FOL-low your intuition!

A critical inspection of classical first-order logic in light of empirical data

Agenda

- research questions
- method
- results
  - existence and non-existence
  - truth-value gaps and gluts
  - conditionals and explosion
- answers to the research questions
- reflection and further research

Logic and Intuition

If one already had a logic in the sense of a systematic theory of correct deduction, it would not be necessary to test infinitely many cases; instead, one could refer to a general principle of that theory. But where does one get such a theory from? The answer is: One builds it. Our intuitions are the starting point of every logic as a general theory of valid reasoning. And they may be a matter of dispute. (Strobach, p. 19)

Research Questions

1) Are the theorems of classical logic in line with our preformal logical intuitions?

2) If this is not the case, which formal systems reflect our intuitions more adequately?

Sample

- attendants of the first lecture on *Introduction to Logic and Argumentation Theory* (n=221)
- mainly (85,5%) no prior knowledge of formal logic
- slightly more (4,5%) women than men
- predominantly (90%) between 18 and 25 years old

Method: Inferences

Questions	Possible Answers
What does your intuition say: Does the sentence labeled with "K" follow from the sentences labeled with "P"?	yes | no
How strong is your intuition?	4-point-scale from *very weak* to *very strong* + alternative option

Method: Formulas

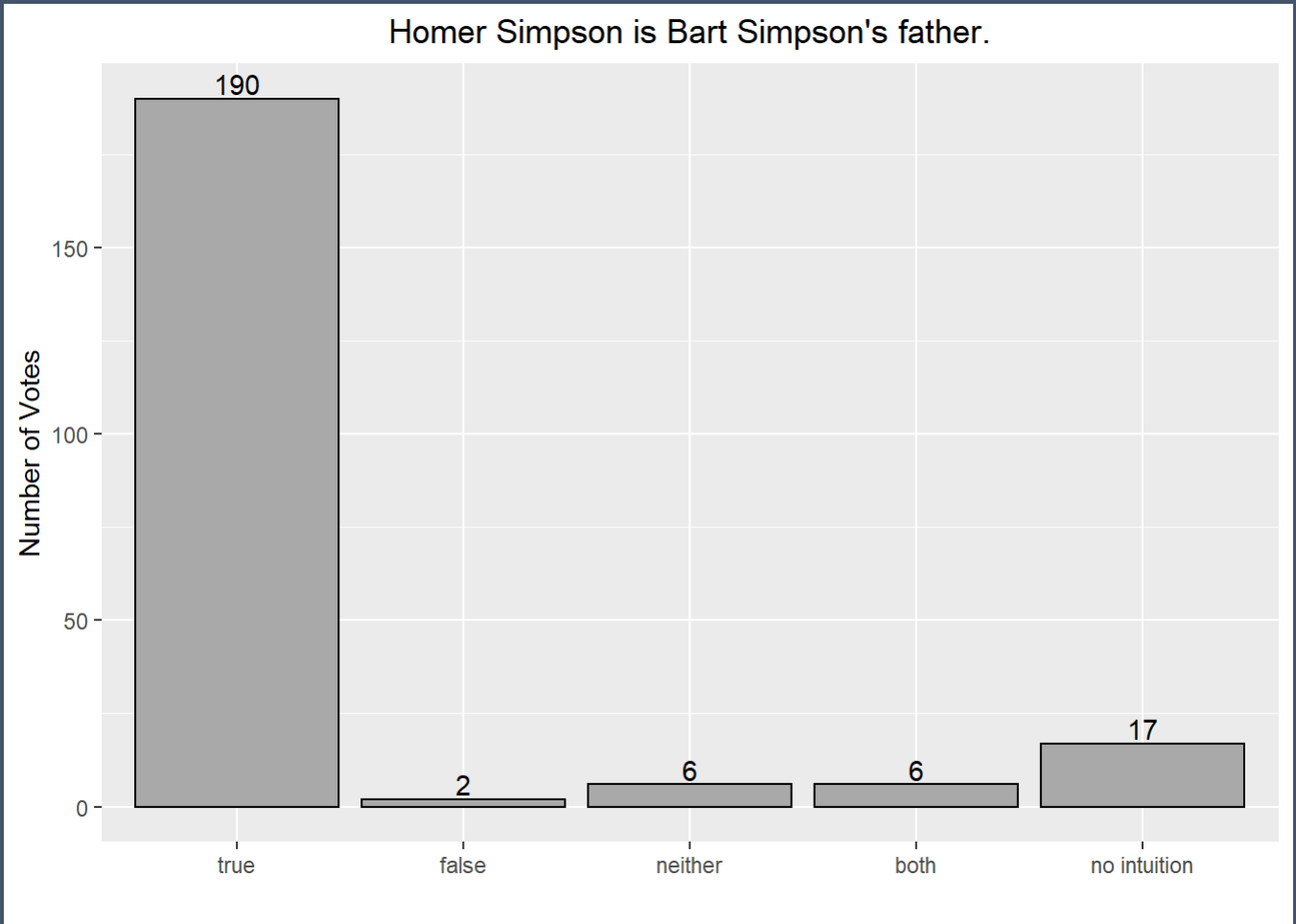
Question	Possible answers
Which truth content would you intuitively assign to the following sentences?	true | false | neither true nor false | both true and false
How strong is your intuition?	4-point-scale from very weak to very strong + alternative option

Method: Areas of Logic

The survey focused on intuitions about
- existence and non-existence
- truth-value gaps and gluts
- conditionals and the principle of explosion.

→ purely descriptive evaluation of the data!

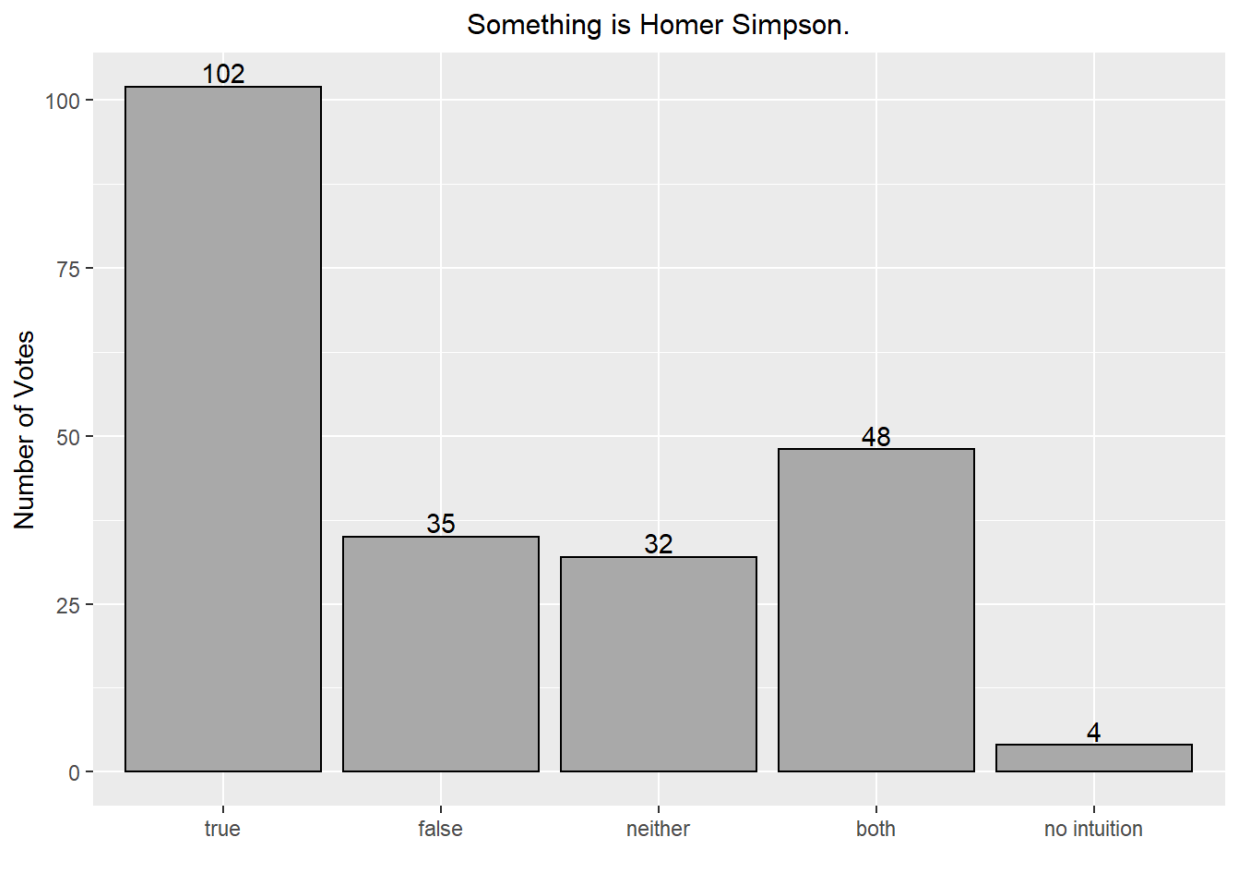
Empty terms

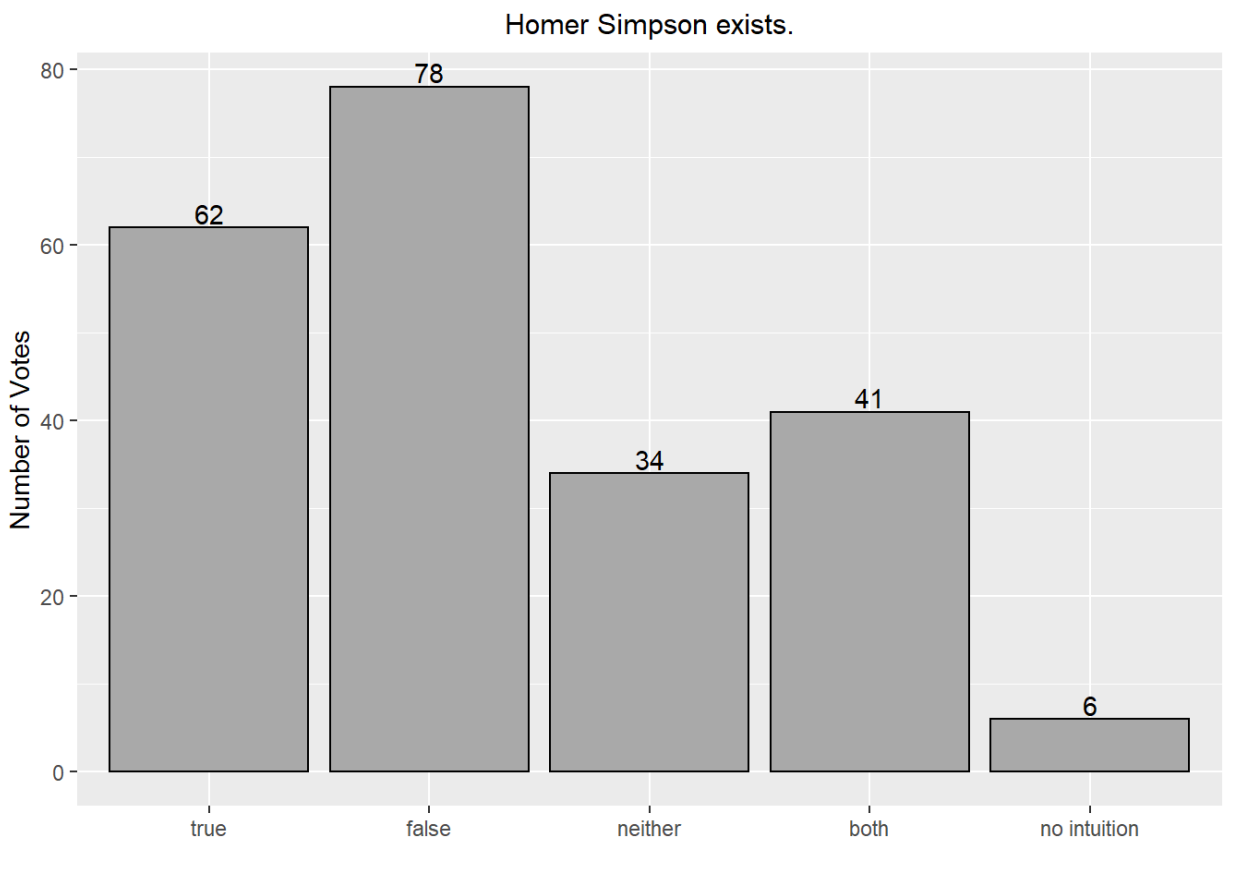


true: 86%

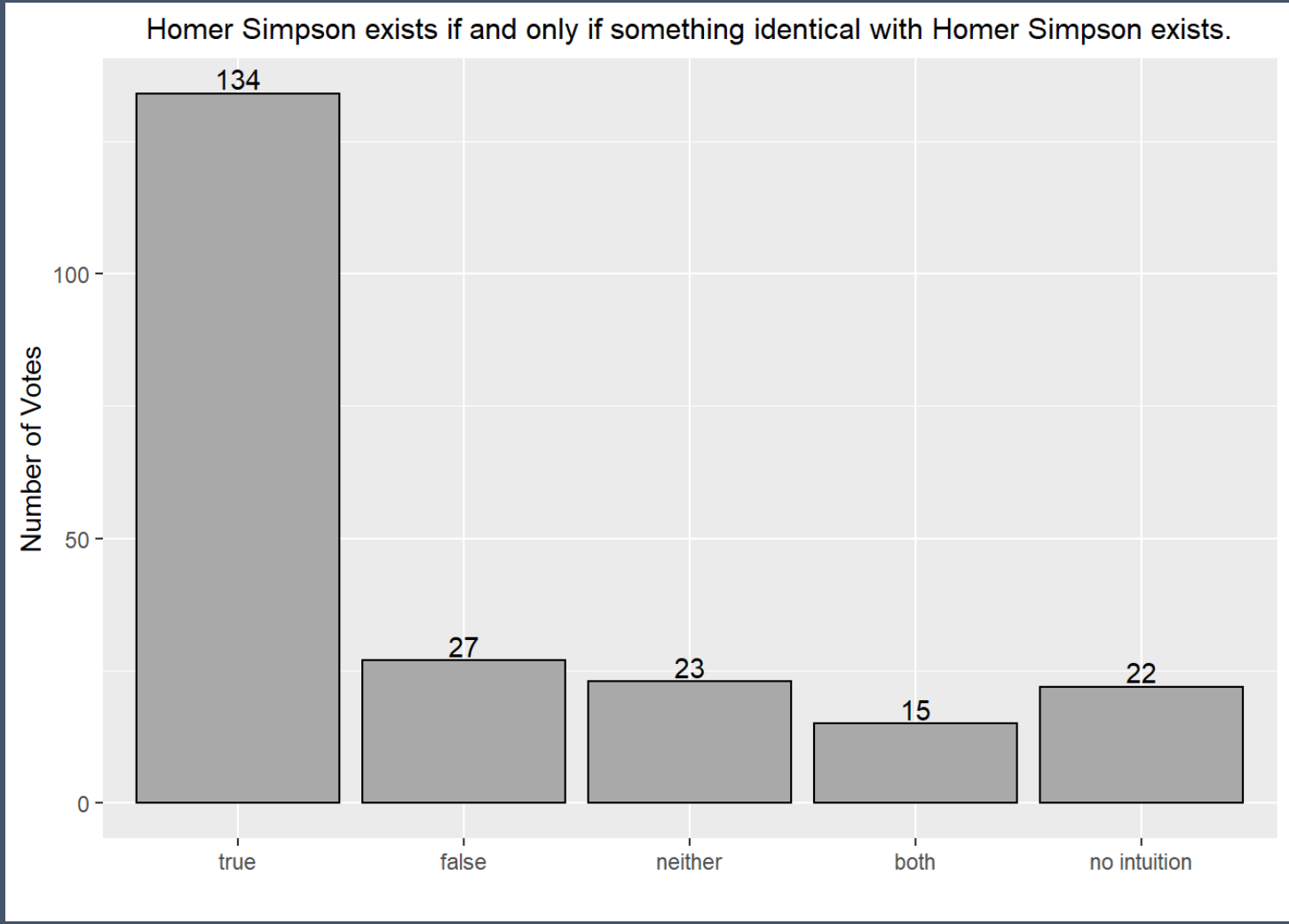
very strong intuition: 78%

Existence vs. Subsistence



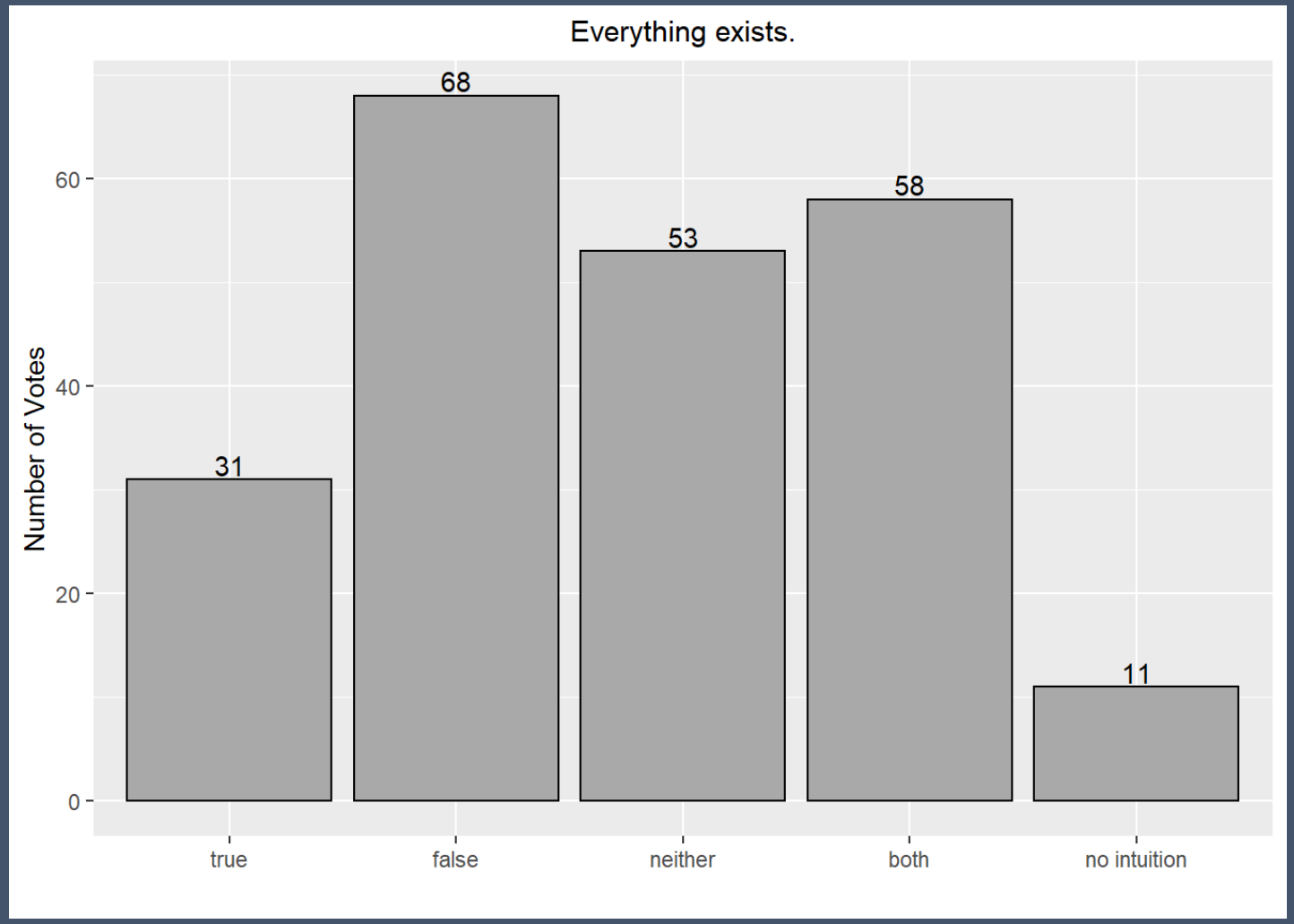


The existence predicate E!



true: 60%
Strong int.: 75%

Quine's legacy



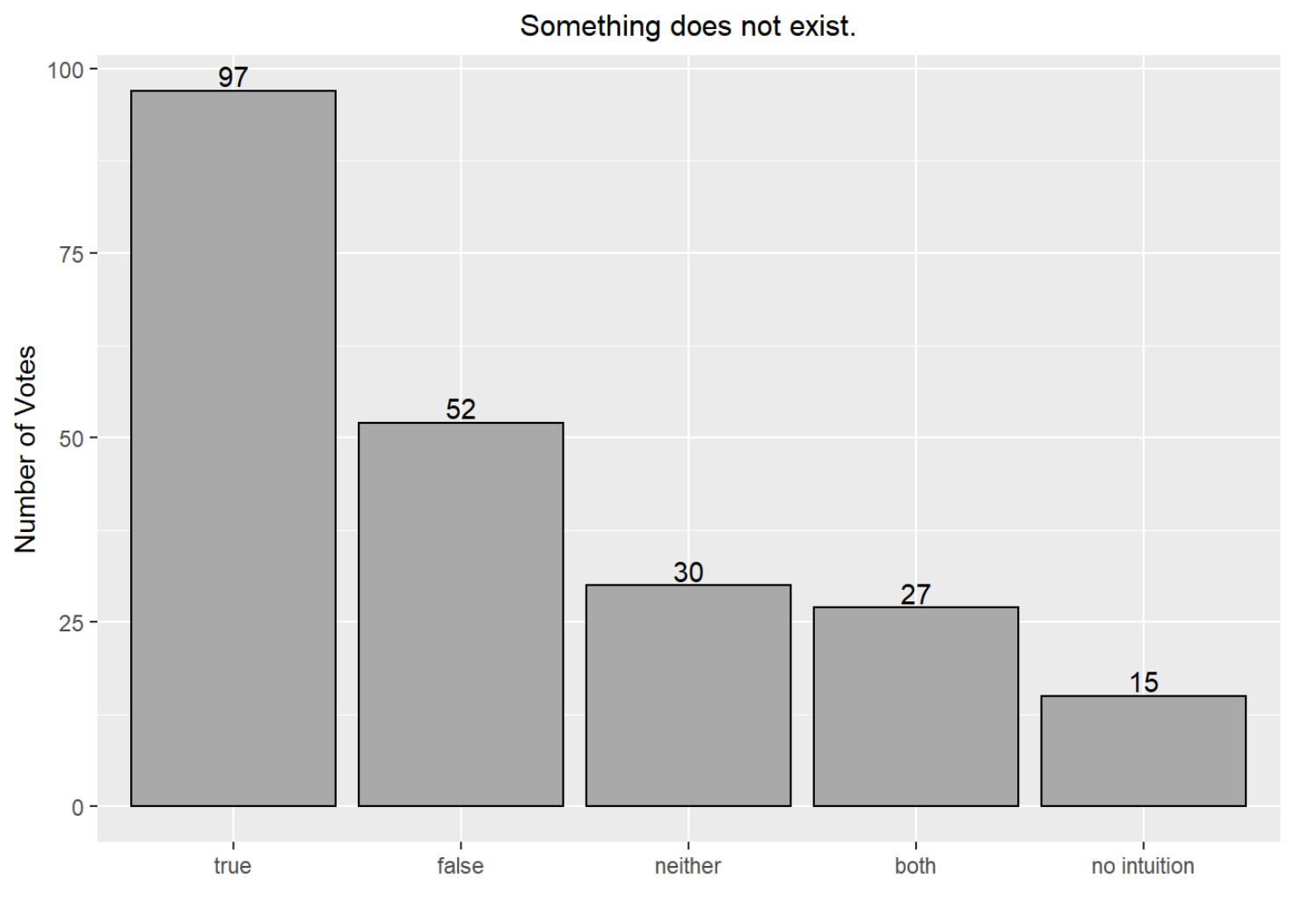
true: 14%
false: 30%
neither: 24%
both: 26%

Quine's legacy

	very weak	weak	strong	very strong
true	4	4	11	12
false	8	16	24	20
neither	6	16	19	12
both	7	18	15	18

A curious thing about the ontological problem is its simplicity. It can be put in three Anglo-Saxon monosyllables: 'What is there?' It can be answered, moreover, in a word – 'Everything' – and everyone will accept this answer as true. (Quine, 1948)

Meinong's Legacy I

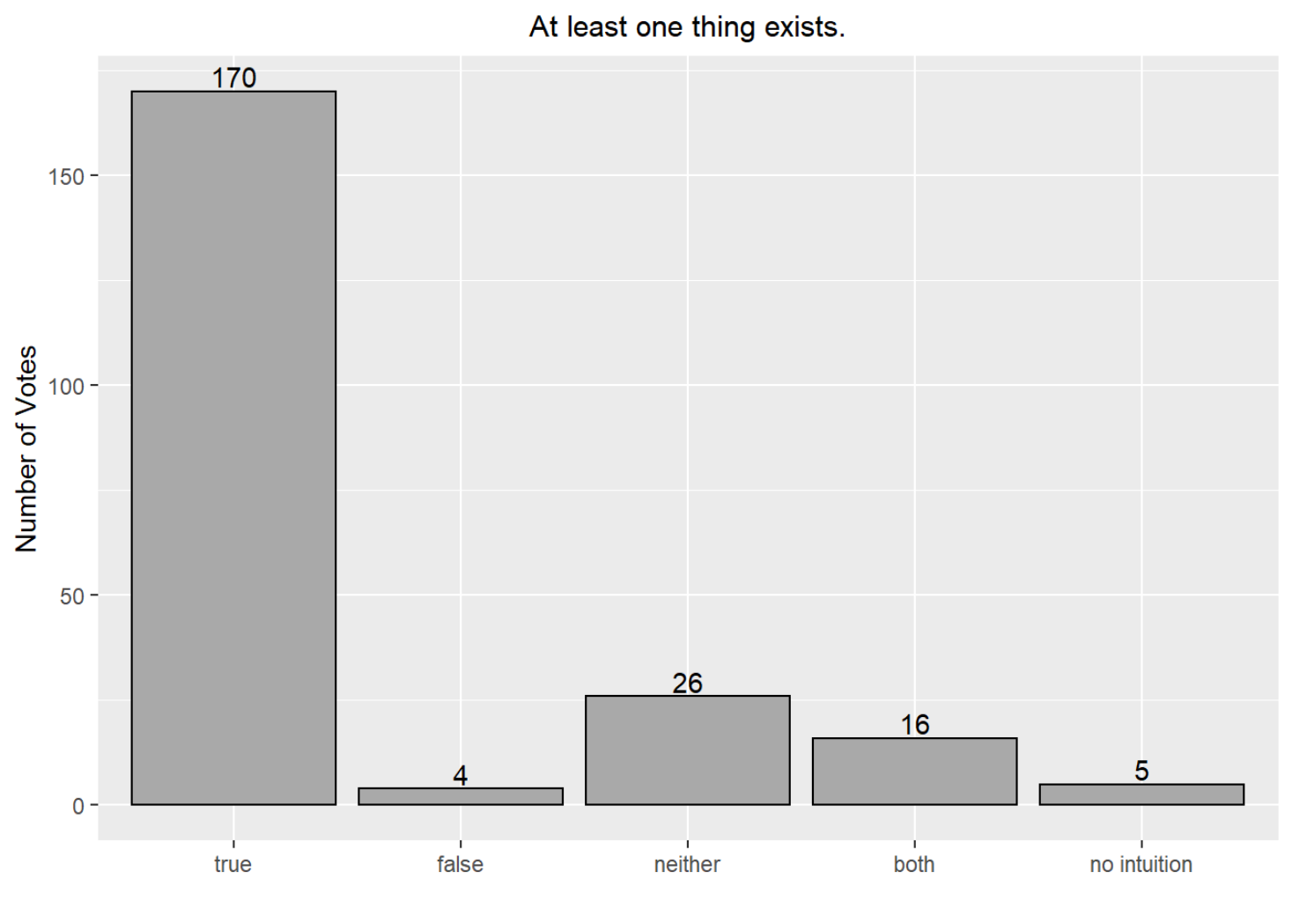


true: 44%
false: 23.5%

Meinong's Legacy II

	very weak	weak	strong	very strong
true	7	11	35	44
false	4	18	15	15
neither	1	13	12	4
both	2	9	13	3

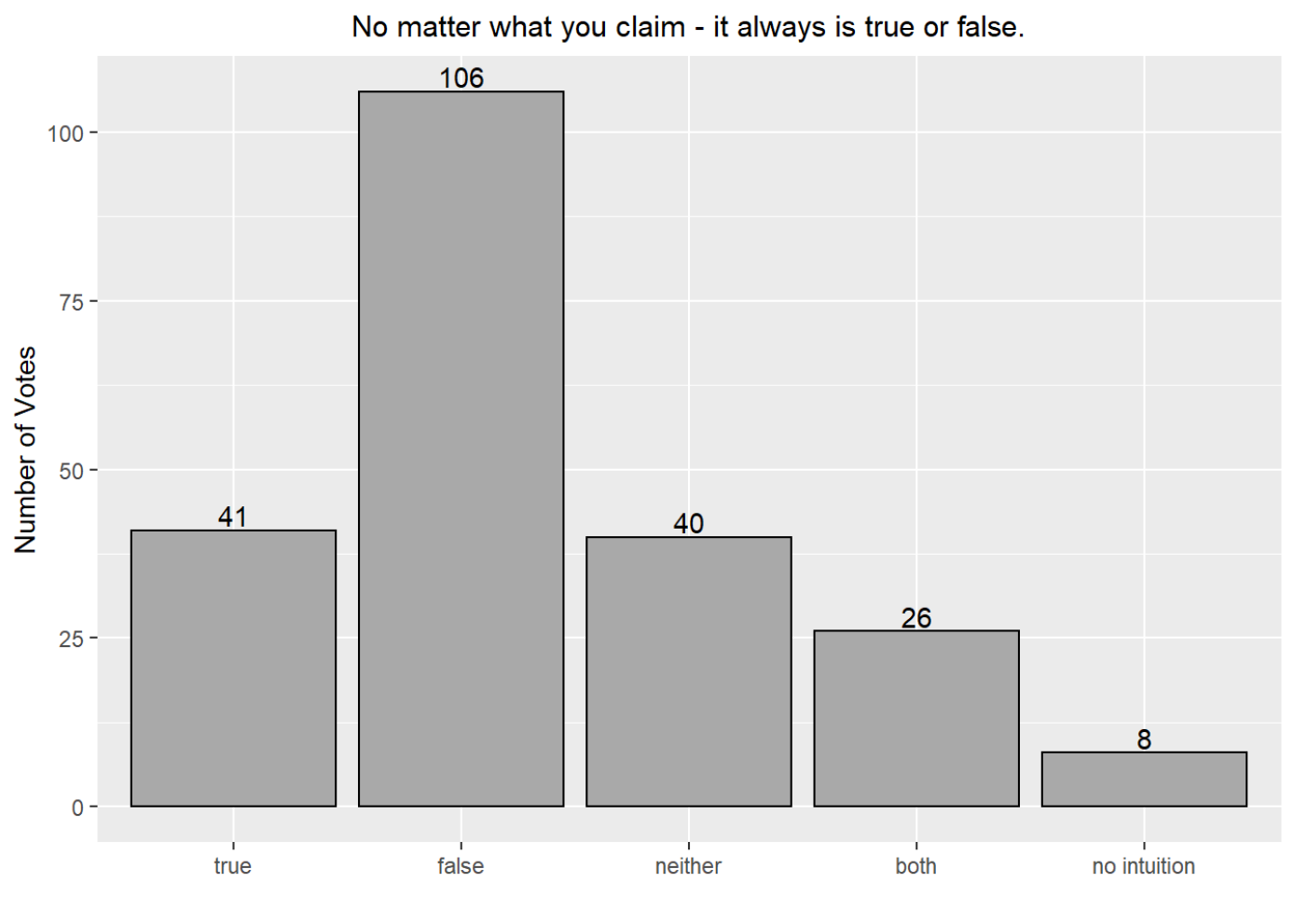
Inclusivity



true: 77%

strong int.: 88%

The Principle of Bivalence I

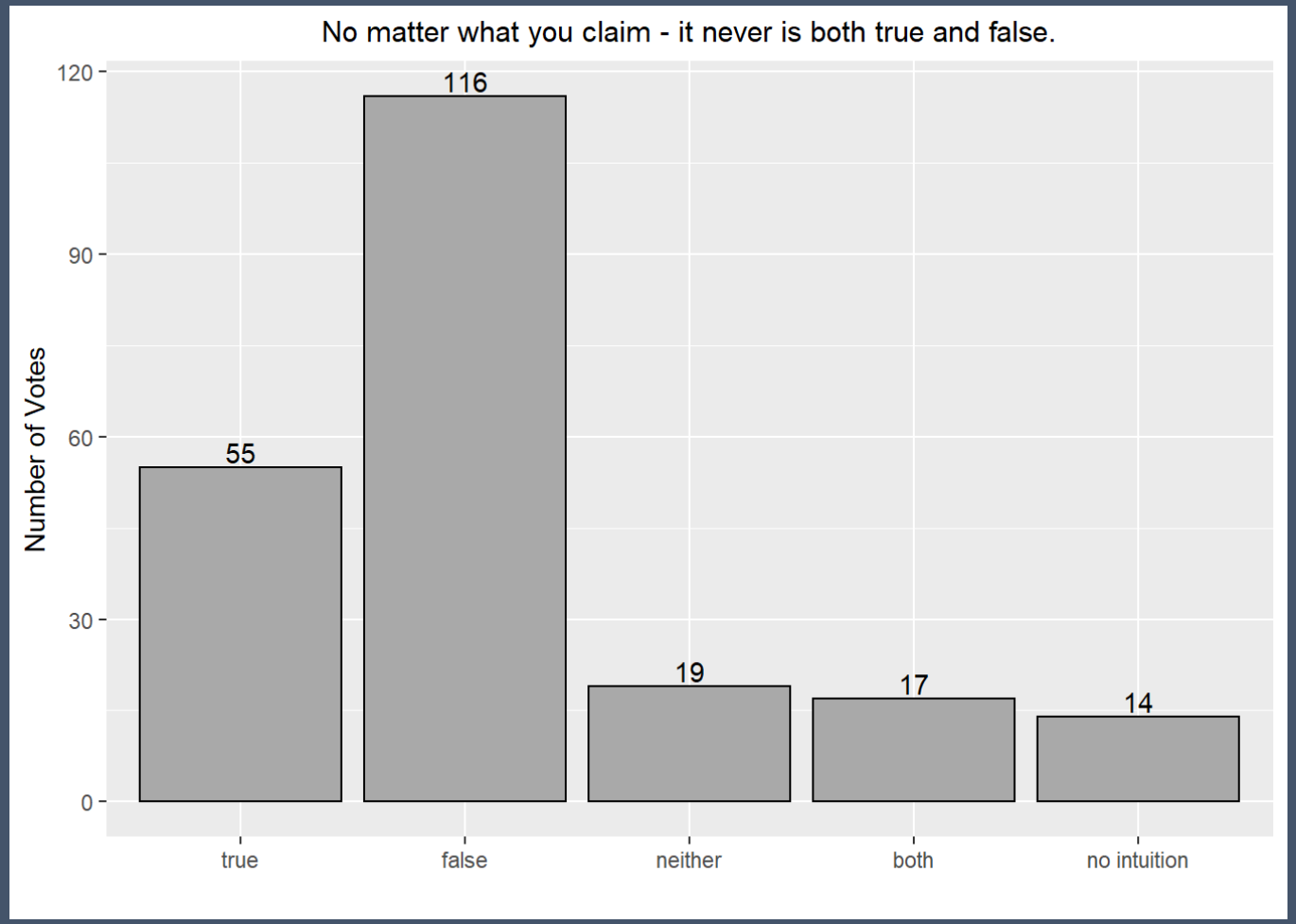


true: 18.5%
false: 48%

The Principle of Bivalence II

	very weak	weak	strong	very strong
true	2	9	10	20
false	8	21	25	52
neither	0	12	26	2
both	4	3	12	7

The Principle of Non-Contradiction I



true: 24.8%
false: 52.4%

The Principle of Non-Contradiction II

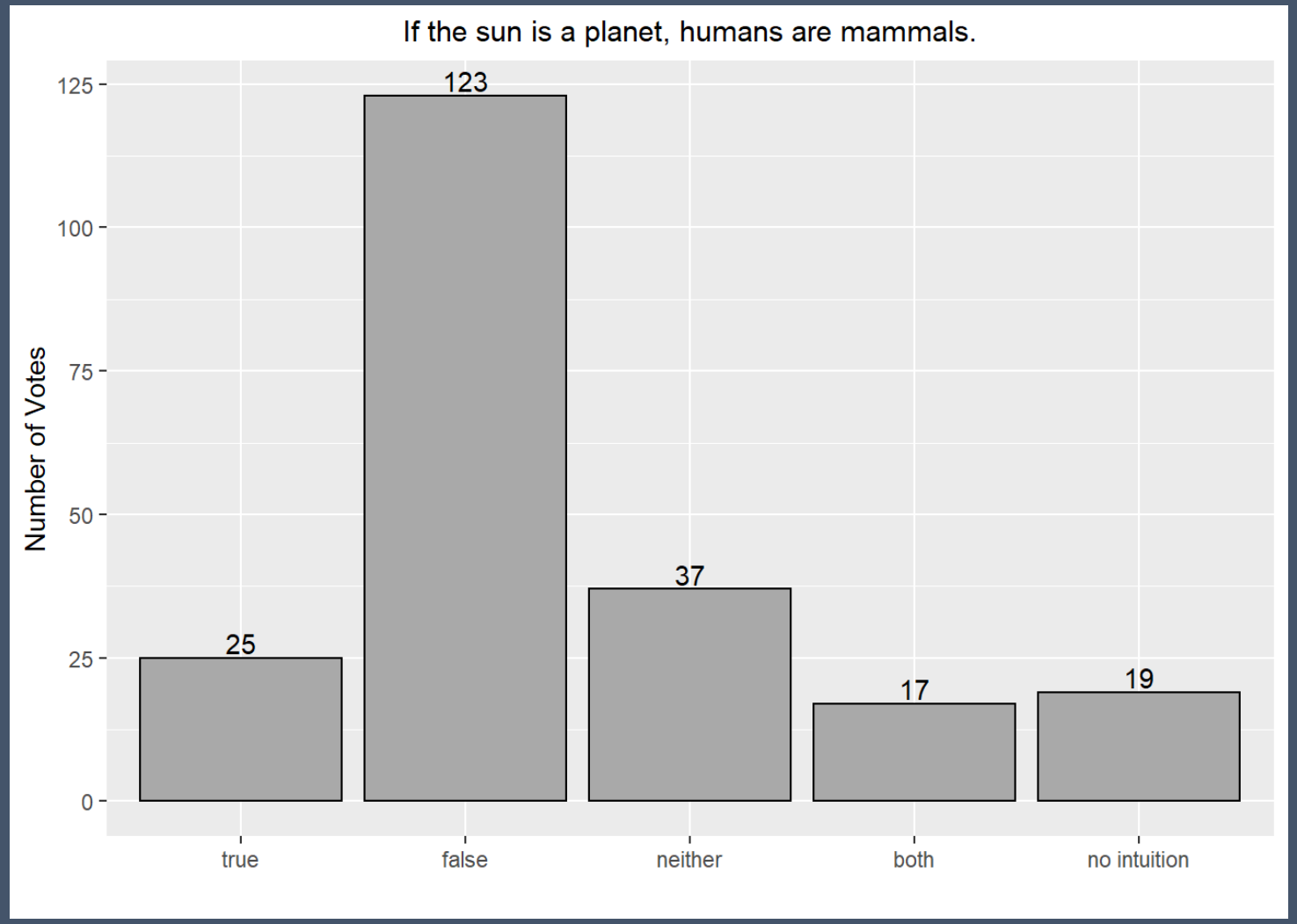
	very weak	weak	strong	very strong
true	2	12	14	27
false	9	27	39	41
neither	3	5	9	2
both	3	5	8	1

Conditionals – Questions

1) Is it intuitively plausible that a conditional sentence is true as soon as its succedent is true – no matter what truth-value is assigned to the antecedent?
2) Is it intuitively plausible that a conditional sentence is true as soon as its antecedent is false – no matter what truth-value is assigned to the succedent?

false antecedent, true succedent	„If the sun is a planet, humans are mammals.“
false antecedent, false succedent	„If Angela Merkel is a member of the SPD, the sun is a planet.“

Conditionals – True succedent I

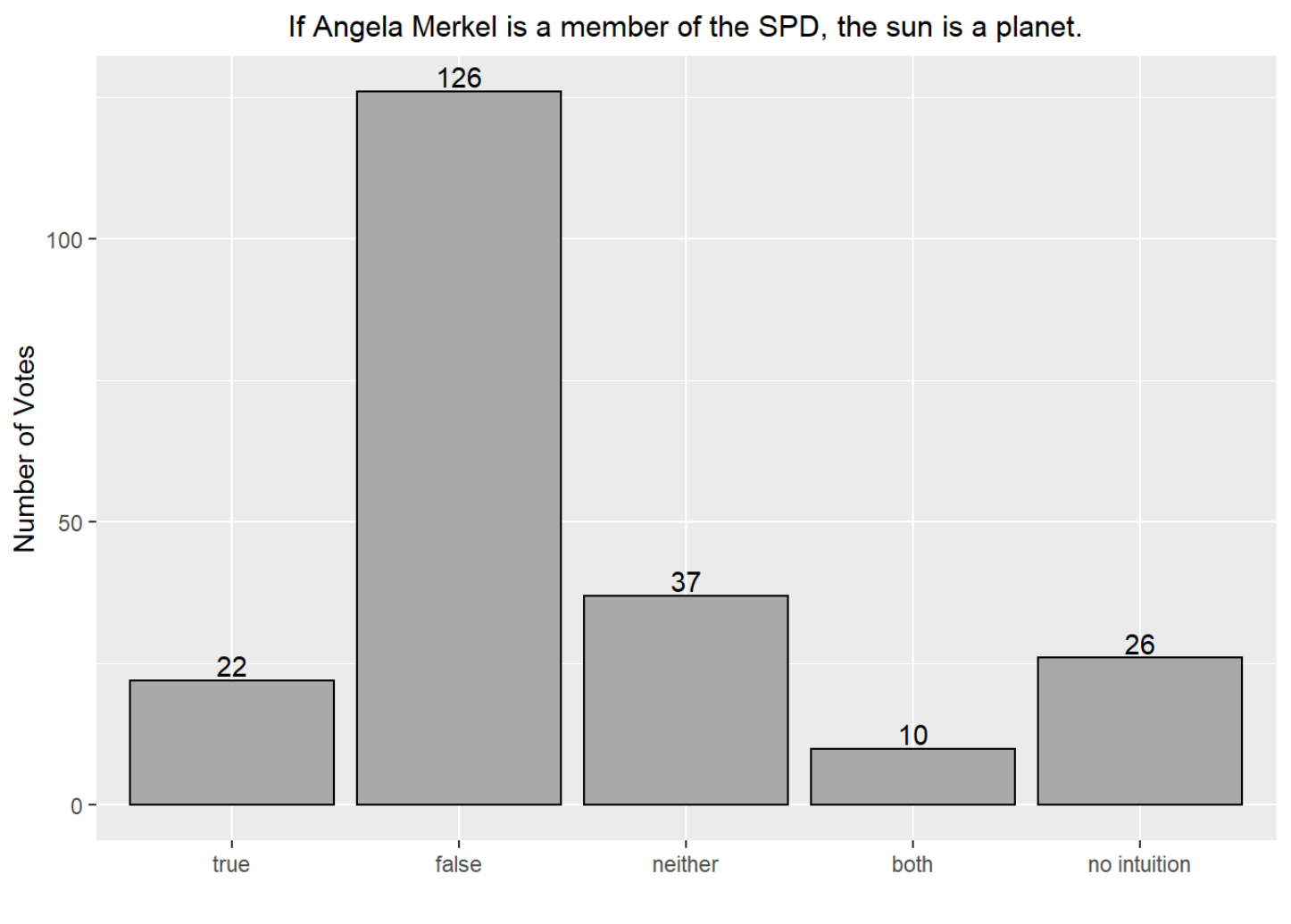


true: 11.3%
false: 56%
neither: 16.7%
both: 7.7%%
no int.: 8.6%

Conditionals – True succedent II

	very weak	weak	strong	very strong
true	5	3	6	11
false	10	18	32	63
neither	8	11	10	8
both	2	4	7	4

Conditionals – False Antecedent I



true: 10%
false: 57%
neither: 16.7%

Conditionals – False Antecedent II

	very weak	weak	strong	very strong
true	3	3	7	9
false	10	15	28	73
neither	6	13	10	8
both	1	4	4	1

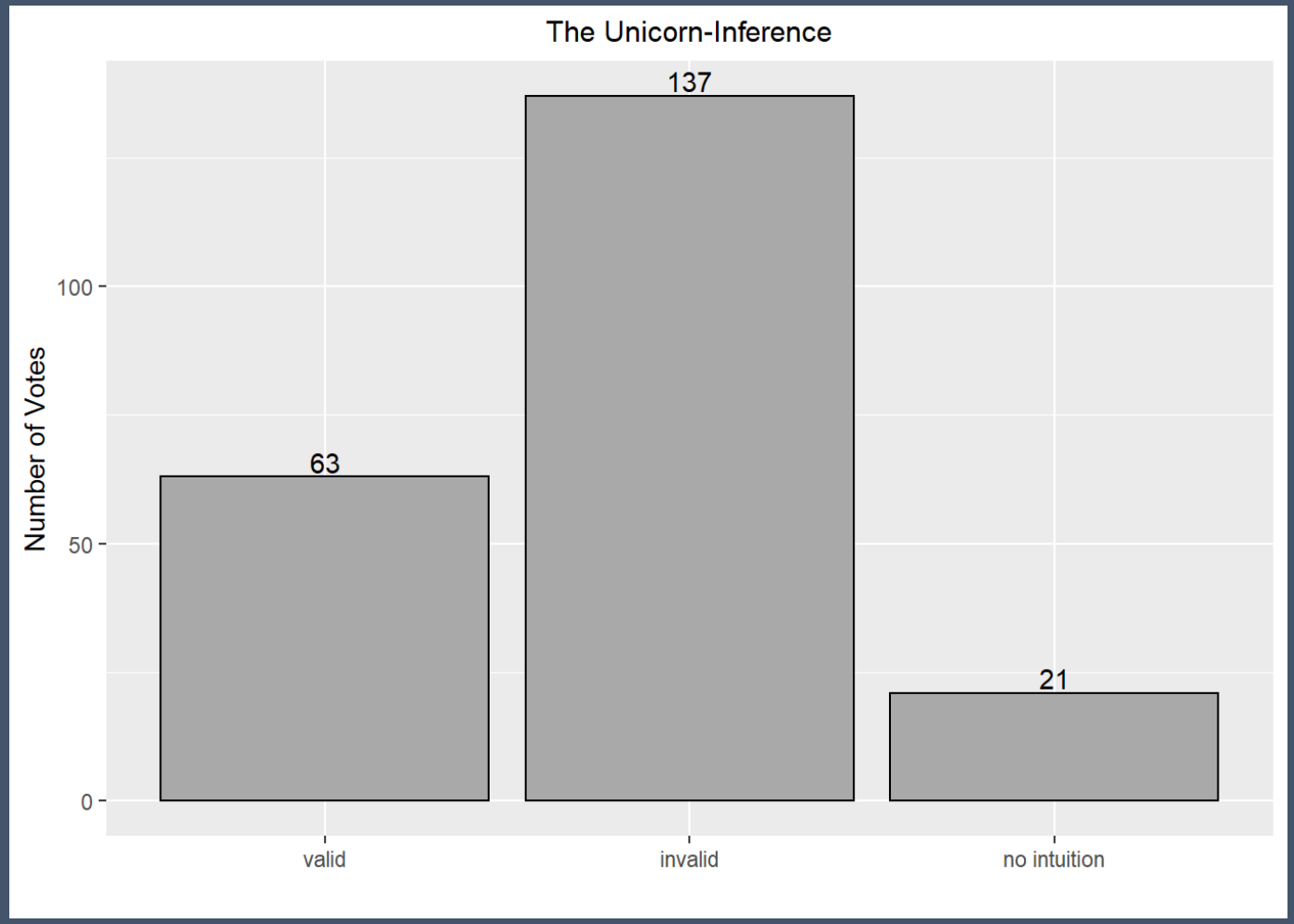
Universally Quanitfied Conditionals I

$\{\sim\exists x\, Ux\} \vDash_{PL} \forall x\, (Ux \rightarrow Nx \wedge \sim Nx)$

P Unicorns do not exist.

K All unicorns are both the most noble and not the most noble mythical creatures.

Universally Quanitfied Conditionals II



valid: 28.5%
invalid: 62%
no int.: 9.5%

Universally Quanitfied Conditionals III

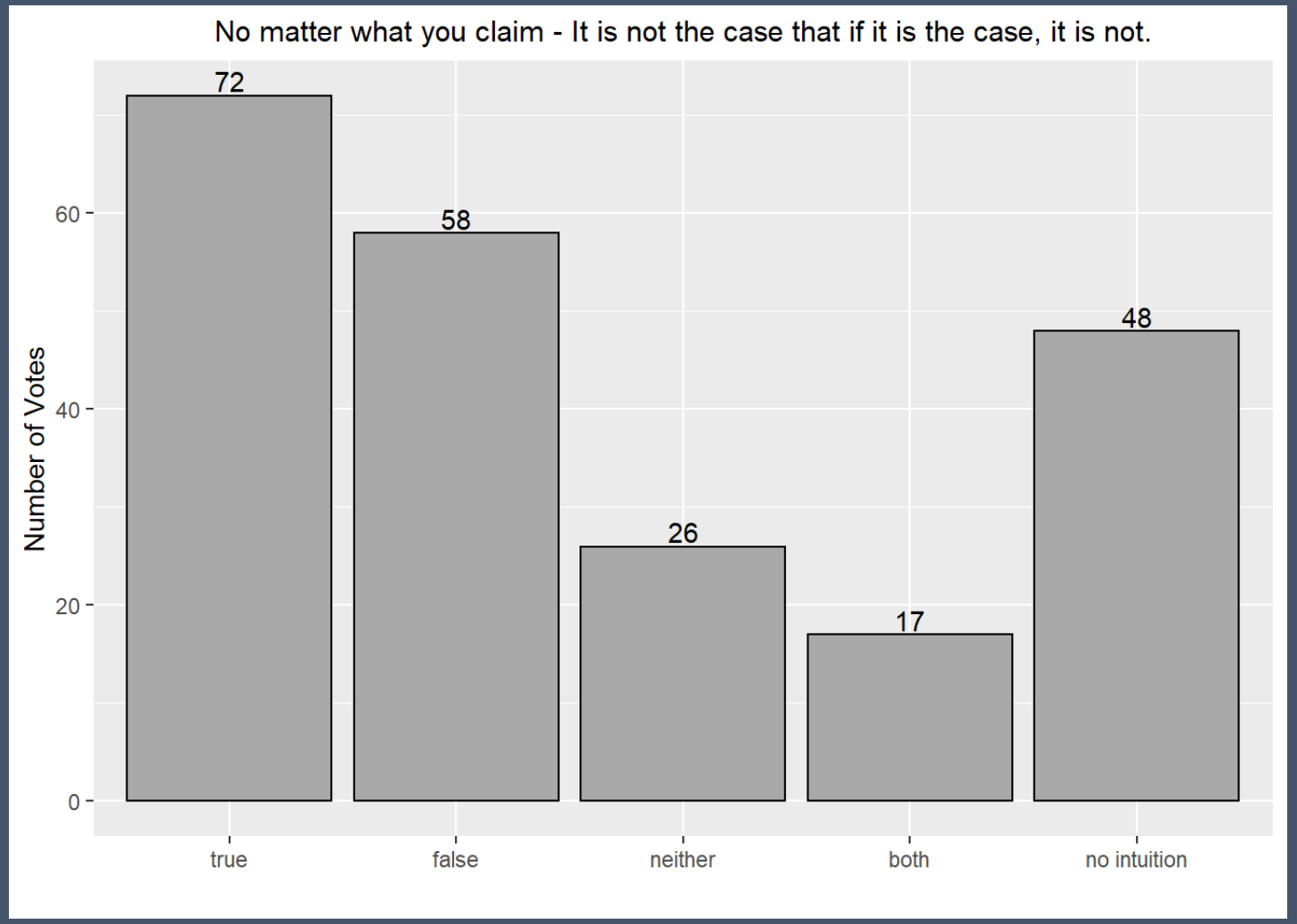
	very weak	weak	strong	very strong
valid	7	16	29	11
invalid	21	34	39	43

Aristotle's Thesis I

$$\models \sim(\alpha \rightarrow \sim\alpha) \mid AT'$$

No matter what you claim – It is not the case that if it is the case, it is not the case.

Aristotle's Thesis II

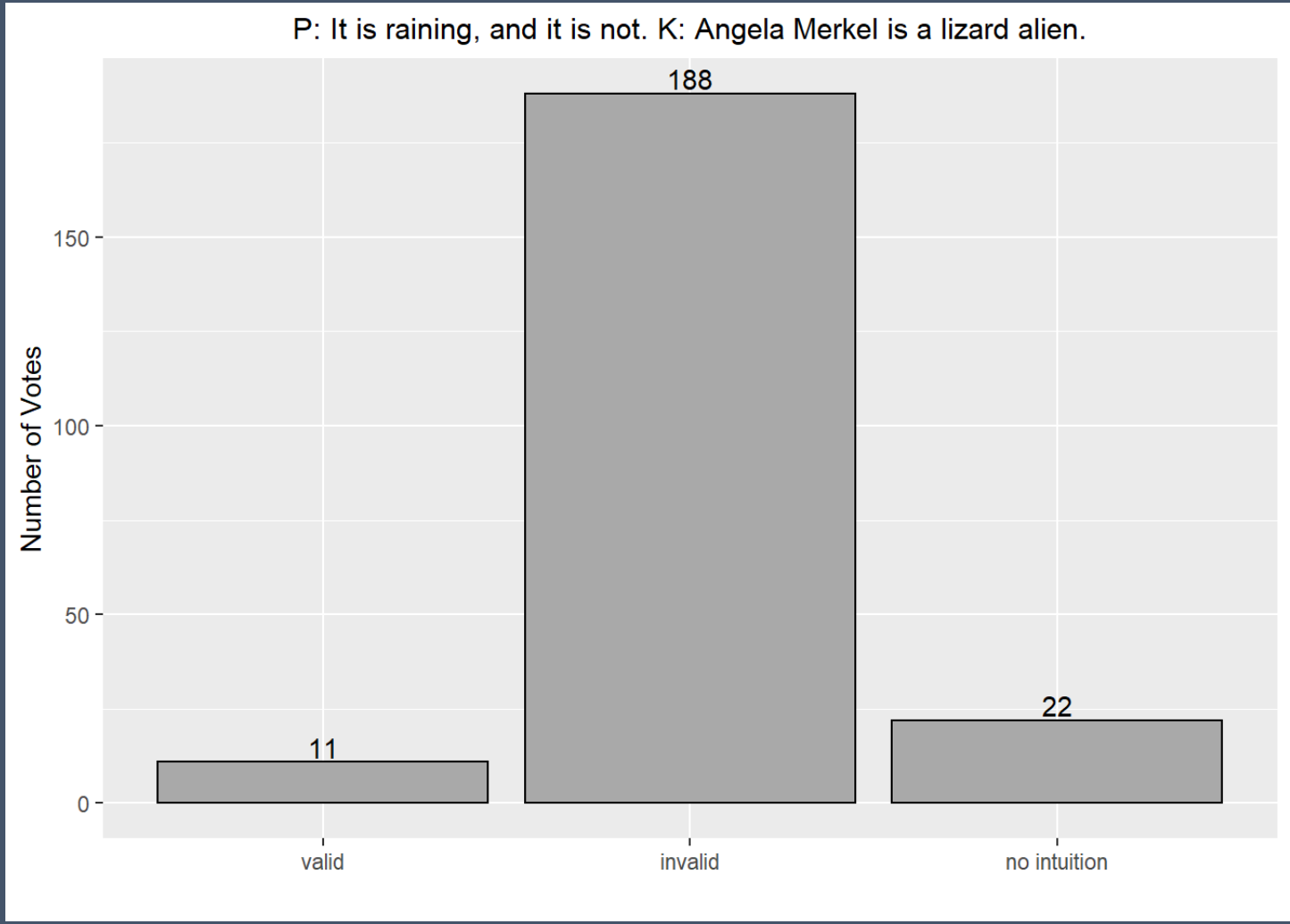


true: 32.6%
false: 26.2%
no int.: 21.7%

Aristotle's Thesis II

	very weak	weak	strong	very strong
true	7	19	20	26
false	10	18	15	15
neither	6	10	7	3
both	2	6	6	3

The Principle of Explosion I



valid: 5%
invalid: 85%
no int.: 10%

The Principle of Explosion II

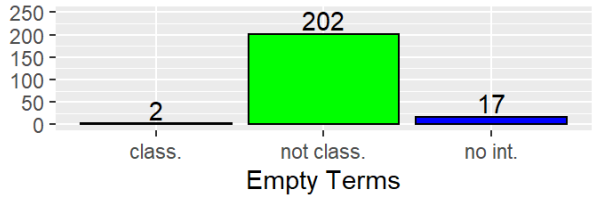
	very weak	weak	strong	very strong
valid	2	2	6	1
invalid	30	12	9	137

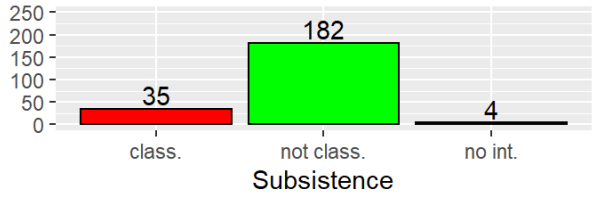
The Principle of Explosion III

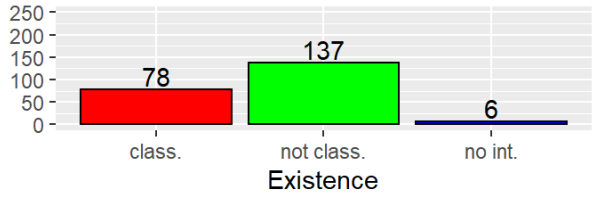
If you do a quiz with your students at the start of the semester und you give them a bunch of principles of inference [and] if you‘ve got explosion [EFQ] on the list, then almost certainly they‘ll say „No, that‘s a crazy principle“. By the end of the semester, when you‘ve hammered them over the head with an introductive textbook of logic, they‘ll say „of course it‘s valid“. But, nonetheless, it is very counterintuitive.

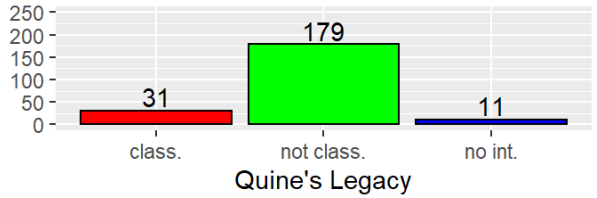
- Graham Priest

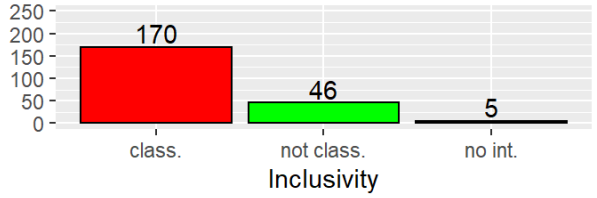
An Overview of the Results

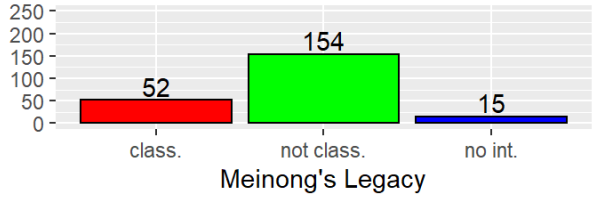


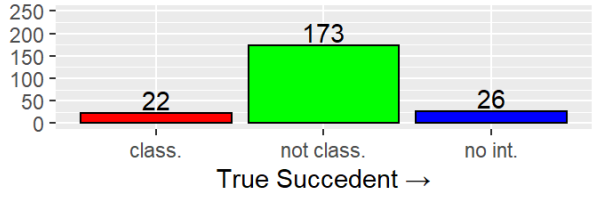


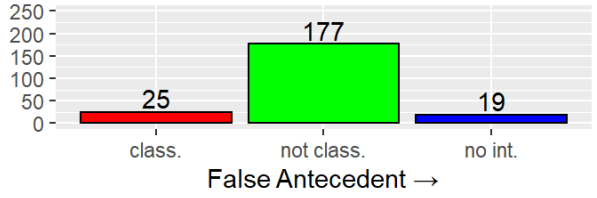


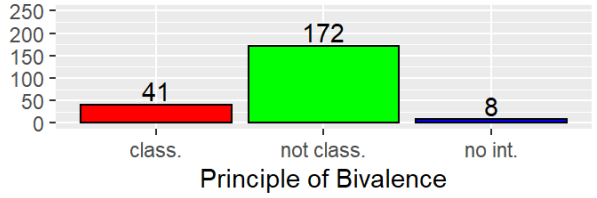


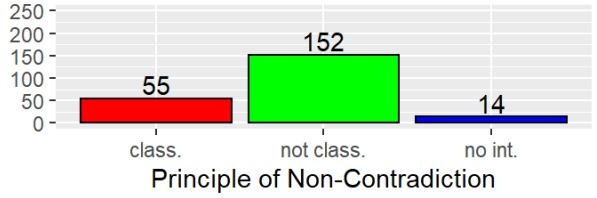


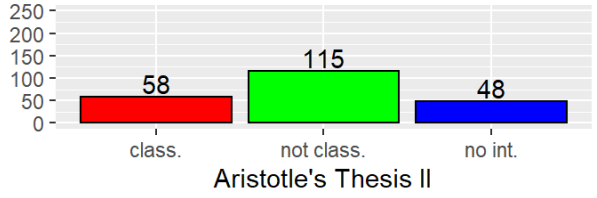


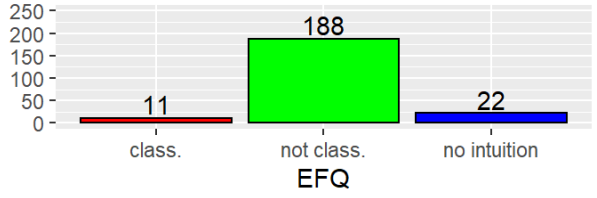


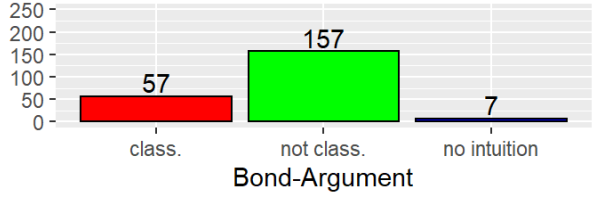


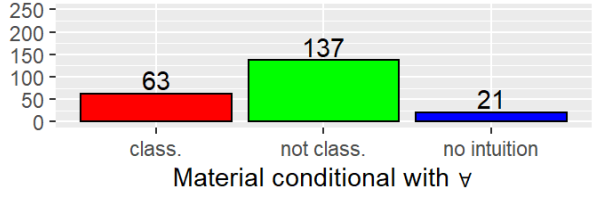












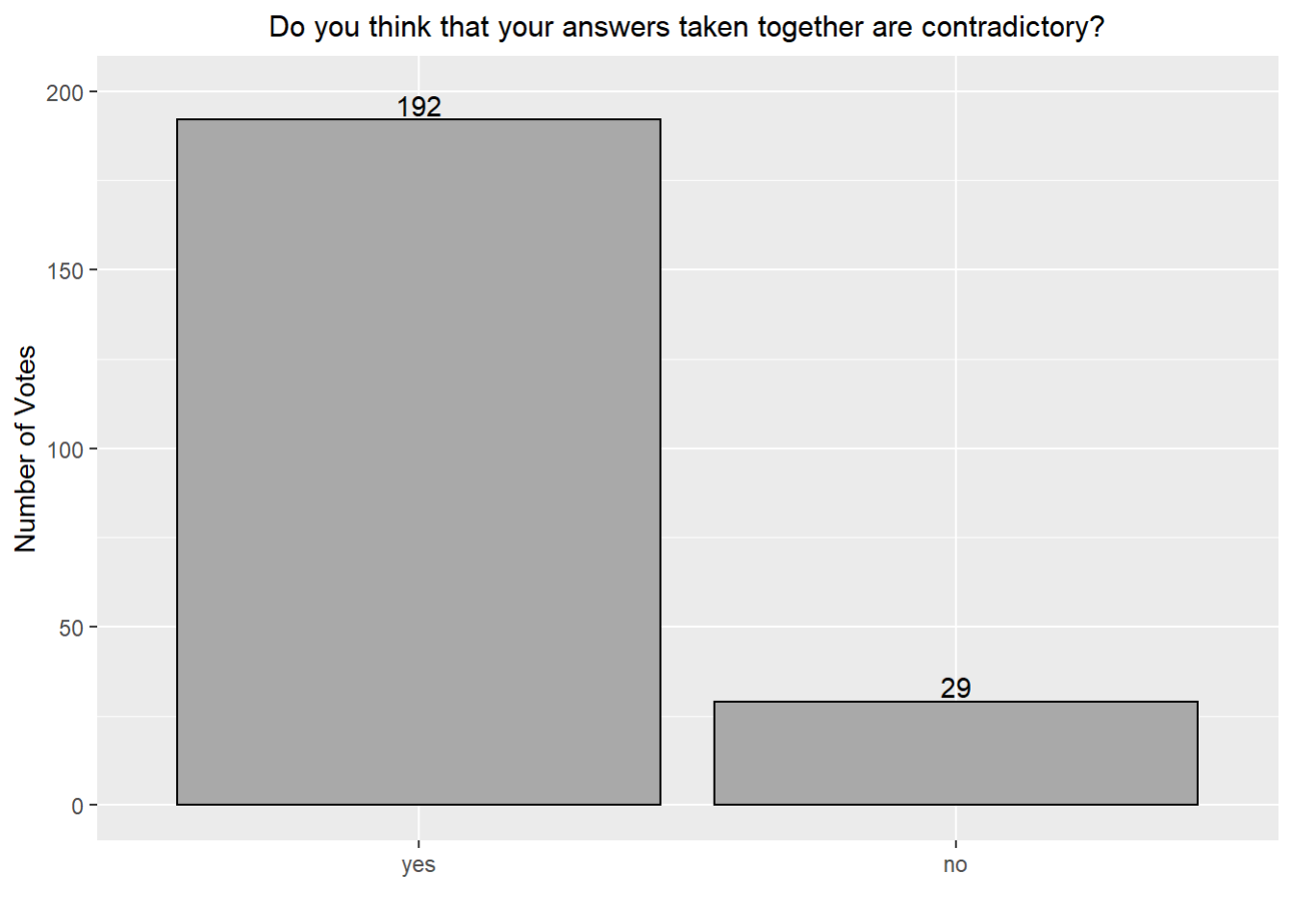
Research Questions – Answers

1) Are the theorems of classical first-order prediate logic in line with our preformal logical intuitions?

No, they are not; the student's intuitions were mainly non-classical!

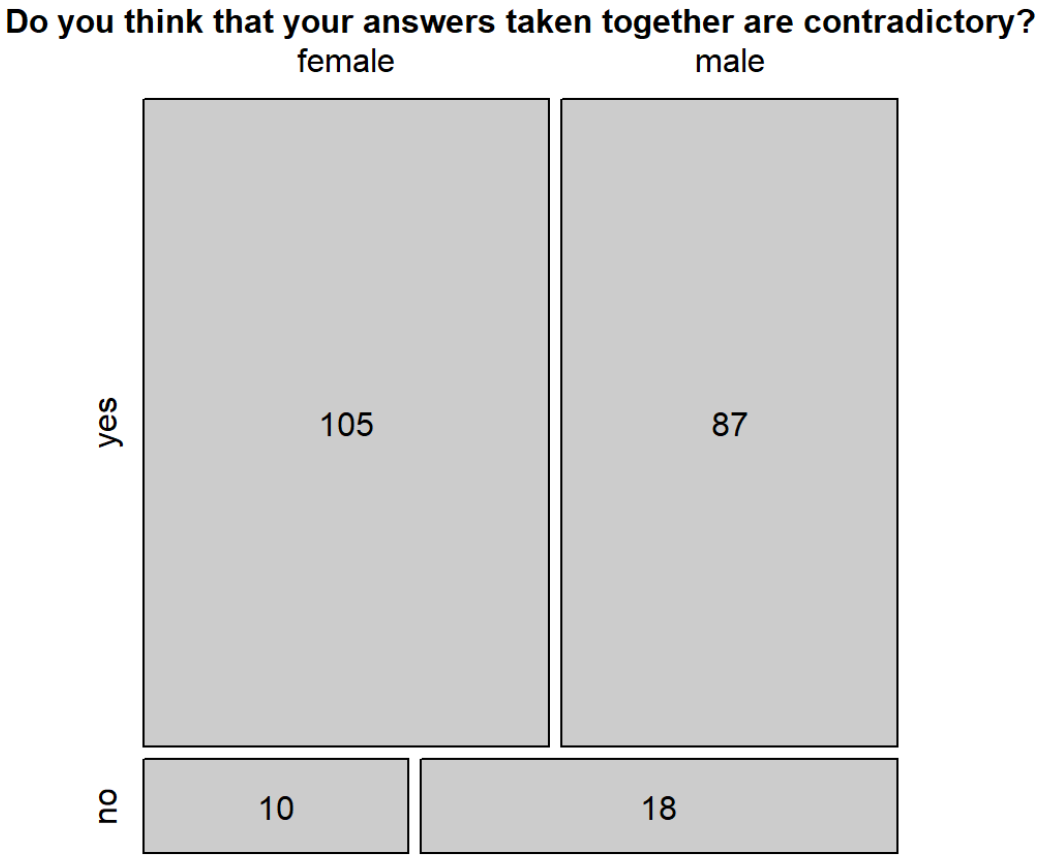
Nonetheless, the participants are for the most part convinced that they gave contradictory answers.

Research Questions – Self-Evaluation I



yes: 82%
no: 18%

Research Questions – Self-Evaluation II



female + yes: 91.3%
male + yes: 82.9%

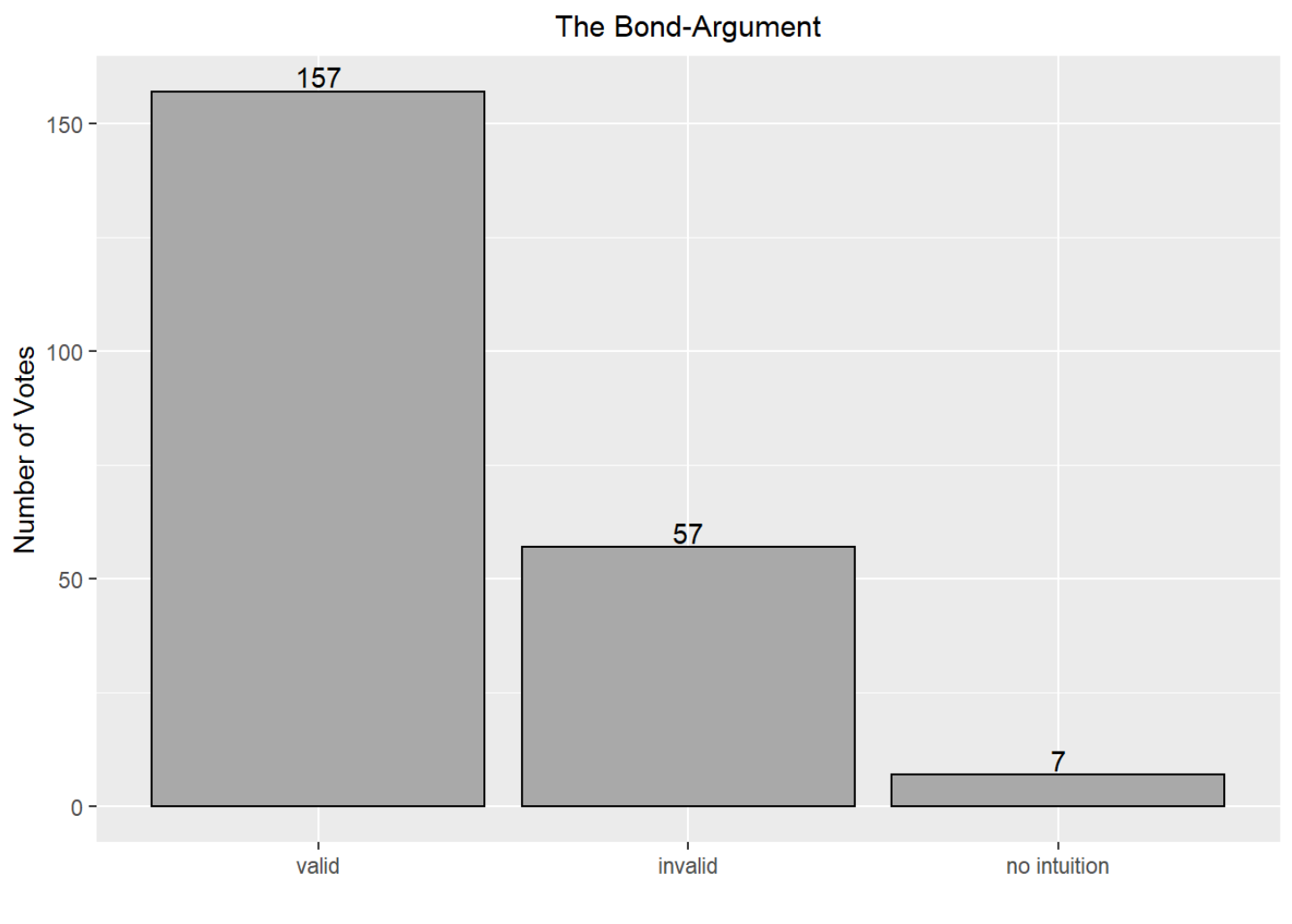
The Bond-Argument

P1 If Bond has a parachute, he will survive the plain crash.

P2 Bond does not have a parachute.

K So he will not survive the plain crash.

The Bond-Argument



valid: 71%
invalid: 25.8%
no int: 3.2%

Research Questions – Answers

2) If this is not the case, which formal systems reflect our intuitions more adequately?

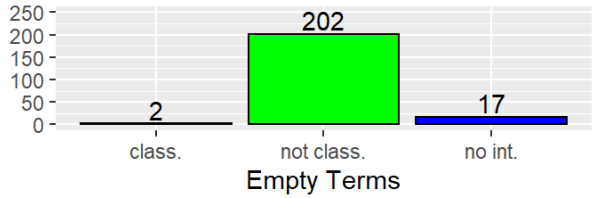
- empty terms, outer quantifiers → non-inclusive PFL
- truth-value gaps and gluts → FDE
- no explosion → paraconsistent logic
- rejection of material conditional → relevance logic?
- Aristoteles‘ Thesis → connexive logic

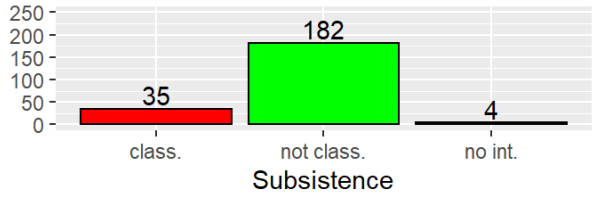
Reflection and Research Desiderata

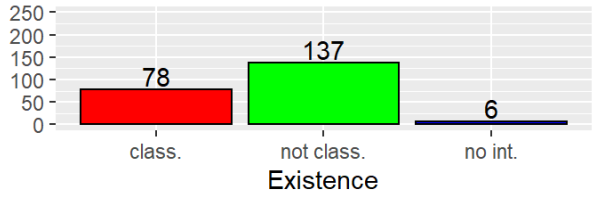
- data not representative
- not all questionable principles examined
- *prima facie* meaningless intuitions
- suggestive examples
- meanings of logical concepts not explained

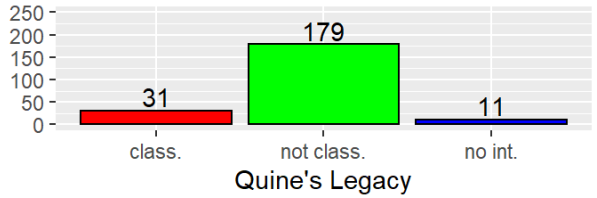
→ More empirical research and theory necessary!

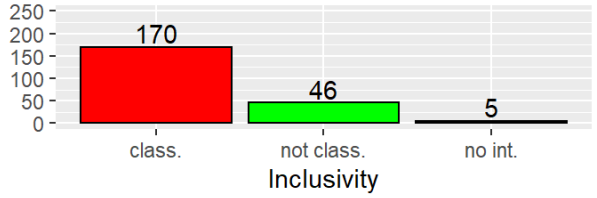
An Overview of the Results

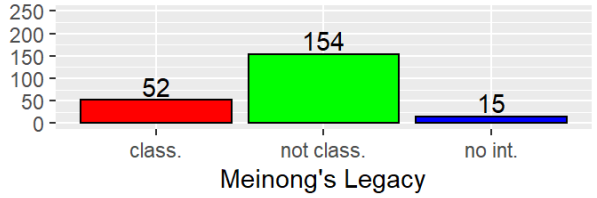


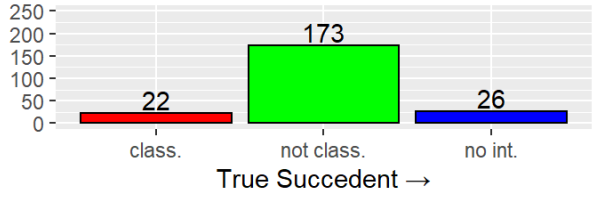


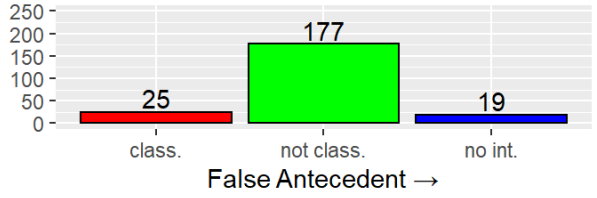


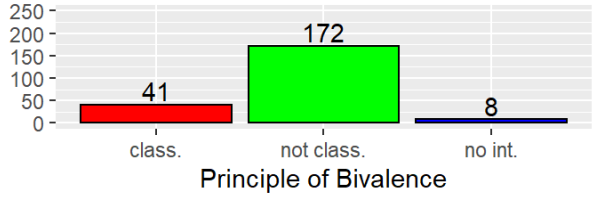


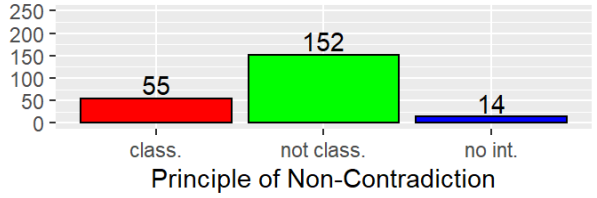


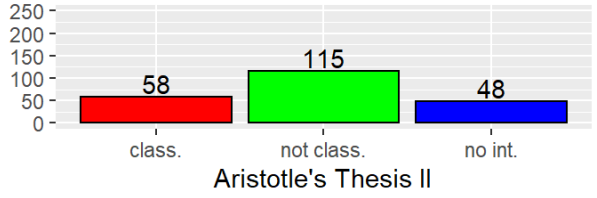


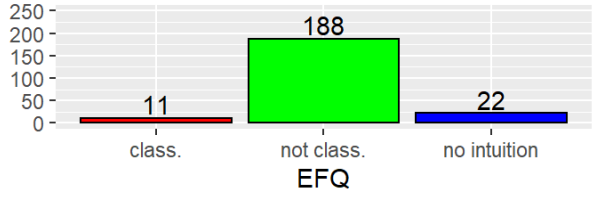


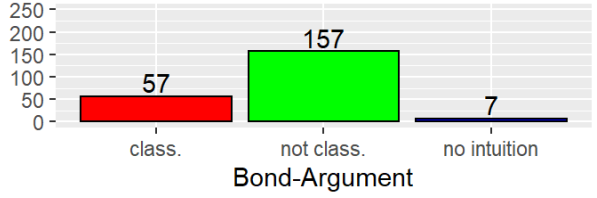


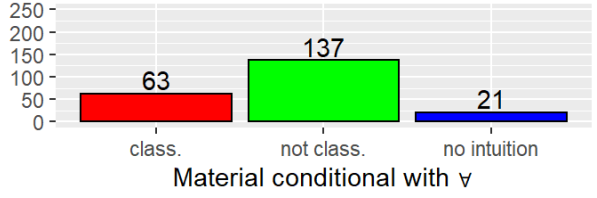












Discussion – Some Suggestions

What are logical intuitions exactly?

(How) Do they differ from other (kinds of) intuitions?

Can logical intuitions lead us astray?

Should we base our formal systems on these? If so, why? If not, why not, and on what else?

Which changes to the method could yield more adequate results?