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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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
Extensional reasoning

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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)
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: 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 bank teller. Cool.

Dani: What? No she’s not a bank teller. Why would you even think that? That’s just weird. You’re weird
(1) Representativeness is linked to speaker intent: The conjunction fallacy arises when the correct intensional inference conflicts with the correct extensional inference.
Predictions?

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

(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 1-3

Experiments 4-6
Predictions?

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

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.

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

…Linda is a feminist

N=20, UNSW
**Exp 1: “taboo task”**

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

…Linda is a feminist

**Exp 2: “mind reading task”**

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

N=20, UNSW

N=103, MTurk
**Exp 1: “taboo task”**

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

…Linda is a feminist

**Exp 2: “mind reading task”**

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

**Exp 3: “probability judgment task”**

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

N=20, UNSW  
N=103, MTurk  
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.
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.
<table>
<thead>
<tr>
<th>Marginal 1</th>
<th>Marginal 2</th>
<th>Conjunction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feminist</td>
<td>Bank teller</td>
<td>Feminist &amp; bank teller</td>
</tr>
<tr>
<td>Engineer</td>
<td>Jazz musician</td>
<td>Engineer &amp; jazz musician</td>
</tr>
<tr>
<td>Introvert</td>
<td>Chef</td>
<td>Introvert &amp; chef</td>
</tr>
<tr>
<td>Journalist</td>
<td>Anxious person</td>
<td>Journalist &amp; anxious person</td>
</tr>
<tr>
<td>Painter</td>
<td>Accountant</td>
<td>Painter &amp; accountant</td>
</tr>
<tr>
<td>Extrovert</td>
<td>Statistician</td>
<td>Extrovert &amp; statistician</td>
</tr>
<tr>
<td>Pacifist</td>
<td>Boxer</td>
<td>Pacifist &amp; boxer</td>
</tr>
<tr>
<td>Butcher</td>
<td>Empath</td>
<td>Butcher &amp; empath</td>
</tr>
<tr>
<td>Writer</td>
<td>Mechanic</td>
<td>Writer &amp; mechanic</td>
</tr>
</tbody>
</table>
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 was a **marginal**, people correctly select that marginal.
Viewed as a communication 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
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
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 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

- Everything is generated randomly by a machine
- Everything is generated by a helpful human

Designed to push people towards **extensional** reasoning or **intensional** reasoning
Cover story

Everything is generated randomly by a machine

Filler trials

All text and options are incoherent

Everything is generated by a helpful human

Text tells a story options are related to the text

Designed to push people towards extensional reasoning or intensional reasoning
Cover story

Designed to push people towards **extensional** reasoning or **intensional** reasoning

Random

Everything is generated randomly by a machine

Social

Everything is generated by a helpful human

Filler trials

All text and options are incoherent

Target trial

Text tells a story, and options mirror the “mismatched marginal”

Text tells a story, and options are related to the text

Designed to push people towards **extensional** reasoning or **intensional** reasoning
Exp. 4

Stimuli
No vignette text; *only* the response option text is manipulated

Analog in T&K (1983)
“Mr G” task

How much does the task rely on natural communication?

Not much
Exp. 4

Stimuli: No vignette text; only the response option text is manipulated

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Not much

Exp. 5

Stimuli: Minimalistic vignette; a single sentence

Analog in T&K (1983): ?

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A little
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Analog in T&K (1983): ?

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A little

Exp. 6

Stimuli: Full vignette; all text from Exp 1-3


How much does the task rely on natural communication?

A lot
Stimuli

No vignette; Just response

The conjunction effect disappears entirely when framed as an extensional reasoning problem.
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.
Exp. 6

Stimuli

Full vignette

No effect whatsoever!

Social

Random

Conjunction

Conjunction
Stimuli

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

How much does the task rely on natural communication?

Not much
A little
A lot
Stimuli

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Full vignette; all text from Exp 1-3

How much does the task rely on natural communication?
- Not much
- A little
- A lot

How much can we push the conjunction effect around?
- 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
People are well calibrated for sequences of the same length.

**Experiment 7**

![Graph showing the relationship between average rating and (log) true probability for different lengths.](image-url)
There is an adjustment for the length of the sequence, but the effect is modest.
**Experiment 7**

T&K used sequences that exploit this mismatch.
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

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

![Sequence](image)

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
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
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.
**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**.
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

Social
T&K
Random

\_(_(ツ)_/\_
Conclusions?
• 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 smart”…

• 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

\[ P(h) \]

The important thing is that these are represented as competing hypotheses for the meaning of the text
the prior probability of each category

\[ P(h) \]

likelihood of each feature according to each category

\[ P(x|h) \]
prior probability of each category

\[ P(h) \]

\[ P(x|h) \]

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.