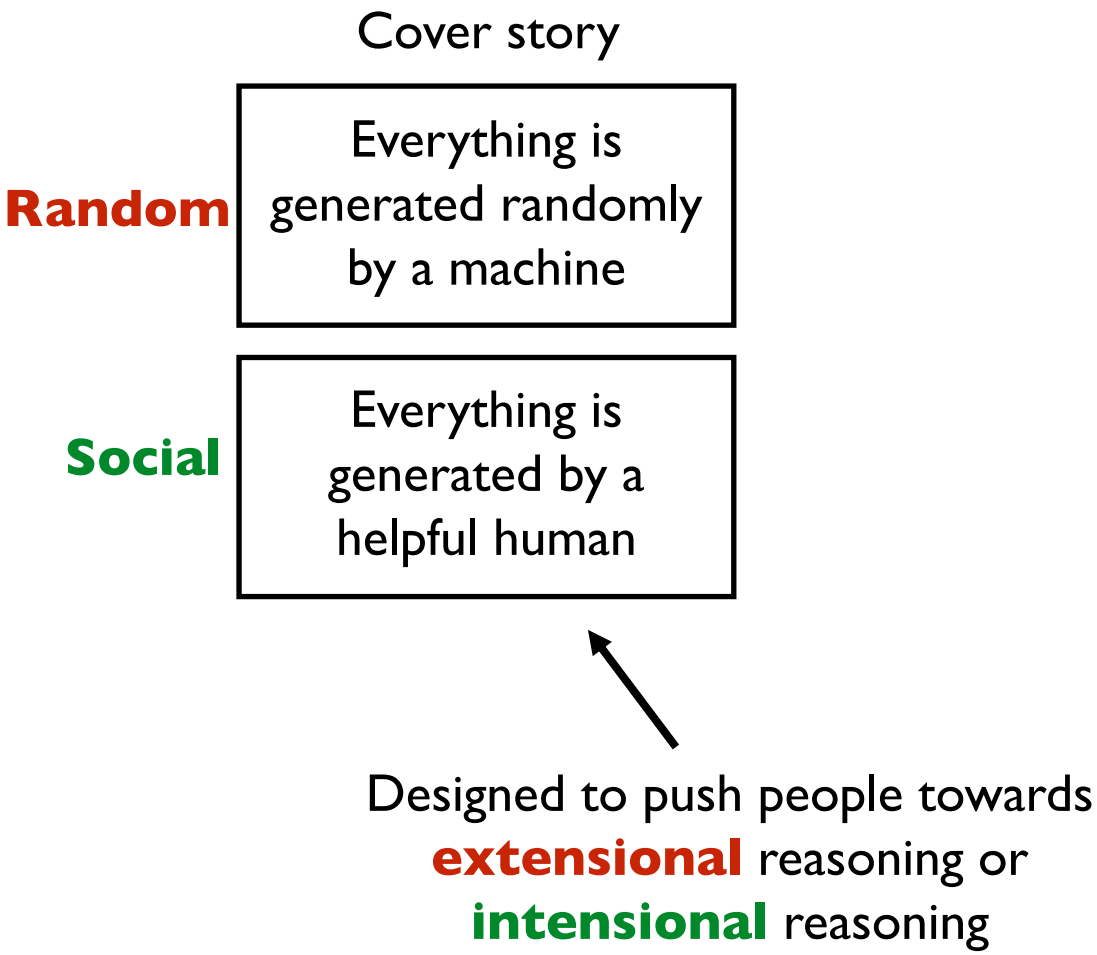

Conjunction
Matched Marginal
Mismatched Marginal
Probability of category membership
60
40
20
0
Marginal
Conjunction
Lure
Response Option

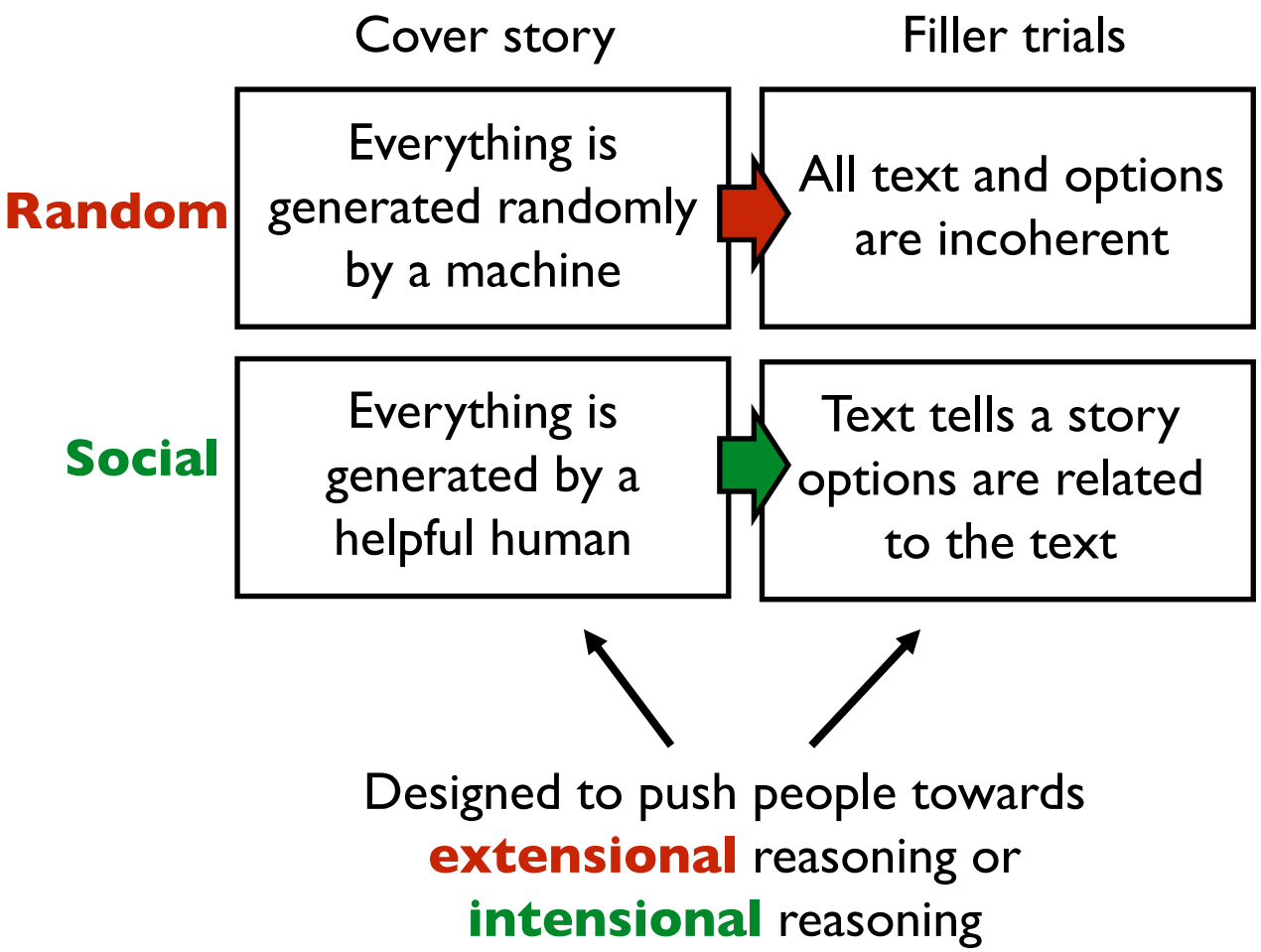
Conjunction effects occur when a *partially correct intensional inference* (feminist bank teller) is placed in conflict with a *technically correct extensional inference* (bank teller)



Experiments 4-6:

Does the strength of the conjunction fallacy depend on the strength of the "demand" to reason intensionally?


Cover story
Random
Everything is generated randomly by a machine
Social
Everything is generated by a helpful human
Designed to push people towards
extensional reasoning or
intensional reasoning


Cover story
Filler trials
Random
Everything is generated randomly by a machine
All text and options are incoherent
Social
Everything is generated by a helpful human
Text tells a story options are related to the text
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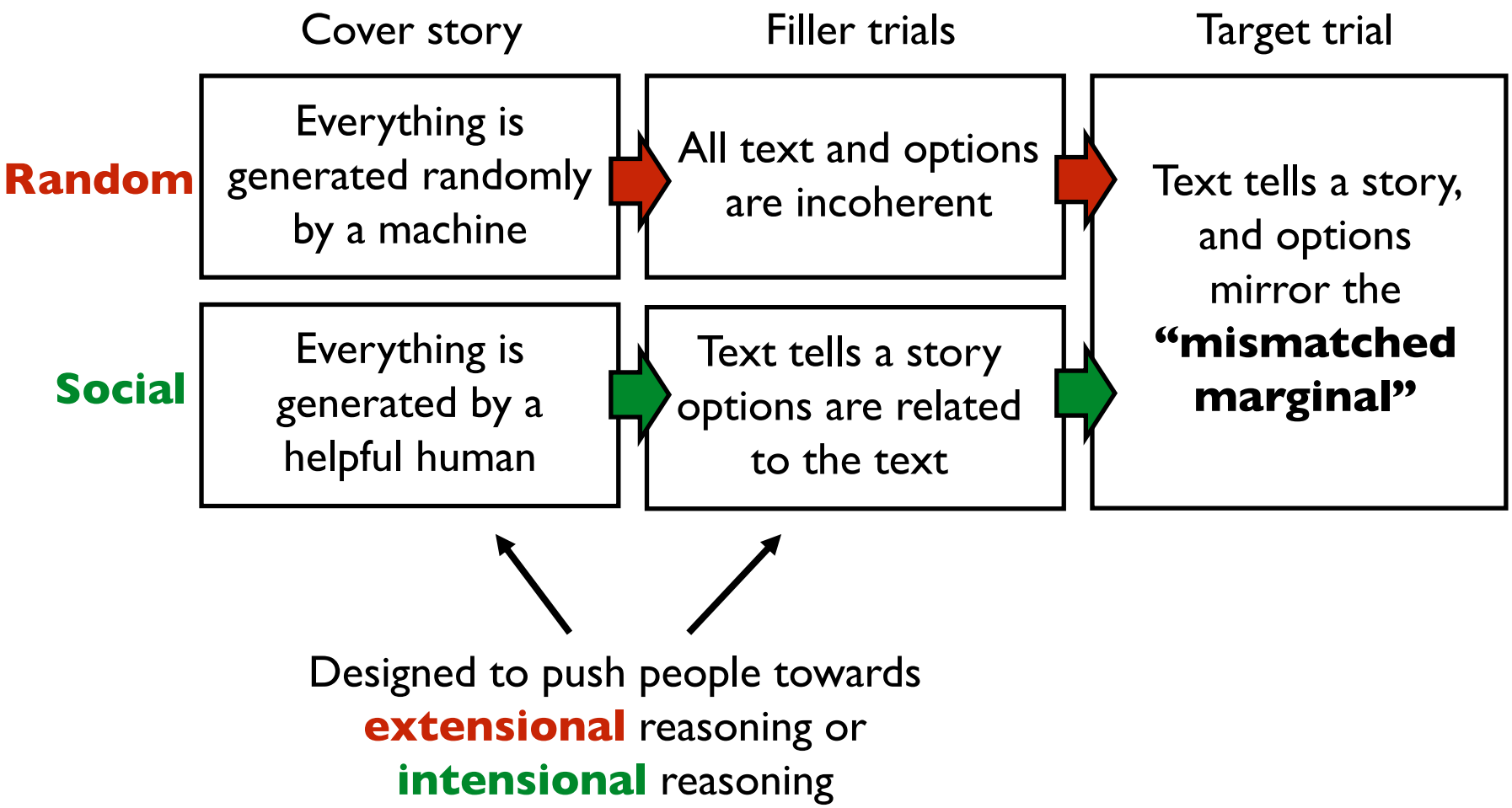
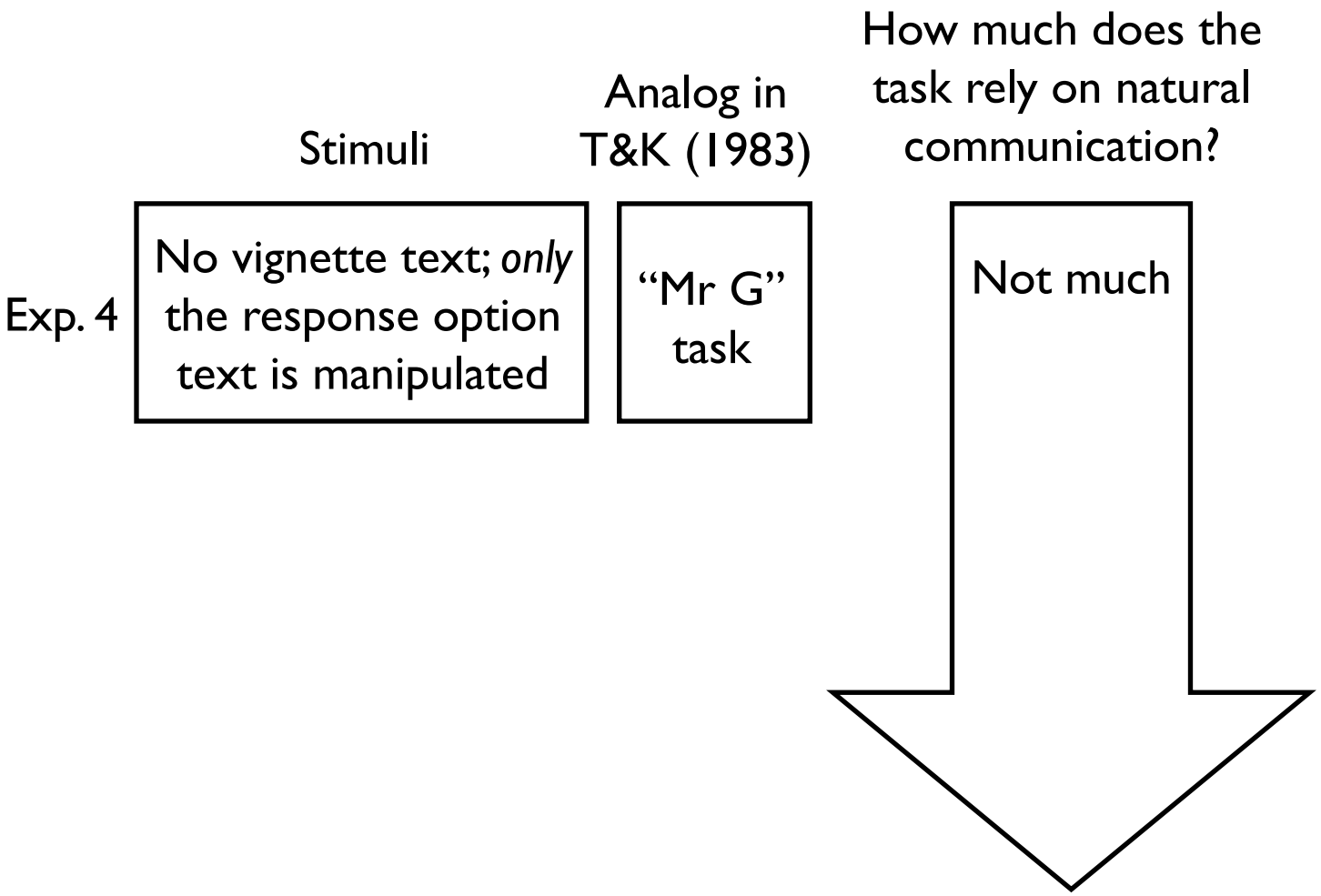
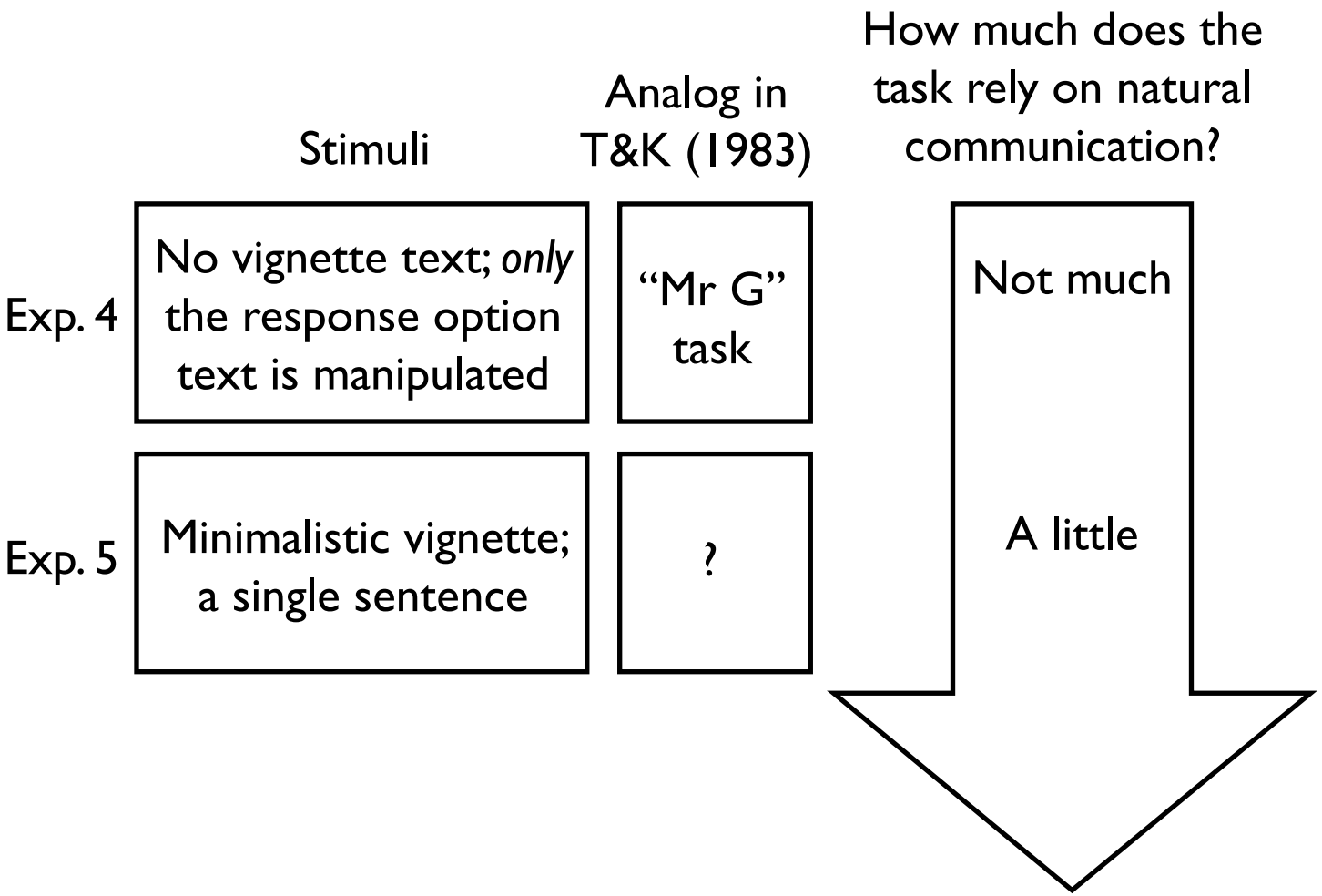

Cover story
Filler trials
Target trial
Random
Everything is generated randomly by a machine
All text and options are incoherent
Social
Everything is generated by a helpful human
Text tells a story options are related to the text
Text tells a story, and options mirror the "mismatched marginal"
Designed to push people towards extensional reasoning or intensional reasoning


How much does the task rely on natural communication?
Analog in T&K (1983)
Stimuli
Exp. 4
No vignette text; *only* the response option text is manipulated
"Mr G" task
Not much


Stimuli
Analog in T&K (1983)
How much does the task rely on natural communication?
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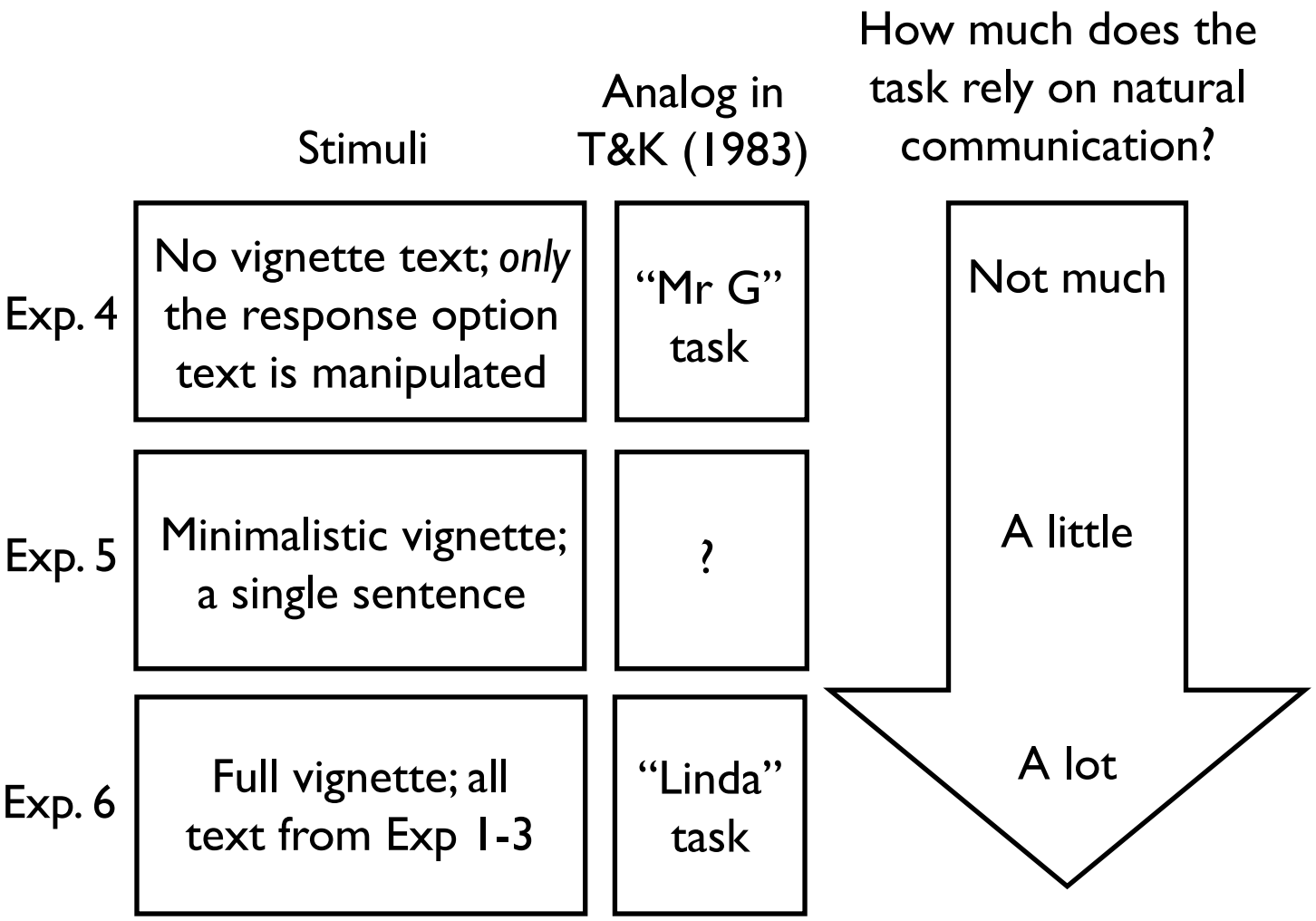
No vignette text; *only* the response option text is manipulated
"Mr G" task
Exp. 5
Minimalistic vignette; a single sentence
?
Not much
A little


Stimuli
Analog in T&K (1983)
How much does the task rely on natural communication?
Exp. 4
No vignette text; *only* the response option text is manipulated
"Mr G" task
Exp. 5
Minimalistic vignette; a single sentence
?
Exp. 6
Full vignette; all text from Exp 1-3
"Linda" task
Not much
A little
A lot

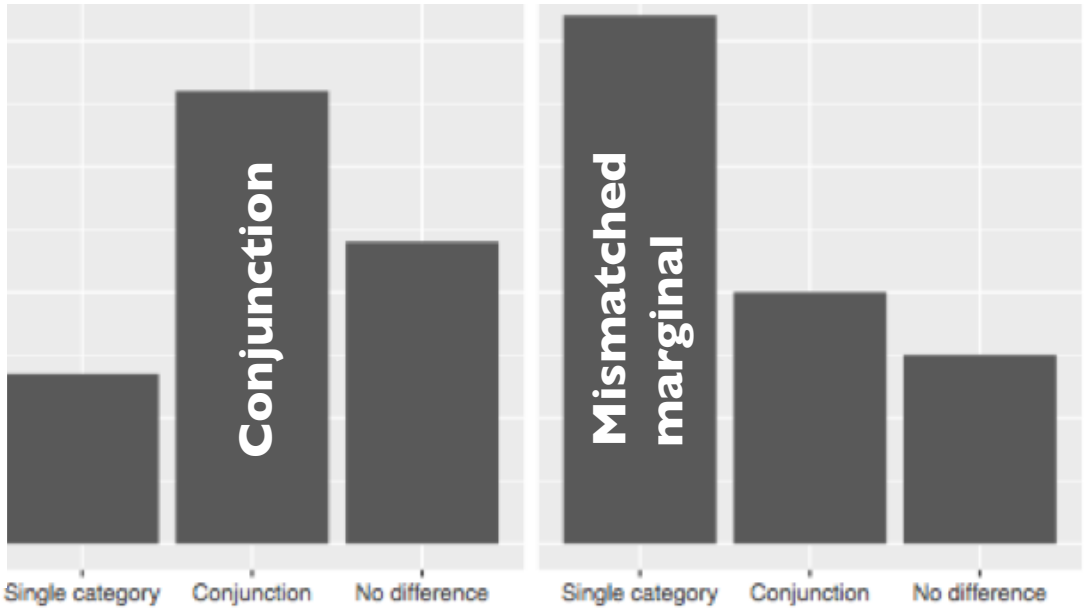
Stimuli

Exp. 4

No vignette;
Just response

The conjunction effect disappears entirely when framed as an extensional reasoning problem

Social **Random**

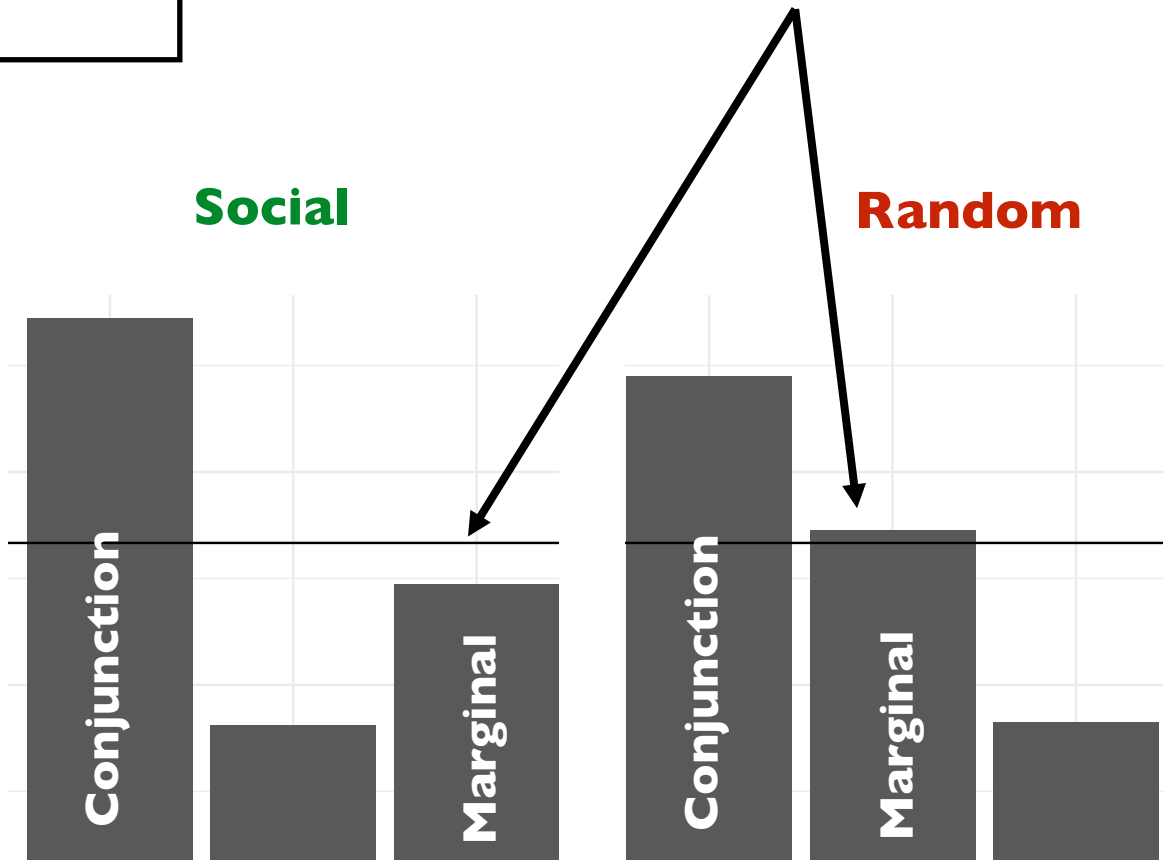


Stimuli

Exp. 5

Minimal vignette

People still produce the conjunction fallacy, but there is a modest effect of the manipulation… A shift in the proportion of people explicitly endorsing the marginal

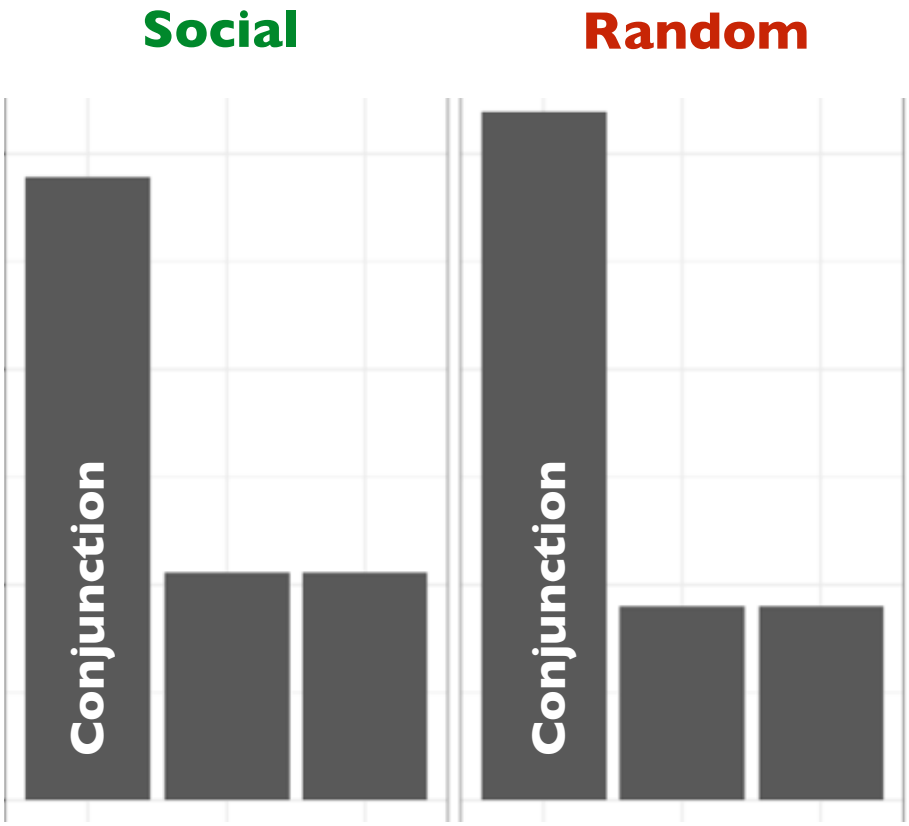


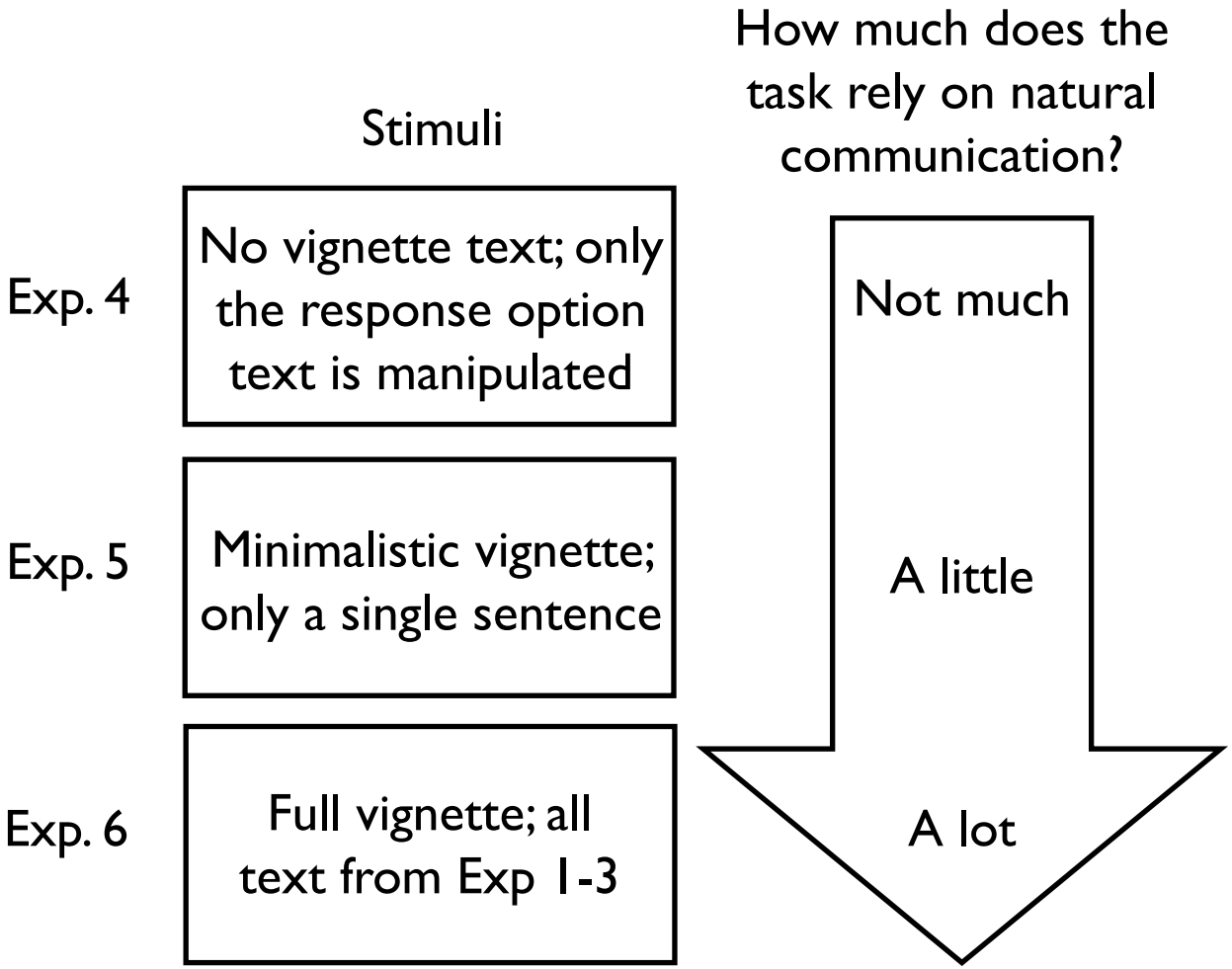
Stimuli

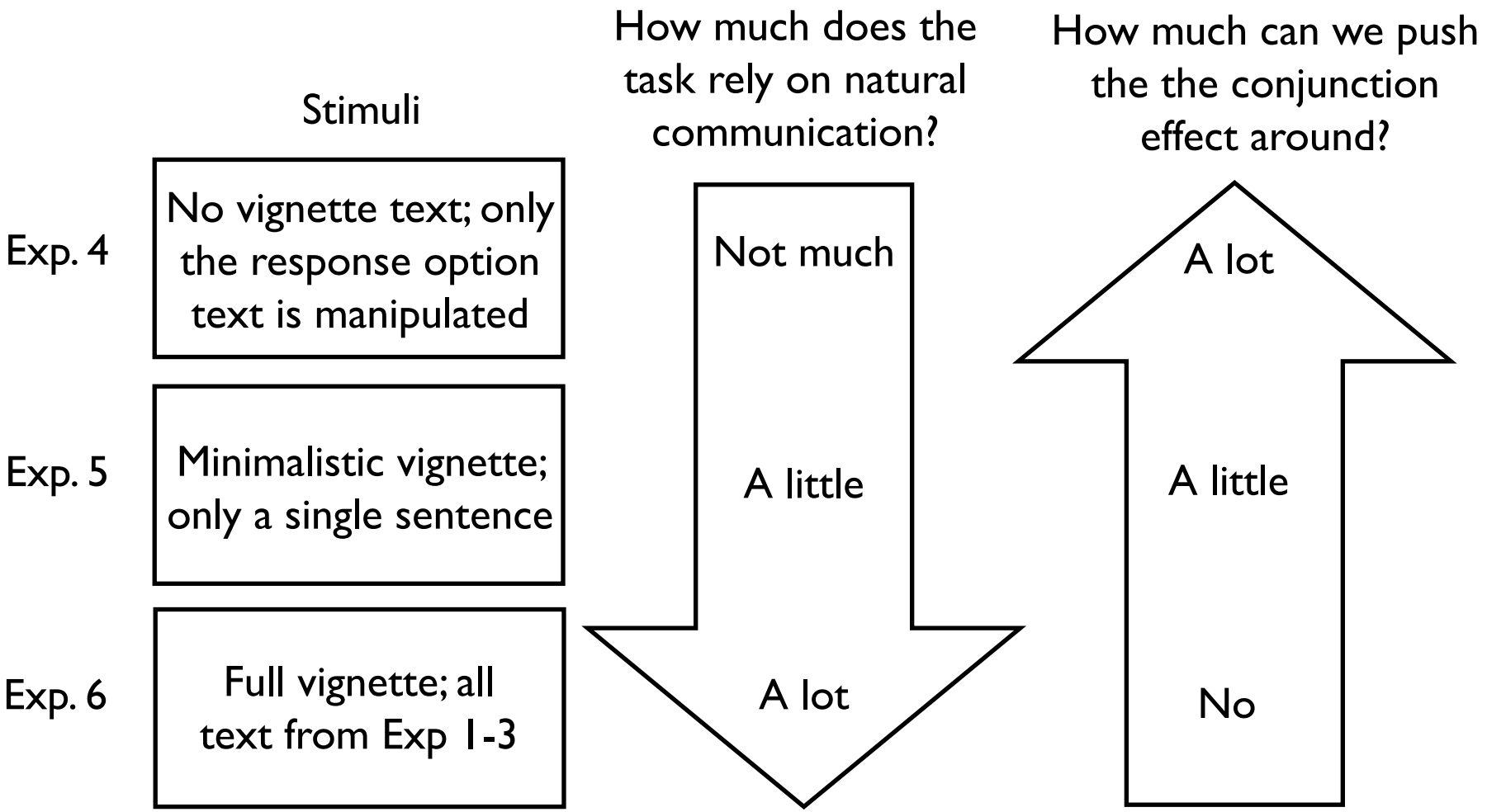
Exp. 6

Full vignette

No effect whatsoever!



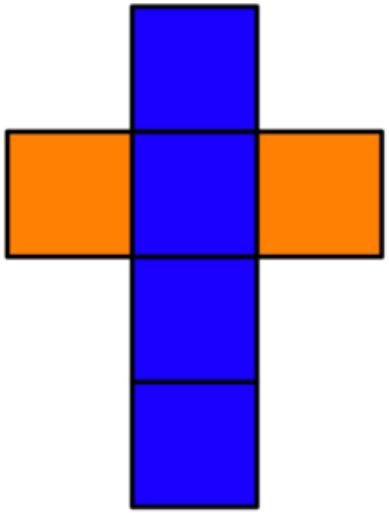

Stimuli
How much does the task rely on natural communication?
Exp. 4
No vignette text; only the response option text is manipulated
Exp. 5
Minimalistic vignette; only a single sentence
Exp. 6
Full vignette; all text from Exp 1-3
Not much
A little
A lot

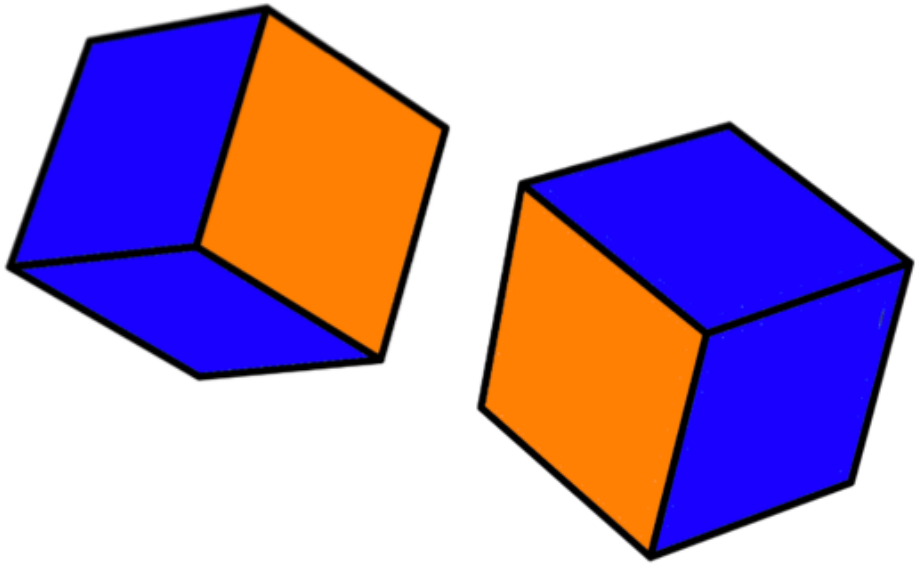

Stimuli
How much does the task rely on natural communication?
How much can we push the the conjunction effect around?
Exp. 4
No vignette text; only the response option text is manipulated
Exp. 5
Minimalistic vignette; only a single sentence
Exp. 6
Full vignette; all text from Exp 1-3
Not much
A little
A lot
A lot
A little
No

Experiments 7-9:

Pragmatic reasoning in a mechanistic probability judgment task

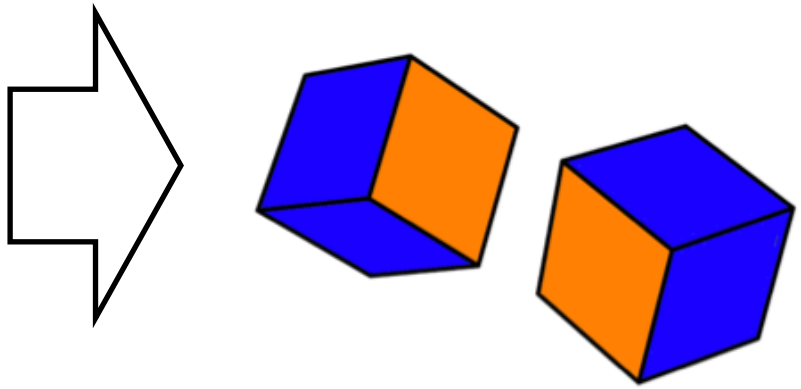
Common methodology: all tasks require people to reason about a die with 4 blue and 2 orange sides





Experiment 7

- Pure probability judgment
- All sequences of length 6 or less



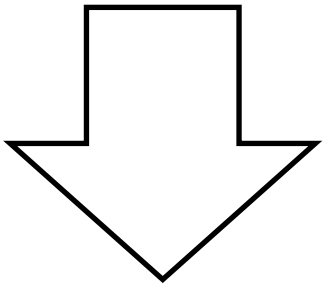
Experiment 8

- Reasoning about intentions
- All sequences of length 6 or less

Experiment 9

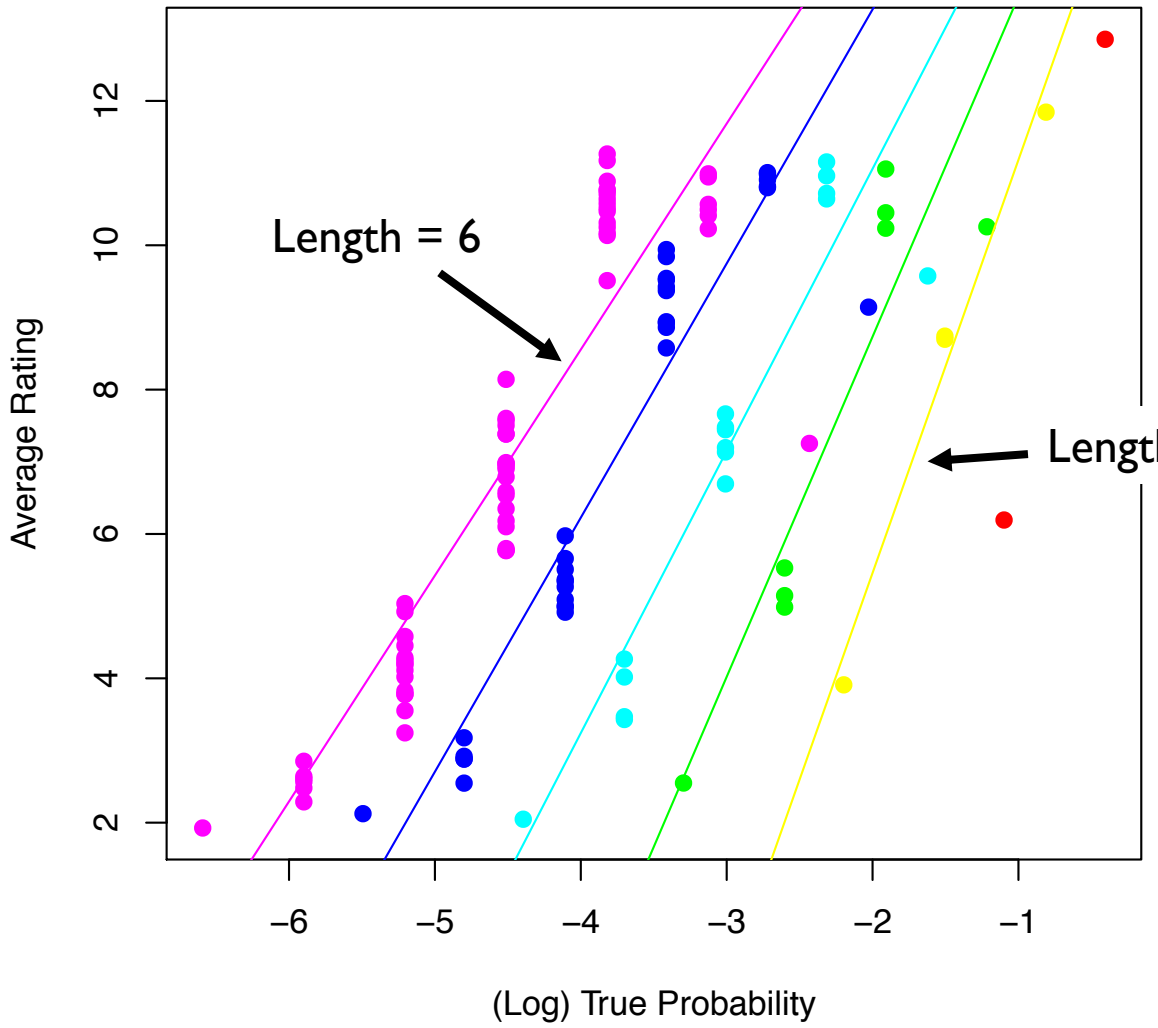
- Manipulate the task demand
- Probabilistic v. pragmatic

Experiment 7



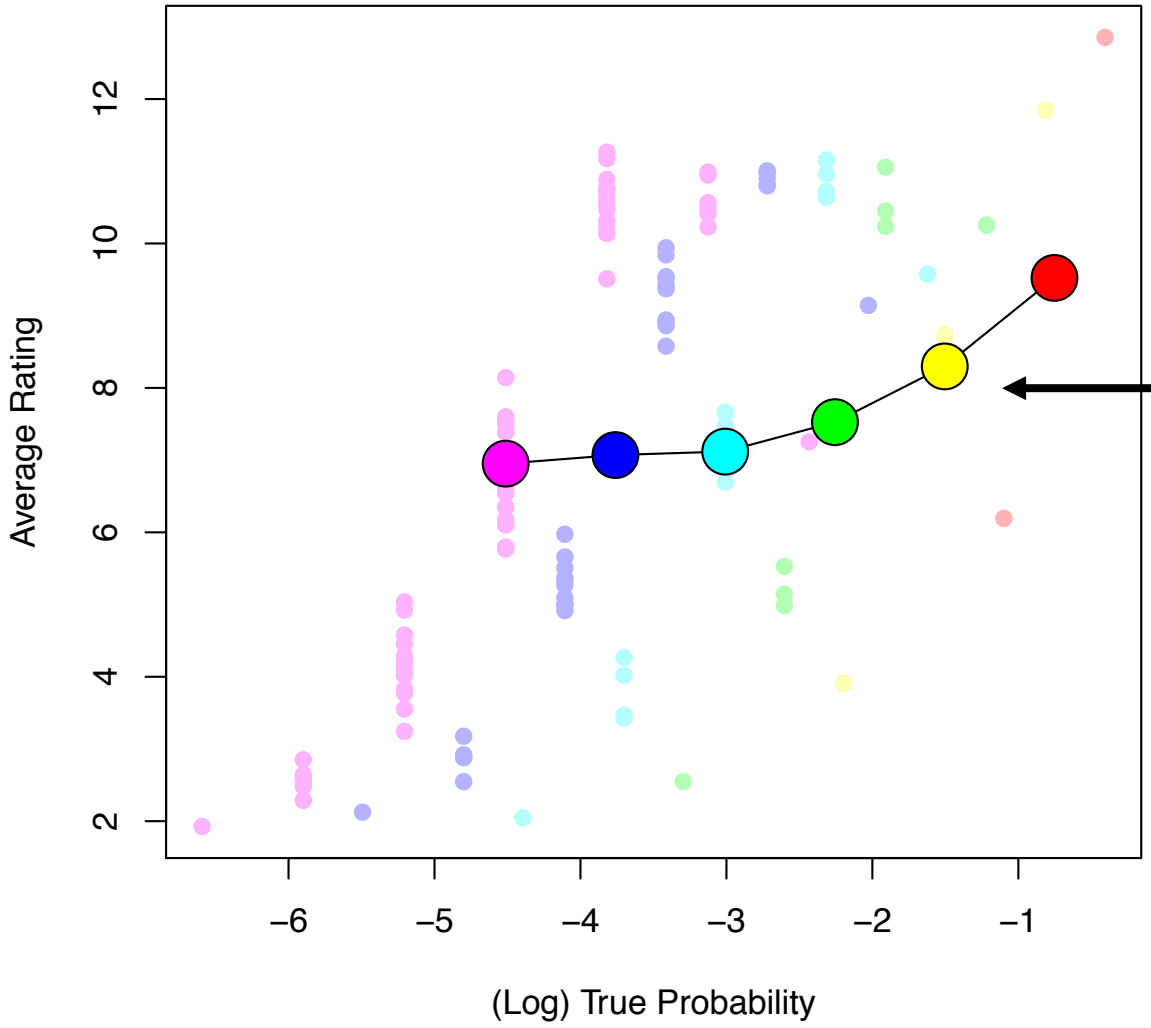
For each trial please indicate how likely you think the sequence is from 1-17, where ***1 is Very Unlikely*** and ***17 is Very Likely***

Experiment 7



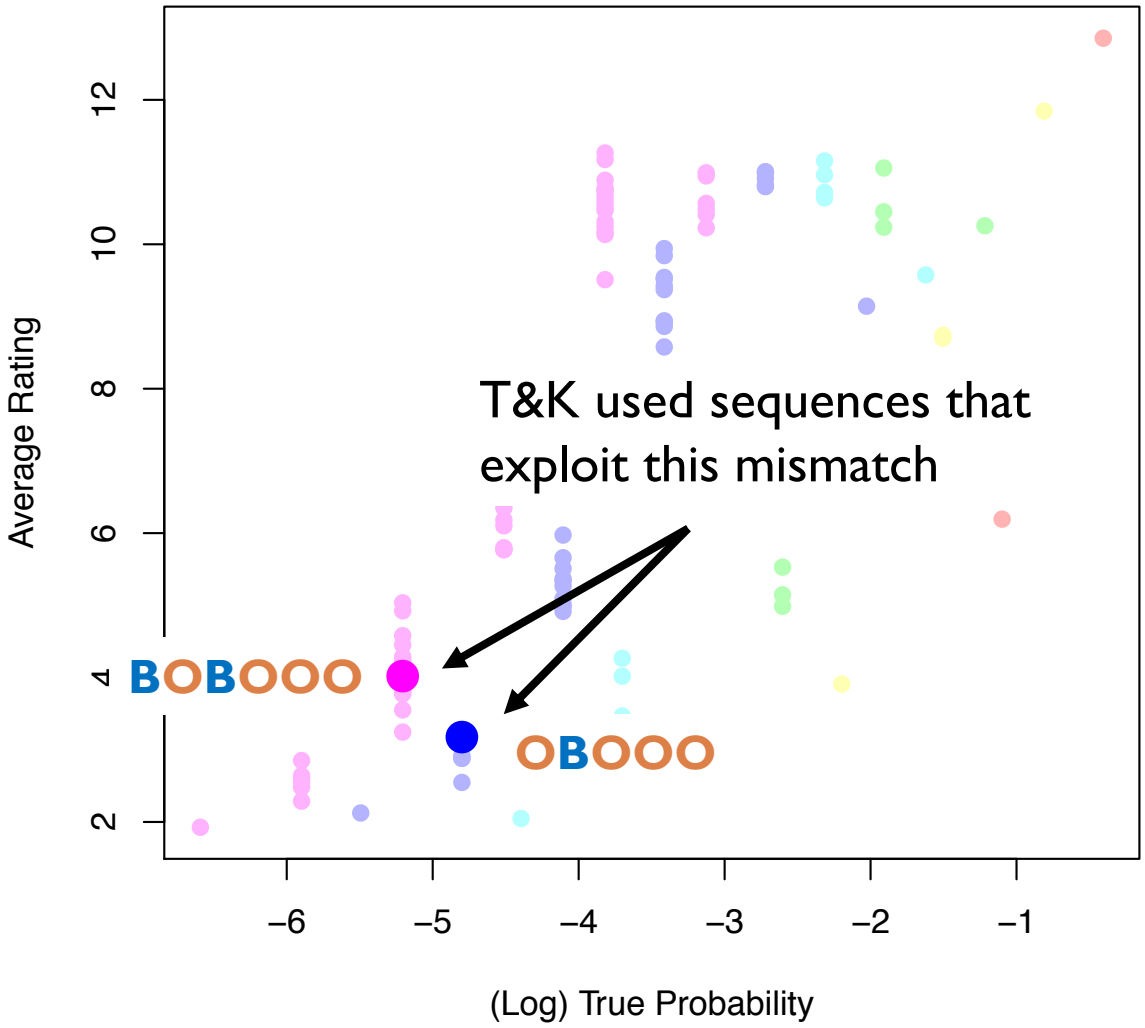
People are well calibrated for sequences of the same length

Experiment 7



There is an adjustment for the length of the sequence, but the effect is modest

Experiment 7



Experiment 7

- No framing
- Pure probability judgment
- All sequences of length 6 or less

Experiment 8

- Reasoning about intentions
- All sequences of length 6 or less

Experiment 9

- Manipulate the task demand
- Probabilistic v. pragmatic

Experiment 8

You should imagine that these sequences have been selected by a helpful teacher, who knows the properties of the dice, to try and teach you about it

Experiment 8

trial: 1/20

The helpful teacher has given you the following sequence...

How many **Blue** sides do you think the dice has?*

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6

How many **Orange** sides do you think the dice has?*

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6

How many **Red** sides do you think the dice has?*

○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6

Experiment 8

Missing data analysis ☺
Gist of it is that people do assume representativeness (not a surprise).

But the data are useful for…

Experiment 7

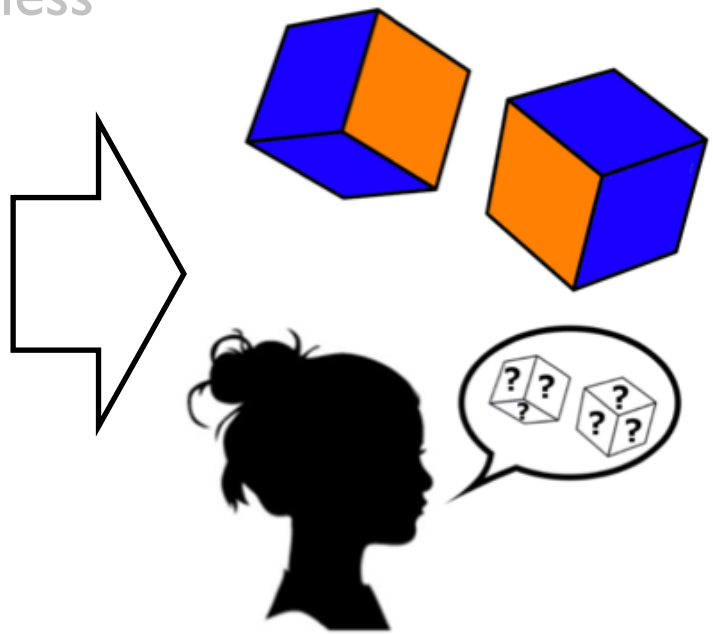
- No framing
- Pure probability judgment
- All sequences of length 6 or less

Experiment 8

- Reasoning about intentions
- All sequences of length 6 or less

Experiment 9

- Manipulate the task demand
- Probabilistic v. pragmatic



Experiment 9

Random

Choose the sequence most likely to appear. After making a selection, people had to actually watch the dice rolls and wait for the outcome sequence before they could move on to the next trial

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Choose the sequence most likely to appear. After making a selection, people had to actually watch the dice rolls and wait for the outcome sequence before they could move on to the next trial

Social

Choose the sequence most likely to teach a human reasoner the properties of the dice. After making a selection, the results from experiment #8 were used to provide feedback about what a real human learner would have inferred

Experiment 9

Random

Choose the sequence most likely to appear. After making a selection, people had to actually watch the dice rolls and wait for the outcome sequence before they could move on to the next trial

Social

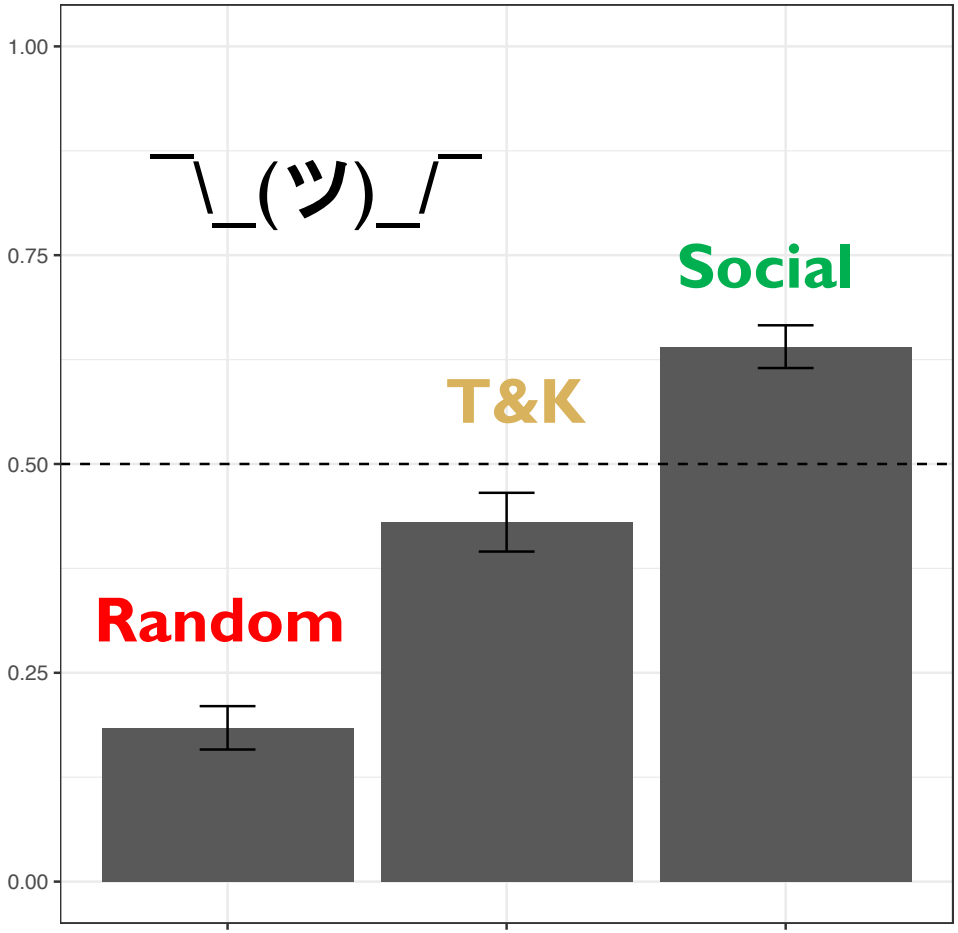
Choose the sequence most likely to teach a human reasoner the properties of the dice. After making a selection, the results from experiment #8 were used to provide feedback about what a real human learner would have inferred

T&K

They were asked to gamble $25 (not real money) on the sequence most likely to appear. Pure description, no feedback or experience provided.

Experiment 9

Proportion of conjunction choices



Conclusions?

"people are smart"…

- Intensional reasoning allows conjunction inference, extensional does not
- The real world necessarily obeys extensional logic; human communication follows intensional logic
- Reasoning can be (partly) changed by shifting the pragmatics

"people are limited"...

- People do sometimes use the wrong kind of logic?
- Strictly construed, T&K style tasks really do ask extensional questions, but people seem to treat them as intensional by default.
- It is very hard to shift this in natural communication, but not so hard when learning from observational data

Thanks!

But didn't X already do this?

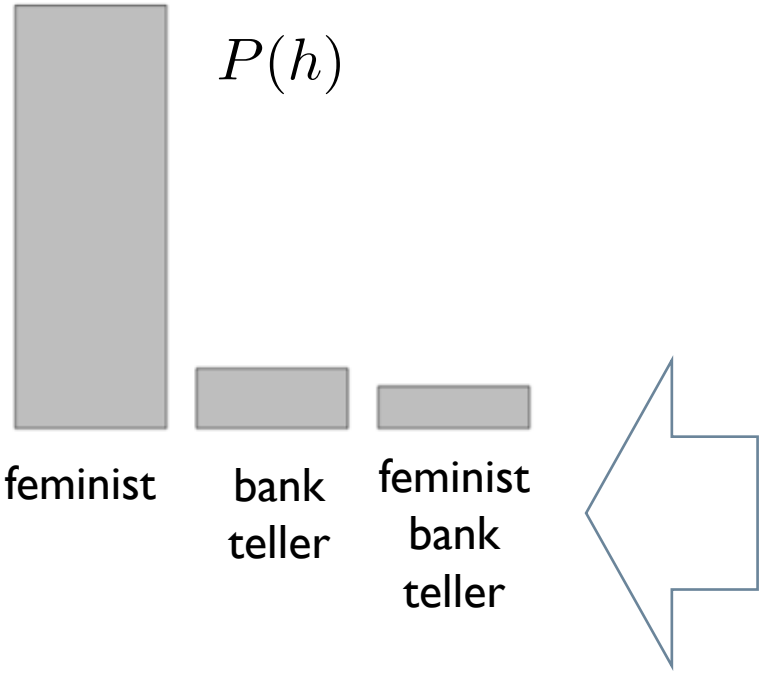
- Tversky & Kahneman… agree with the "extensional vs intuitive" idea, but it can't all be representativeness because we can manipulate the effect by changing the task demands

- Hertwig & Gigerenzer… agree with their "pragmatic" theory, but disagree with the limitation to low level pragmatics about the meaning of the word "and"

- Griffiths, Tenenbaum, Shafto, Goodman etc… agree with Bayesian models of representativeness and pragmatic reasoning (and in fact have implemented them for these tasks!), but those ideas haven't ever been applied to the conjunction fallacy

An overly simplistic Bayesian model of intensional reasoning

prior probability of each category



The important thing is that these are represented as <u>competing</u> hypotheses for the meaning of the text

prior probability of each category

$P(h)$

feminist

bank teller

feminist bank teller

$P(x|h)$

likelihood of each feature according to each category

feminist

bank teller

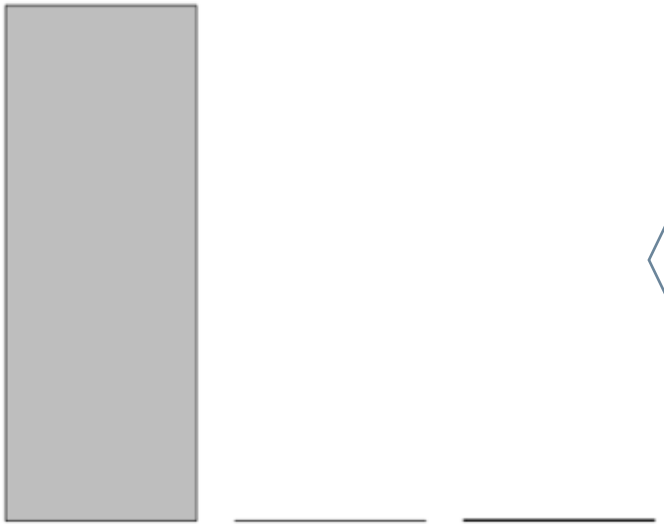
feminist bank teller

prior probability of each category

description of Linda x

Posterior distribution over all three hypotheses for the intension of the Linda story

$$P(h|x) \propto P(x|h)P(h)$$



The intended meaning of the Linda story is that "Linda is a feminist"

Posterior distribution over
two hypotheses for the
intension of the Linda story