Plurals as higher-order scalar predicates: Unifying cumulativity and non-maximality

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Topic of this talk

- Broader research project: Investigate cumulativity in the context of other 'non-classical' phenomena of plural semantics
- This talk: Relation to non-maximality effects, which are arguably best viewed as a case of context-dependency.
- In contrast, the cumulative/distributive distinction is usually conceived of in terms of LF ambiguity.
- I will argue for a unified account of both phenomena in terms of context-dependency.

Cumulative and distributive construals

(1) *The students read the books.*

Standard distributive construal

LF: [[*the students*] [DIST [**read the books*]]]

Standard truth conditions: 'Each of the students read all of the books.'

Standard cumulative truth conditions

LF: [[*the students*] [***read the books*]]

Truth conditions: 'Each of the students read at least one of the books, and each of the books was read by at least one of the students.'

Question

The standard assumption is that the choice between cumulative and distributive readings reflects an LF ambiguity of some kind. see e.g. Champollion to appear

Is this correct or should we assume a single LF with a context-dependent semantics? compare Schwarzschild 1996

Other hallmarks of semantic plurality

Homogeneity effects

In **many contexts**, sentences with plural embedded under negation or other operators have stronger truth conditions than expected:

(2) *The students didn't read the books.*
$\rightsquigarrow$ None of the students read **any** of the books.

see Schwarzschild 1994, Löbner 2000, Gajewski 2005, Križ 2015, Chatain 2020 a.o.

Non-maximality effects

In **some contexts**, the interpretation of definite plurals is weaker than expected:

(3) *The students read the books.*
$\not\rightsquigarrow$ Each of the books was read by a student.

see e.g. Kroch 1974, Brisson 1998, Malamud 2012, Križ 2015 ...

Questions

- How does cumulativity relate to these phenomena? Is cumulativity itself a context-dependent phenomenon?
- Are context-dependent effects in cumulative sentences derived from the homogeneity/non-maximality properties of the individual DPs? cf. Chatain 2020

Claims

1. Context-dependent choice between distributive and cumulative construals relative to an 'issue'/QUD. No LF-ambiguity needed.
2. Homogeneity and non-maximality effects indicate presence of a denotation gap (e.g. truth-value gap) that is resolved in a QUD-dependent manner.

   following Križ 2015, see also Malamud 2012
3. Cumulative construals reflect a kind of 'global non-maximality' that arises whenever two plural expressions are composed.
4. Cumulativity isn't due to homogeneity/non-maximality of individual plural DPs. Sentences with multiple plurals have denotation gaps, but these may arise 'globally' from the compositional mechanism.

Roadmap for this talk

1. Argue for a context-dependency view of the cumulative/distributive contrast.
2. Present the QUD-based approach to non-maximal readings of definite plurals, as introduced in Križ (2015).
3. Combine it with a composition-based view of cumulativity (Schmitt 2019).

1. Goals of this talk
2. Contextual constraints on cumulative construals
3. The puzzle: QUD-dependence and interacting sources of non-maximality
4. Plural sets and plural scales
5. Cumulativity and composition-based truth-value gaps

QUD-based constraints on cumulativity

Pre-theoretical truth-value judgments on sentences with two plurals in cumulative scenarios are affected by contextual 'goals' or QUD.

'Distributive' context: No cumulative reading

DISTRIBUTIVE SCENARIO: Next week, five of my students will be examined individually by an external committee. To pass the exam, one needs to be familiar with all ten books on the reading list. However, my students are not well prepared. Two students have read only books 1-5 on the reading list and the other three have read books 6-10.

(4) *The five students have read the ten books on the list.* not true

'Cumulative' context: Cumulative reading possible

CUMULATIVE SCENARIO: Next week, five of my students have to do a presentation together. The presentation is supposed to cover a reading list of ten books. To reduce their workload, the students decided that two of them would read books 1-5 and the others would read books 6-10.

(5) *The five students have read the ten books on the list.* true

Thanks to Keny Chatain for discussion of these judgments.

QUD-based constraints on cumulativity

(6) *The five students have read the ten books on the list.*

The two scenarios just given do not differ wrt. the actual extension of *read*.

So what explains the contrast? There is an obvious pragmatic account:

Natural implicit QUD in the DISTRIBUTIVE SCENARIO

'Has each of the individual students read everything needed to pass the exam?'

Cumulative reading of (6) doesn't contextually entail an answer. Only the distributive reading is relevant to the QUD.

Natural implicit QUD in the CUMULATIVE SCENARIO

'Have the students, between them, read everything their presentation is supposed to cover?'

Both readings of (6) contextually entail an answer. The cumulative reading is relevant to the QUD.

This account of how (6) is disambiguated relies on the assumption that **an utterance of (6) would be unmotivated if it didn't address the QUD**.

But we find similar context-dependent effects if this assumption is not met ...

‘No, but . . . ’ test

In both English and German, unmodified plural sentences cannot be used to shift the QUD from a ‘distributive’ QUD to one answered by the cumulative construal.

(7) A: [Has each of the five students read the ten books on the list?]
B: *#No, but the five students have read the ten books on the list.*
B′: *#Nein, aber die fünf Studierenden haben die zehn Bücher von der Liste*
no but the five students have the ten books from the list
gelesen.
read
‘No, but the five students have read the ten books on the list.’

This is weird because shifting the QUD is no problem once the plural sentence is disambiguated by a modifier (8-c).

(8) B″: *Nein, aber zusammengenommen haben die fünf Studierenden die zehn*
no but together-taken have the five students the ten
Bücher von der Liste gelesen.
books from the list read
‘No, but in total/taken together, the five students have read the ten books on the list.’

‘No, but . . . ’ test

(9) [A: Has each of the five students read the ten books on the list?]
B: #*No, but* ***the five students have read the ten books on the list***.

What is going on here?

- B gives a direct ‘no’ answer to A’s question, so no reason to expect subsequent utterances to address this question.
- Usually a subsequent utterance may shift the QUD to another subquestion in a broader question strategy.
- With *zusammengenommen*, which forces a non-distributive reading, QUD can be shifted towards a question answered by that reading.
- Assuming that there are separate cumulative and distributive LFs, B’s ‘no’ answer should be compatible with the cumulative, but not with the distributive LF.
- But then why can’t B’s answer shift the QUD towards a question answered by the cumulative LF?

What I will argue for

(9) involves context-dependency (previous QUD influences truth conditions), but not genuine ambiguity. cf. experimental work: Poortman 2016, Maldonado 2018
⇒ No longer (wrongly) predicts disambiguation in a ‘no, but . . . ’ context.

‘No, but . . . ’ test

Interestingly, the quantificational paraphrases usually given for cumulative sentences can easily trigger a QUD-shift:

(10) A: [Has each of the five students read the ten books on the list?]
B: *Nein, aber jeder von den fünf Studenten hat mindestens eines von den*
no but each of the five students has at.least one of the
Büchern gelesen und jedes Buch hat mindestens ein Student gelesen.
books read and every book has at.least one student read
‘No, but each of our students has read at least one of the books and for each of the books, there is at least one student who has read it.’

⇒ Cumulative sentences are not semantically equivalent to their standard paraphrases.

This is unsurprising if these paraphrases are not context-dependent in the same way.

Assumption behind this reasoning: Contextual parameters cannot be shifted to change the QUD unless this is overtly marked. ⇒ We observe this independently!

We can't exploit context-dependency to shift the QUD

Clear case of context-dependency rather than ambiguity: Domain restriction.

the ski jumpers can be interpreted as 'the German ski jumpers' in certain contexts, but there are probably no distinct LFs with and without the predicate *German*.

(11) CONTEXT: The ski jumping World Cup is coming up. For a team to participate, all team members have to test negative for Covid. All the teams already know their test results, except for the Austrians and the Germans.

A: *Und, wurden irgendwelche österreichischen Schispringer positiv*
and were any Austrian ski.jumpers positive
getestet?
tested
'So, did any Austrian ski jumpers test positive?'

B: *#Nein, aber* ***alle Schispringer*** *wurden positiv getestet.*
no but all ski.jumpers were positive tested
'No, but all the ski jumpers tested positive.'

B's utterance here cannot mean that all the *German* ski jumpers tested positive.

⇒ We cannot exploit context-dependency to shift the QUD, even if the contextual parameter values suggested by the original QUD yield a contextual contradiction.

QUD-based constraints on non-maximality

Interim summary

- Cumulative readings of sentences with multiple plurals are not easily available if the QUD is answered only by a distributive reading.
- This QUD-dependency cannot be exploited to shift the QUD away from a 'distributive' question, unless the sentence is *unambiguously* cumulative.
- This property of the cumulative/distributive contrast is shared by some other context-dependency phenomena.

All of this lends some initial plausibility to the context-dependency approach, but doesn't rule out an ambiguity approach.

Next steps

- Show that non-maximality interacts in the same way with a QUD/'issue'.

Križ 2015

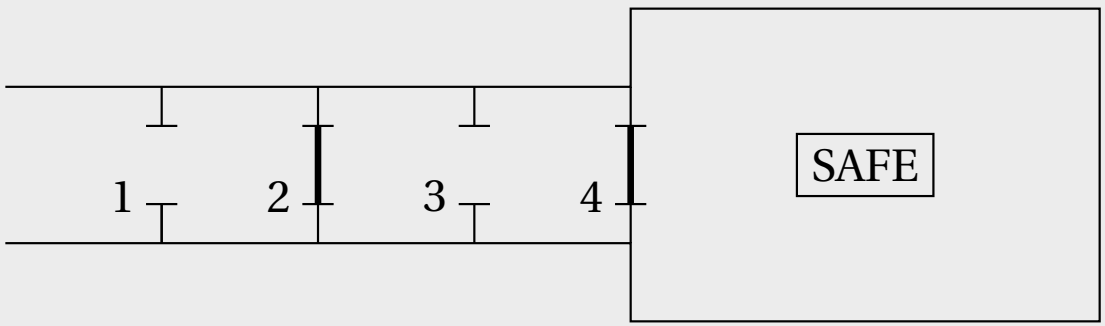
- Argue against an LF-ambiguity approach to non-maximality.
- Explore the idea that cumulativity and non-maximality reduce to the same deeper semantic phenomenon.

QUD-based constraints on non-maximality

MAXIMAL SCENARIO: Non-maximal reading unavailable

(12) A bank vault has four doors as pictured below. A and B are planning a heist. Their goal is to reach the safe. B has found out that doors 1 and 3 are actually open, so all they have to do is break the other two doors.

adapted from Krifka (1996), Malamud (2012)



(13) A: [*Can we really break in just like that?*]
B: *Well,* ***the doors are open****, but it won't be easy . . .* not true

⇝ non-maximal scenario not sufficient to make (13-B) true

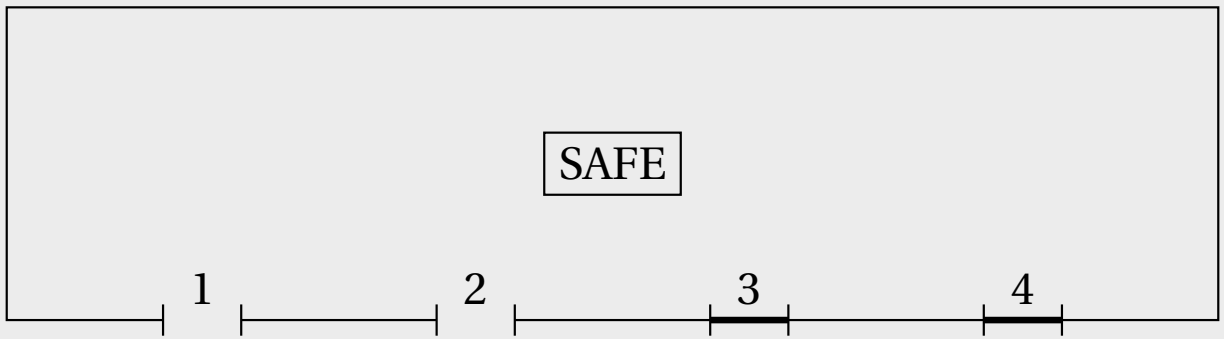
Natural QUD in this scenario: 'Can we reach the safe (without breaking any locks)?'
Given the floor plan, an existential reading ('some doors are open') does not contextually entail an answer to this QUD.

QUD-based constraints on non-maximality

NON-MAXIMAL SCENARIO: Non-maximal reading available

(14) A bank vault has four doors as pictured below. A and B are planning a heist. Their goal is to reach the safe. B has found out that doors 1 and 2 are actually open, so all they have to do is defeat the security guards.

adapted from Krifka (1996), Malamud (2012)



(15) A: [*Can we really break in just like that?*]
B: *Well,* ***the doors are open****, but it won't be easy . . .* true

⇝ non-maximal scenario sufficient to make (15-B) true

Natural QUD in this scenario: 'Can we reach the safe (without breaking any locks)?'
Given the floor plan, an existential reading contextually entails an answer to this QUD.

Existential/universal ambiguity?

Non-maximal readings of definite plurals are clearly QUD-dependent (Križ (2015); see Malamud (2012) for similar ideas in a different framework).

Could this reflect disambiguation between an existential and a universal LF?

'No, but . . .' test for non-maximality

Again, relevance-based disambiguation doesn't seem to be the whole story . . .

(16) A: *Has John really read all the books?*
B: #*No, but* ***John has read the books***.

⇒ In the context of a 'maximal'/universal QUD, non-maximal readings are unavailable even as a means of shifting the QUD.

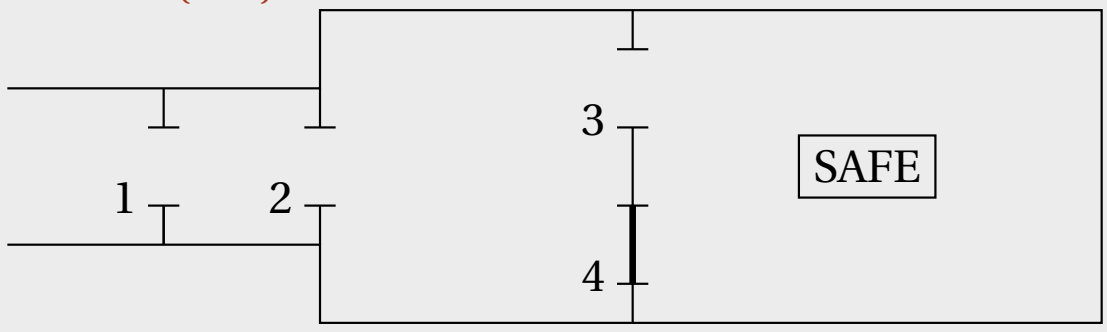
Another argument against LF ambiguity

- Some contexts give rise to intermediate construals that seem to be true in some, but not all non-maximal scenarios.

  (17) *The doors are open.*
  ⇝ Some plurality of doors that is sufficient to reach the safe is open.

- These scenarios require distinctions between different 'non-maximal pluralities'.
- Treating this as LF ambiguity, not context-dependency, leads to a proliferation of LFs that each encode a QUD or other specific properties of the context.

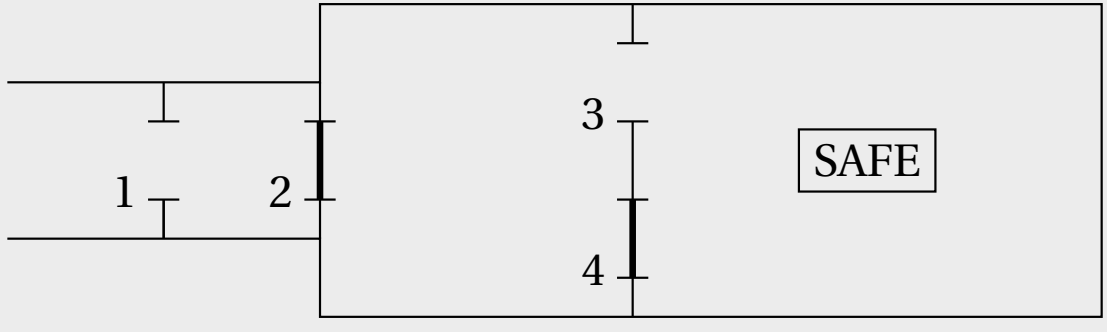
Intermediate scenario (1/2)



(18) A: [*Can we really break in just like that?*]
B: *Well, **the doors are open**, but it won't be easy ...* true

⇒ Non-maximal construal available in principle.

Intermediate scenario (2/2)



(19) A: [*Can we really break in just like that?*]
B: *Well, **the doors are open**, but it won't be easy ...* not true

⇒ Non-maximal construal not available for this particular plurality of doors.

Interim summary

The availability of a cumulative construal depends on an 'issue'/QUD.

The same has been argued to hold for non-maximal construals of plural definites.

Križ (2015, 2016), see also Malamud (2012)

Although the issue isn't completely settled, there are two reasons to think this reflects semantic context-dependency:

- Existence of 'intermediate' construals for non-maximality if context doesn't provide straightforward existential or universal QUD
- Empirical parallels with other cases of context-dependency ('no, but . . . ' test)

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The QUD-based approach to non-maximality

Križ (2015)

- Common source for non-maximality and homogeneity effects: truth-value gaps.
- Compositional semantics yields three-valued propositions. The truth-value gap is then narrowed depending on an 'issue' (not always the overt QUD).
- Homogeneity effects due to interaction of truth-value gaps with embedding operators and discourse phenomena.
- Requires a distinction between the semantic truth value of a sentence and the truth value it is judged to have relative to a given 'issue' q.
  (Križ uses the term 'true enough' for the latter; cf. also the notion of 'tolerant truth' in Burnett 2017.)

Some notation

Given a three-valued proposition p:

- $[p]_+$: set of worlds making p (semantically) true, i.e. mapped to 1 by p
- $[p]_-$: set of worlds making p (semantically) false, i.e. mapped to 0 by p
  $[p]_+$ and $[p]_-$ are mutually exclusive (non-contradiction), but not jointly exhaustive (no excluded middle).
- $[p]_+^Q$: set of worlds in which p is 'true enough' relative to issue Q.

The QUD-based approach to non-maximality

Basic idea: Truth-value gap may be narrowed along the lines specified by the partition of the logical space that the issue Q provides.

Addressing an issue

cf. Križ 2015

A three-valued proposition p addresses an issue Q iff no partition cell of Q contains both worlds in $[p]_+$ and worlds in $[p]_-$.
i.e. no answer to Q is compatible with p being true and with p being false

'True enough' relative to an issue

cf. Križ 2015

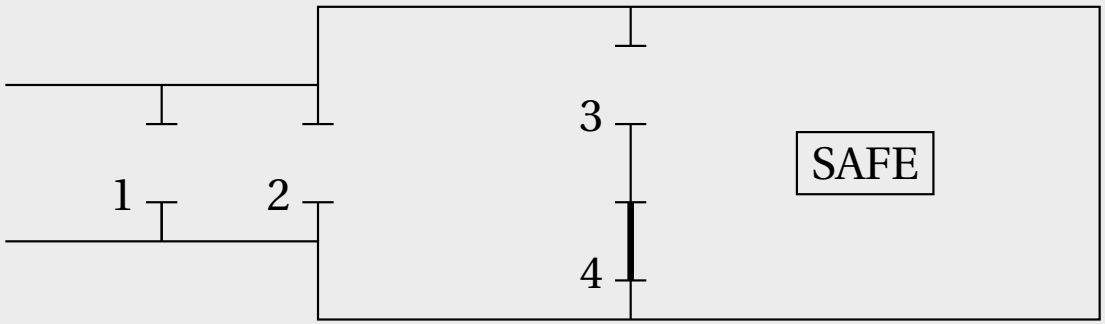
$[p]_+^Q = \{w \in W \mid \exists w'.w' \in [p]_+ \wedge w' \sim_Q w\}$, where $\sim_Q$ is the relation of being in the same partition class of Q
p is true enough in a world w iff the answer to Q in w is the same as in at least one world where p is semantically true

Empirical generalization about non-maximality

Relative to an issue Q given by the context, a plural sentence may be true in a non-maximal scenario iff that scenario answers Q in the same way as a maximal scenario.

Example: Intermediate non-maximal construal

Intermediate non-maximal scenario (1/2)



(20) A: [*Can we really break in just like that?*]
B: *Well,* ***the doors are open****, but it won't be easy . . .* true

Semantics for definite plurals

⟦*The doors are open*⟧ = p where

a. $[p]_+ = \{w \mid$ all the doors are open in $w\}$

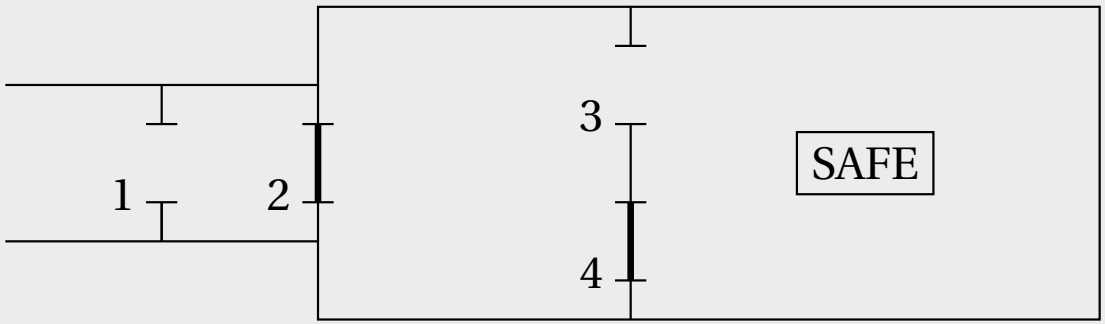
b. $[p]_- = \{w \mid$ none of the doors are open in $w\}$

Predictions

- Issue: $Q = \{\lambda w.$the safe cannot be reached without breaking locks in w, $\lambda w.$the safe can be reached without breaking locks in $w\}$
- A world w matching the picture above is in $[p]_+^Q$, so (20-B) is 'true enough'.

Example: Intermediate non-maximal construal

Intermediate non-maximal scenario (2/2)



(21) A: [*Can we really break in just like that?*]
B: *Well,* ***the doors are open****, but it won't be easy . . .* true

Semantics for definite plurals

$[\![$*The doors are open*$]\!] = p$ where

a. $[p]_+ = \{w \mid$ all the doors are open in $w\}$

b. $[p]_- = \{w \mid$ none of the doors are open in $w\}$

Predictions

- Issue: $Q = \{\lambda w.$the safe cannot be reached without breaking locks in w, $\lambda w.$the safe can be reached without breaking locks in $w\}$
- A world w matching the picture above is not in $[p]_+^Q$ – (21-B) is not 'true enough'.

Back to cumulativity

(22) *The five students have read the ten books on the list.*

The observation we started with, rephrased

(23)
a. GENERAL SCENARIO: Two students have read only books 1-5 on the reading list and the other three have read books 6-10 ...
b. 'DISTRIBUTIVE' ISSUE Q_D: Will the students be well prepared if they are examined individually on all the books on the list? (22) not true
c. 'CUMULATIVE' ISSUE Q_C: Will the students be well prepared if they have to do a joint presentation on all the books on the list? (22) true

Extending the QUD-based generalization to cumulativity

- Relative to a contextually given issue Q, a plural sentence may be true in a cumulative scenario iff that scenario answers Q in the same way as a 'maximal' scenario.
- If a distributive scenario is possible, it counts as 'maximal'.
- If a distributive scenario is ruled out (e.g. by world knowledge), there is no such QUD-dependent variation.
  Not discussed further in this talk, but see Poortman (2016), Tieu et al. (2018) for experimental results supporting this point

Semantic gaps in cumulative sentences

(24) ⟦*The five students have read the ten books on the list.*⟧ = p where

a. $[p]_+ = \{w \mid$ each of the five students has read all of the ten books in $w\}$

b. $[p]_- =$
$\{w \mid$ none of the five students has read any of the ten books in $w\}$

Relative to the 'CUMULATIVE' ISSUE Q_C

- $[p]_+^Q$ contains all worlds in which the issue is resolved in the same way as in a world in $[p]_+$ – i.e. all worlds in which the students as a group are well prepared.
- These are the worlds in which each book has been read by some student(s) – including worlds described by our cumulative scenario. ⇒ (24) true in scenario

Relative to the 'DISTRIBUTIVE' ISSUE Q_D

- $[p]_+^Q$ contains all worlds in which the issue is resolved in the same way as in a world in $[p]_+$ – i.e. all worlds in which each student has read all the books.
- This set does not include worlds described by our cumulative scenario.

⇒ (24) false in scenario

Interim conclusion

Context-dependent constraints on cumulative readings fall out if sentences with multiple plurals have denotation gaps, as proposed before for non-maximality.

Side issue: Blocking of non-maximality by numerals

(25) ⟦*The five students have read the ten books on the list.*⟧ = p where

a. $[p]_+ = \{w \mid$ each of the five students has read all of the ten books in $w\}$

b. $[p]_- =$
$\{w \mid$ none of the five students has read any of the ten books in $w\}$

- This predicts a non-maximal interpretation for each individual plural DP involved.
- In particular: p should be able to be 'true enough' in a scenario where some books were not read by any student.
- Correct for unmodified definites (*the books*), but not for definites with numerals.

(26) SCENARIO: Next week, five of my students have to do a presentation together. It is supposed to cover part of the reading list, which includes ten books. It is up to the students which books they select. To reduce their workload, the students decided that two of them would read books 1-4 and the others would read books 5-8. (25) not true

- A pragmatic blocking account of this restriction is possible: Non-maximality for *the ten books* blocked by alternatives such as *nine books, eight books* ...
- But this account presupposes the weak (non-maximal) semantics for plural definites that I will develop below.

Where does the truth-value gap come from?

To sidestep this 'blocking' issue, let's use examples without numerals:

(27) $[\![$*The students have read the books on the list.*$]\!] = p$ where

a. $[p]_+ = \{w \mid$ each of the students has read all of the books in $w\}$
b. $[p]_- = \{w \mid$ none of the students has read any of the books in $w\}$

Križ (2015)

(27) has a truth-value gap due to homogeneity effect of plural definites. If not every student read books or some books were not read by students, it is neither true nor false.

But in a cumulative scenario in which each student read books and each book was read by students, the sentence is context-independently true.

Present approach

(27) semantically neither true nor false in cumulative scenario.
Two sources of denotation gaps: individual plural definites and cumulation.

Where does the truth-value gap come from?

Chatain (2020)

- Sentences with multiple plurals context-independently true in cumulative scenarios (as in Križ 2015).
- But a connection is drawn between cumulativity and truth-value gaps, so this approach is similar in spirit to the present work.
- Cumulative readings have the same source as homogeneity effects with definites (certain alternatives of the plural definite).

Problem

Works for definites, but what about cumulative sentences with two indefinites/quantifiers? cf. also Schmitt 2013, Križ 2015 for relevant points

(28) a. *Five of my students read all the books on the list.*
b. *Five of my students read four of the books on the list.*

Neither argument individually triggers homogeneity or a truth-value gap.

(29) a. *John read all the books on the list.*
b. *John read four of the books on the list.*

Context-dependency with indefinites/quantifiers

The arguments for context-dependency of cumulative readings extend to indefinites/quantifiers.

(30) *Fünf von meinen Studierenden haben alle Bücher von der Liste gelesen.*
five of my students have all books from the list read
'Five of my students have read all the books on the list.'

'Distributive' context: Cumulative reading unavailable

DISTRIBUTIVE SCENARIO: Next week, five of my students will be examined individually by an external committee. To pass the exam, one needs to be familiar with all ten books on the reading list. However, my students are not well prepared. Two students have read only books 1-5 on the reading list and the other three have read books 6-10. (30) not true

'Cumulative' context: Cumulative reading possible

CUMULATIVE SCENARIO: Next week, five of my students have to do a presentation together. The presentation is supposed to cover a reading list of ten books. To reduce their workload, the students decided that two of them would read books 1-5 and the others would read books 6-10. (30) true

Context-dependency with indefinites/quantifiers

Results of the 'no, but …' test a bit less clear with indefinites, but examples of the following kind suggest there is still QUD-dependency:

(31) A: [So, has any of your students individually read four of the books on the list?]

B: *Nein, aber fünf von meinen Studierenden haben #(insgesamt) vier von den Büchern gelesen.*
no but five of my students have #(in.total) four of the books read
'No, but five of my students read four of the books (in total).'

Consequences

Following the line of reasoning established earlier in this talk, the choice between cumulative and distributive reading should be QUD-dependent even if there is no definite plural in the sentence.
So, sentences like (31-B) should still have denotation gaps.

Note: This raises lots of puzzles concerning non-upward-monotonic modified-numeral DPs (*exactly four books*), which I can't address yet.

Truth and falsity conditions with gaps

The students have read the books.

(32)
a. (context-independently) true iff each of the students has read all of the books
b. (context-independently) false iff none of the students has read any of the books
c. **(context-dependent or) neither true nor false** otherwise

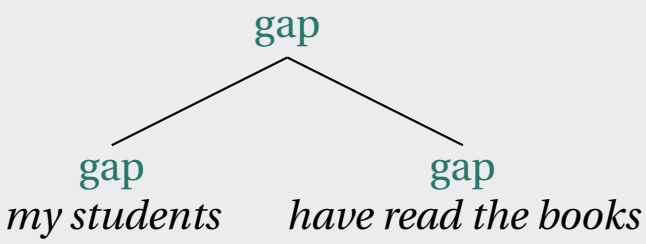
Five of the students have read all of the books.

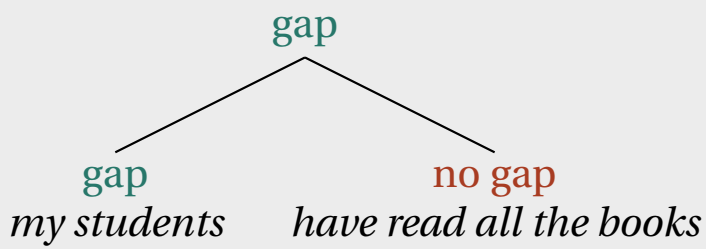
(33)
a. (context-independently) true iff there are five students who each read all of the books
b. (context-independently) false iff not all of the books have been read by a student or there are fewer than five students who have read any of the books
c. **(context-dependent or) neither true nor false** otherwise

Note: This falsity condition is the negation of the standard cumulative reading, while the truth conditions express a distributive reading.
So, cumulative scenarios fall into the context-dependent gap.

Two interacting sources of semantic gaps

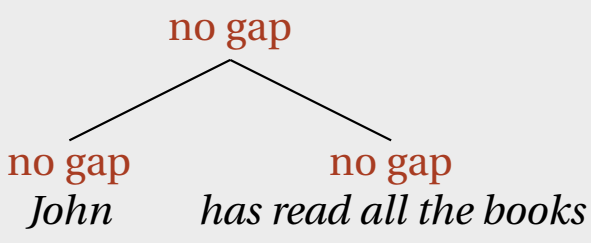
The standard 'projection' picture ...

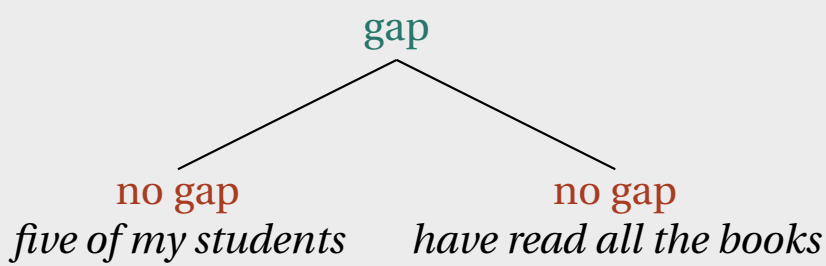




Gaps always introduced by particular plural subconstituents.

The indefinite/quantifier puzzle





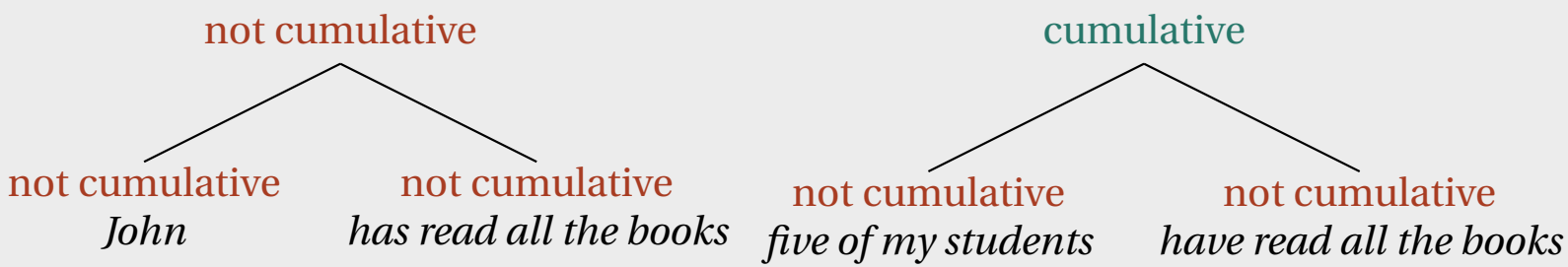
Gaps may arise from combination of two gap-less plural subconstituents.

⇒ Cumulative sentences have a semantic property arising from combination of two plurals that is not necessarily present in sentences containing only one of them.

Next steps

- I will informally sketch a semantics in which cumulativity is itself such a global, composition-based property ('Plural Projection', Schmitt 2019, Haslinger & Schmitt 2018).
- In this system, there are no special cumulative predicate meanings. Cumulativity arises from special composition rules that we need to apply when combining two plurals.

Cumulativity as a global property



- This semantics is two-valued and derives the standard cumulative truth conditions, so it has to be adapted to model semantic gaps and let the composition rules introduce them.
- Since plurality is a cross-categorial property in this framework, the notion of a semantic gap also has to be extended to other categories.

1. Goals of this talk
2. Contextual constraints on cumulative construals
3. The puzzle: QUD-dependence and interacting sources of non-maximality
4. **Plural sets and plural scales**
5. Cumulativity and composition-based truth-value gaps

Plural Projection: Basic assumptions

Assumption 1: Pluralities are a cross-categorial notion.

Motivation: t-based conjunctions may have cumulative readings

(34) *The neighbors saw John **smoke and drink**.*
SCENARIO: Neighbors A and B saw John smoke; C and D saw John drink.
cf. Krifka 1990, Schmitt 2013

Theoretical consequences

- For any type a, expressions usually thought to have type a may denote pluralities that stand in a one-to-one correspondence to sets of atomic meanings of type a.
- In this talk: I'll work with sets directly and permit the empty set. This doesn't affect the basic idea behind the system. cf. Schwarzschild 1996
- Summing up two atoms (singleton sets) {**a**} and {**b**} gives us {**a**, **b**}.
- Summing up {**drink**} and {**smoke**} gives us the plurality {**drink**, **smoke**}.

Plural Projection: Basic assumptions

Assumption 2: Plural structure 'projects' up in the tree

Motivation: Cumulative readings that cannot be attributed to cumulation at predicate level. (Schmitt 2019; cf. also Schein 1993, Kratzer 2003 a.o.)

(35) a. *The two girls* [*saw* [*Jenny* [*drink and* [*smoke* [***two cigarettes***]]]]

b. SCENARIO: Ada saw Jenny drink and smoke a Marlboro. Bea saw Jenny smoke a Gauloise.

Crucial aspect of this example

The two girls cumulates simultaneously with the conjunction and with ***two cigarettes***, which is embedded in the conjunction.
This cumulative relation cannot be due to cumulative reading of a single lexical predicate in the sentence.

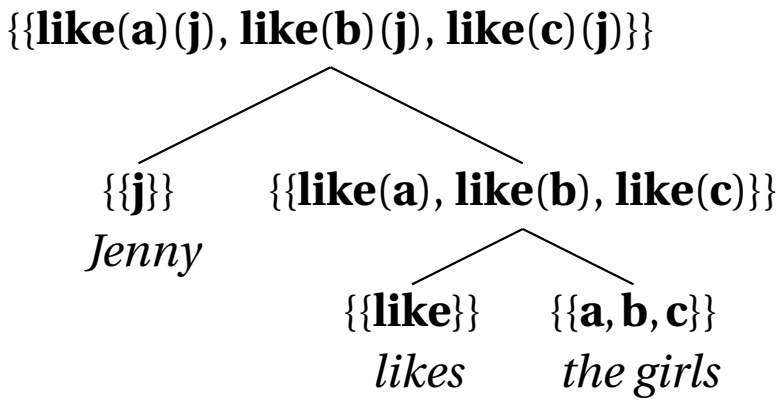
1. Cumulation within the embedded clause? Doesn't work because the subject of *drink* and *smoke* is *Jenny*, a non-plural individual.
2. LF-movement of *two cigarettes* to derive cumulative predicate? Doesn't work: Predicts wrong truth conditions + Coordinate Structure Constraint violation.

Consequence

An expression like *Jenny drink(s) and smoke(s) two cigarettes* must have a plural denotation with accessible parts to permit cumulativity.

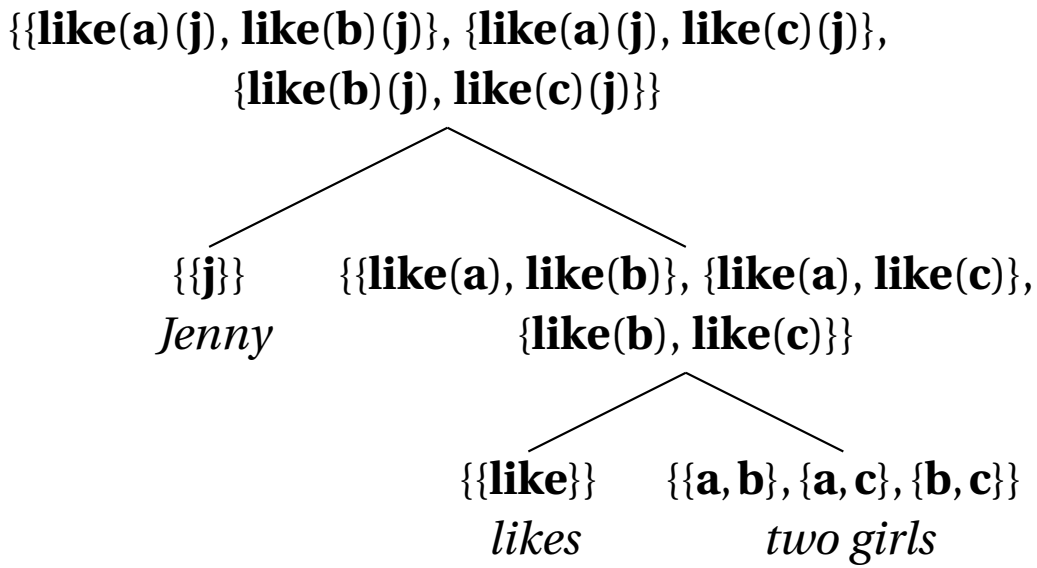
Implementation (Schmitt 2019, Haslinger & Schmitt 2018)

- Plural expressions denote sets of pluralities of atomic denotations of whichever type they are usually thought to have.
  Analogy: Alternative Semantics (Hamblin 1973, Rooth 1992, Kratzer & Shimoyama 2002), but elements of the alternative sets are pluralities.
- In my set-based version: regular type $a \mapsto$ plural set of type $\langle\langle a, t\rangle, t\rangle$.
- If some constituent has a plural denotation, so do more complex constituents containing it.



Plural Projection

The further level of sets of pluralities is motivated by the treatment of cumulativity, but also indefinites:



Truth and falsity

A plural set $S \in D_{\langle\langle\langle s,t\rangle,t\rangle,t\rangle}$ is true in w iff there is a $P \in S$ such that all elements of P are true. Otherwise S is false in w.

Existential quantification over 'alternative set'; universal quantification over parts of each plurality.

Why adding truth-value gaps is not straightforward

One problem with this system is that it is two-valued, so homogeneity and non-maximality in (36) are not accounted for.

(36) a. *Jenny likes the girls.*
b. {{**like**(**a**)(**j**), **like**(**b**)(**j**), **like**(**c**)(**j**)}}

We could try to say that (36) is neither true nor false if only some elements of the plurality in (36-b) are true. But this won't work for (37):

(37) a. *Jenny likes two girls.*
b. {{**like**(**a**)(**j**), **like**(**b**)(**j**)}, {**like**(**a**)(**j**), **like**(**c**)(**j**)}, {**like**(**b**)(**j**), **like**(**c**)(**j**)}}

- Attempt 1: A plural set is false only if some plurality in the set consists exclusively of false propositions.
  ⇒ Non-starter: If there are four girls and Jenny likes two of them, (37-a) comes out true and false simultaneously.
- Attempt 2: A plural set is false only if all pluralities in the set consist exclusively of false propositions.
  ⇒ Inadequate: (37-a) not predicted false if Jenny likes exactly one girl.

An analogy: Vague scalar predicates

Interim summary

- I informally sketched the motivation for the 'plural projection' semantics from Schmitt (2019) and part of her system.
- In this system, any expression containing a plural has a denotation with a plural structure. We want to preserve this property.
- But there is a problem: it is not obvious how to encode the 'gaps' underlying homogeneity and non-maximality.

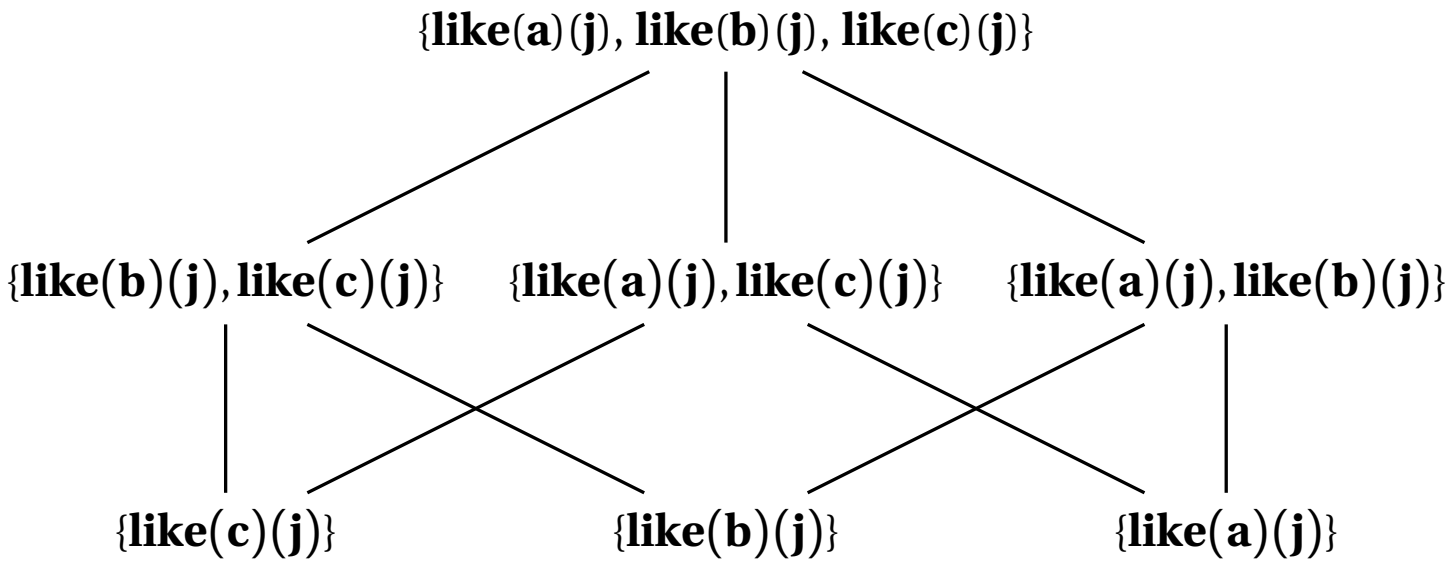
A starting point: Plural sets are partially ordered

Consider the following plural set, which might be a possible denotation for *Jenny likes some girls* in this framework:

(38) {{**like**(**a**)(**j**), **like**(**b**)(**j**), **like**(**c**)(**j**)},
{**like**(**a**)(**j**), **like**(**b**)(**j**)}, {**like**(**a**)(**j**), **like**(**c**)(**j**)}, {**like**(**b**)(**j**), **like**(**c**)(**j**)},
{**like**(**a**)(**j**)}, {**like**(**b**)(**j**)}, {**like**(**c**)(**j**)}}

Given our previous assumption that pluralities of propositions are interpreted via conjunction, this set has an inherent partial ordering based on entailment.

Plural sets are partially ordered



Partial ordering of a plural set

For a plural set S of type $\langle\langle a, t\rangle, t\rangle$, where a is t-based:
For any $p, q \in S$, $p <_S q$ iff $\bigwedge_q \sqsubset \bigwedge_p$, where $\sqsubset$ is cross-categorial proper entailment and $\bigwedge$ is cross-categorial Boolean conjunction.

Example: For S pictured above,
$\{\mathbf{like(a)(j)}, \mathbf{like(b)(j)}, \mathbf{like(c)(j)}\} >_S \{\mathbf{like(b)(j)}, \mathbf{like(c)(j)}\}$,
because $\mathbf{like(a)(j)} \wedge \mathbf{like(b)(j)} \wedge \mathbf{like(c)(j)} \sqsubseteq \mathbf{like(b)(j)} \wedge \mathbf{like(c)(j)}$.

An analogy: Vague scalar predicates

- There is another class of linguistic phenomena that involve ordering relations and are claimed to give rise to truth-value gaps: vague scalar predication.
- Here, we are interested in approaches to such predicates that do not use degrees and order individuals directly (see Klein 1980, Burnett 2017 a.o.).

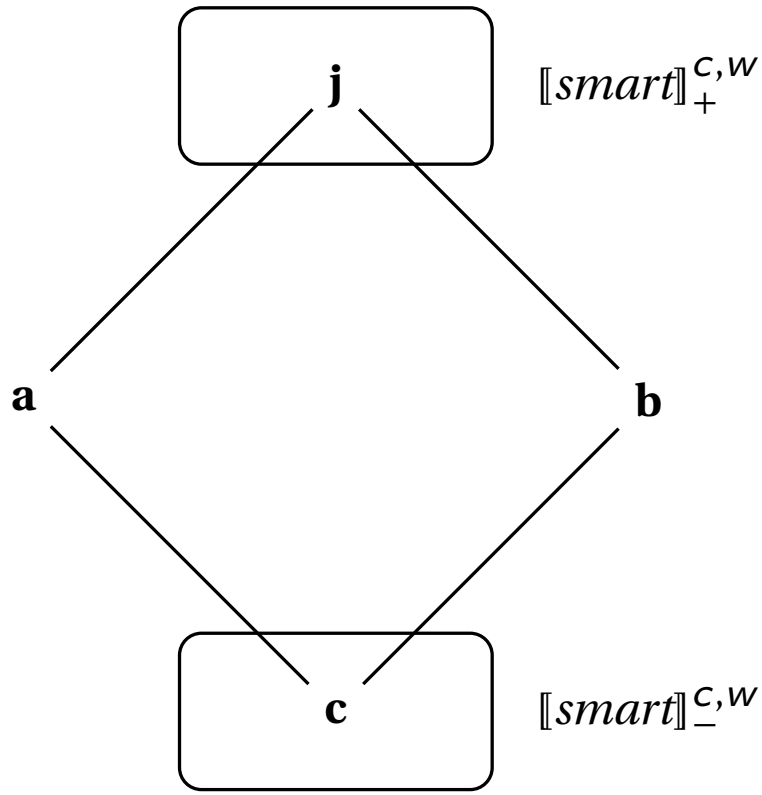
(39) a. *Jenny is smarter than Bill.*
b. *Jenny is smart.*
c. *Jenny is not smart.*

Note: Ordering might not be total in this case either – Jenny may be smarter than Bill in some respects but not others. Klein 1980

- In such theories, the semantics of a scalar predicate like *smart* must provide at least
  - a partial ordering $<_{smart}$ between individuals cf. (39-a)
  - and functions mapping each context c and world w to a positive extension $[\![smart]\!]_{+}^{c,w}$ and a negative extension $[\![smart]\!]_{-}^{c,w}$. cf. (39-b,c)

Illustration: Vague scalar predicates

A potential scale for *smart*:



Plurals as higher-type scalar predicates

This analogy can be exploited to define a system that

- gives plurals denotations with the internal structure we need for complex cases of cumulativity
- and is flexible enough to let us distinguish between plurals with and without denotation gaps.

Plural scales

Each plural expression with 'parts' of some t-based type a denotes a plural scale. This is a triple $S = \langle [S], [S]_+, [S]_- \rangle$ where $[S] \in D_{\langle\langle a,t\rangle,t\rangle}$ is a set of pluralities and:

a. the positive set $[S]_+$ and the negative set $[S]_-$ are nonempty subsets of $[S]$;
b. $[S]_+$ and $[S]_-$ are convex sets wrt. the entailment-based ordering $<_{[S]}$ (which I will write as $<_S$). That is, if two pluralities are in $[S]_+ / [S]_-$, so are all the pluralities ordered in between.
c. for any $p \in [S]_-$ and $q \in [S]_+$, $p <_S q$;
d. every minimal element of $<_S$ is in $[S]_-$ and every maximal element is in $[S]_+$.

Note: I avoid the terms 'positive/negative extension' because the elements of the scale will generally be of intensional types (e.g. propositions).

Illustration: Plural scales

Scale S for *Jenny likes the girls* (with denotation gaps):

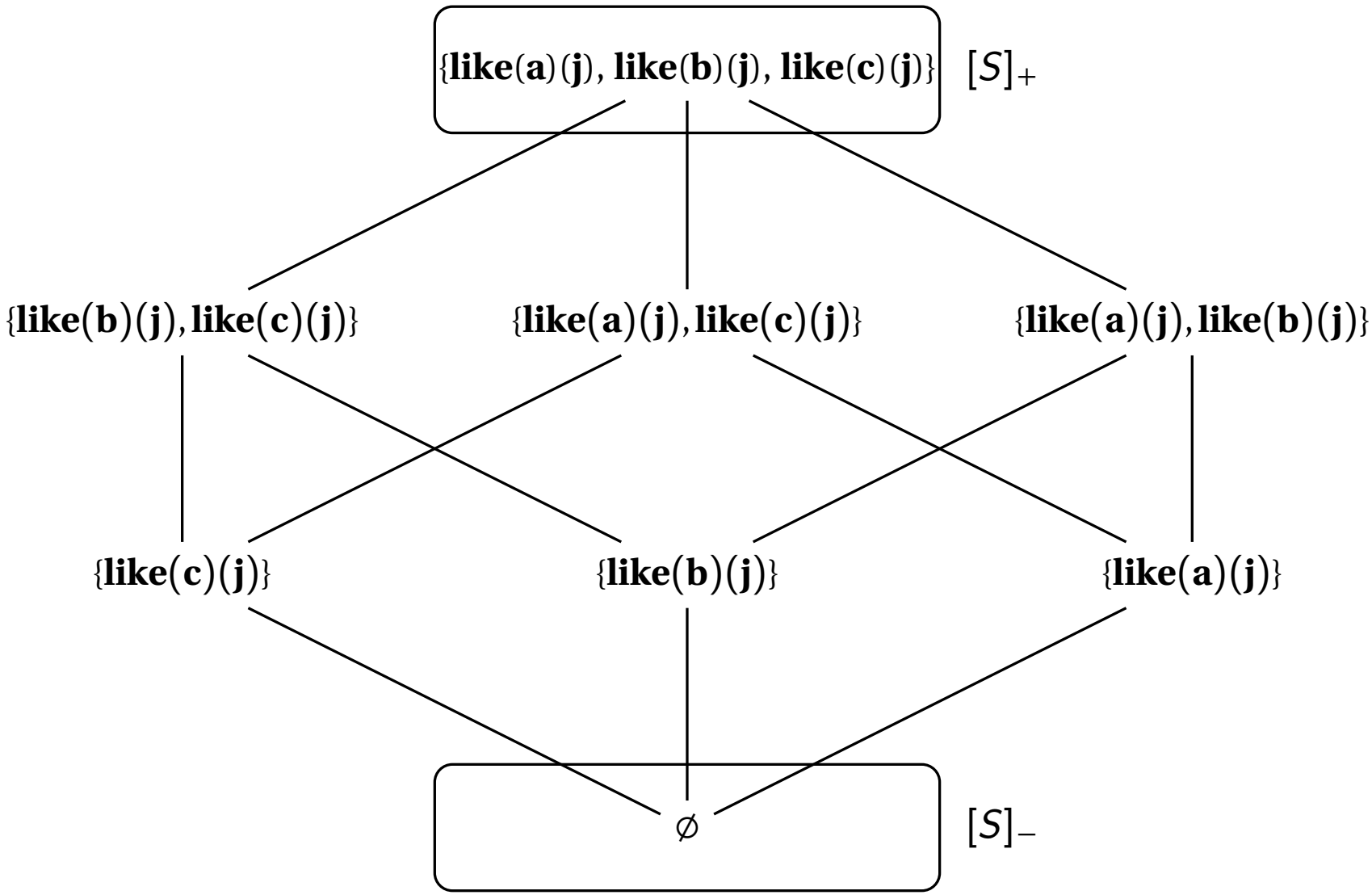
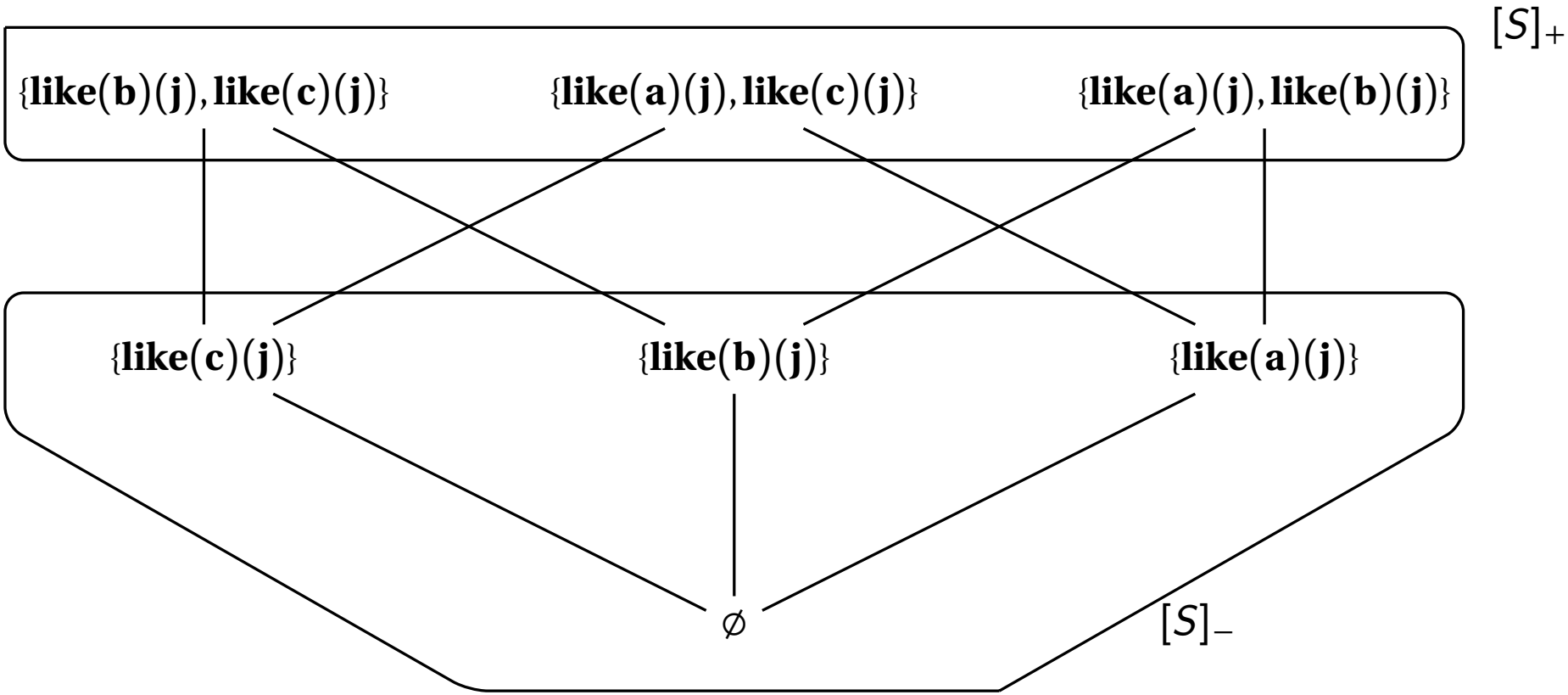


Illustration: Plural scales

Scale S for *Jenny likes two girls* (no denotation gap):



From plural scales to truth/falsity conditions

Next steps

- Spell out the mapping from 'positive set' to truth conditions and from 'negative set' to falsity conditions.
- Show how plural scales for complex constituents, including cumulative sentences, may be derived compositionally.

Simplifying assumptions

Here, to simplify things, we'll look at plural scales with the following properties:

- They are downward-closed, i.e. for any set (encoding a plurality) on the scale, all its subsets are on the scale.
- The elements of the pluralities are of a t-based type.
- Any two atomic elements of pluralities on S are logically independent.

- Given a plural scale of propositions with these properties, we can derive a partition of the logical space via exhaustification of each plural proposition.
- Each element of the original scale corresponds to a unique partition class.
- These partition classes give rise to truth and falsity conditions.

From plural scales to truth/falsity conditions

Given a plural scale $S = \langle [S], [S]_+, [S]_- \rangle$, where the elements of the pluralities in S are of a t-based type:

(40) The set $\text{AT}(S)$ of atoms of S is defined as $\{x \mid \exists P \in [S].x \in P\}$, the set of all elements of the pluralities in $[S]$.

(41) We further define $\mathscr{C}_S = \{\bigwedge A \mid A \subseteq \text{AT}(S)\}$
= the set of all conjunctions of atoms on the scale

(42) If the pluralities in S consist of propositions, the partition associated with S is a triple $P_S = \langle [P_S], [P_S]_+, [P_S]_- \rangle$ where

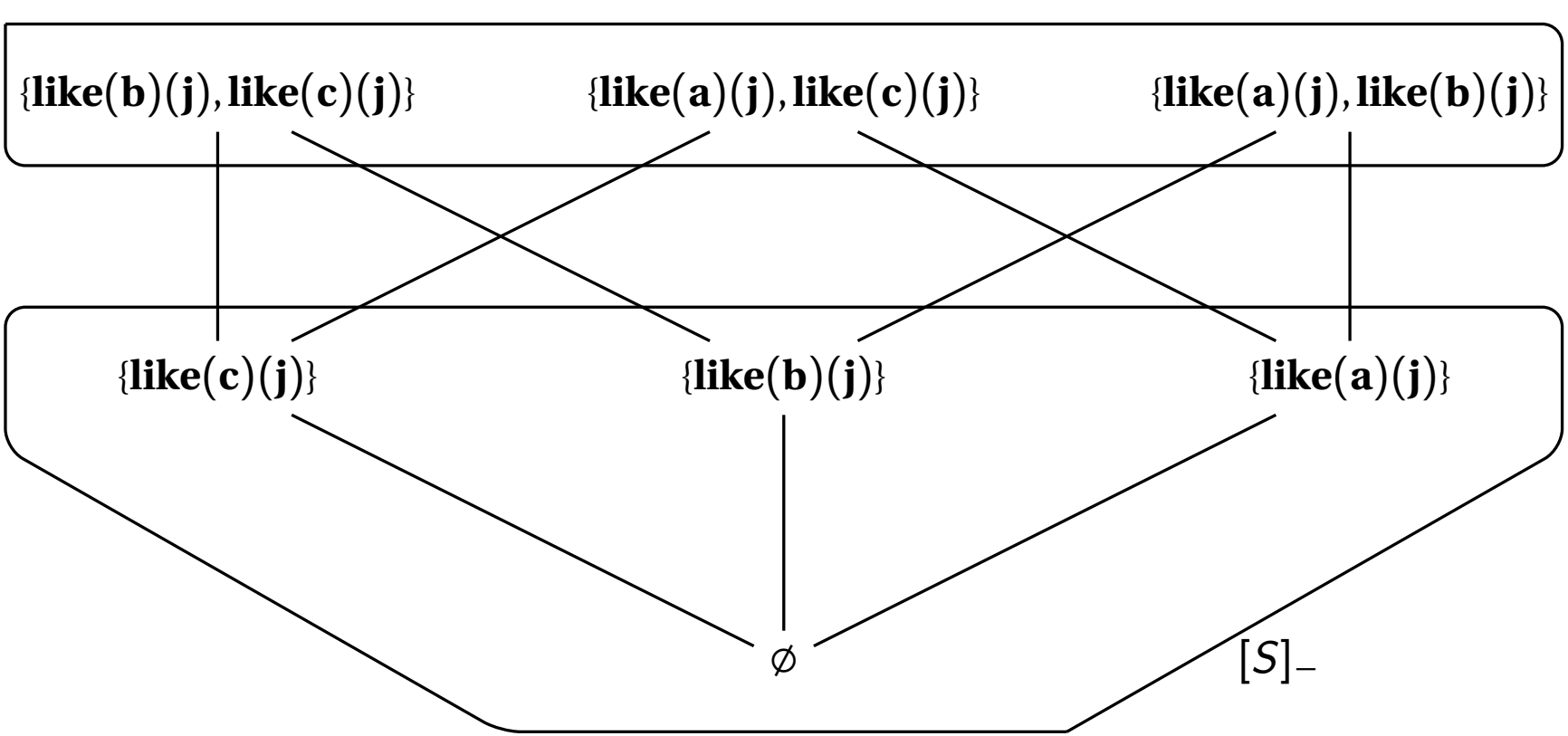
a. $[P_S] = \{p \wedge \bigwedge\{\neg a \mid a \in \text{AT}(S) \wedge p \not\sqsubseteq a\} \mid p \in \mathscr{C}_S\}$
the set of all exhaustified versions of conjunctions from $\mathscr{C}_S$

b. $[P_S]_+ = \{p \in [P_S] \mid \exists P \in [S]_+.p \sqsubseteq \bigwedge P\}$
the set of all partition cells that entail some plurality in $[S]_+$

c. $[P_S]_- = \{p \in [P_S] \mid \nexists P \in [S] \backslash [S]_-.p \sqsubseteq \bigwedge P\}$
the set of all partition cells that only entail pluralities in $[S]_-$

Illustration: Partition associated with a scale

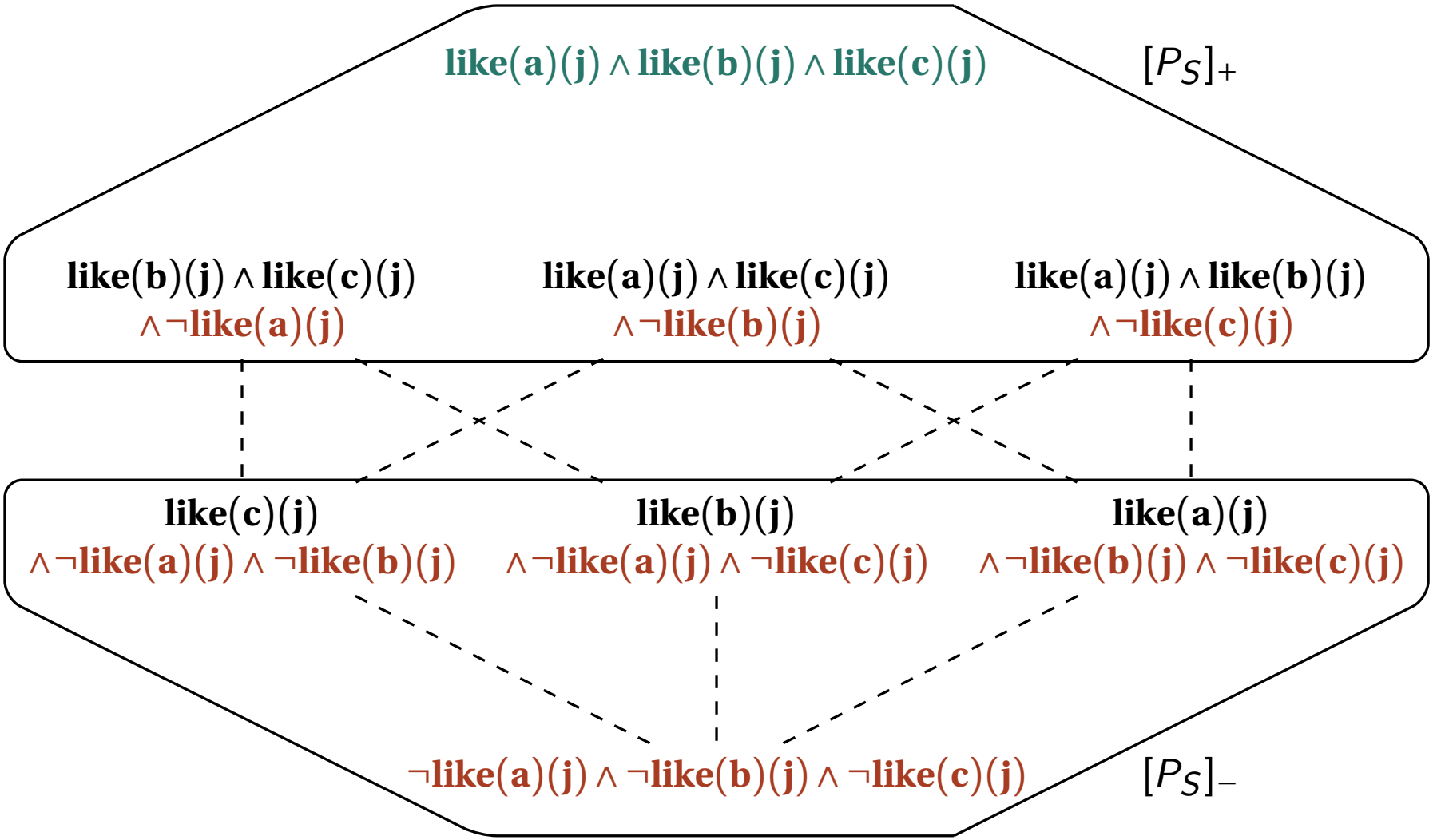
Here's the scale for *Jenny likes two girls* again ...



$\text{AT}(S) = \{\textbf{like}(\textbf{a})(\textbf{j}), \textbf{like}(\textbf{b})(\textbf{j}), \textbf{like}(\textbf{c})(\textbf{j})\}$

We now form all the conjunctions of these atoms (including those that entail that Jenny likes more than two girls).

Illustration: Partition associated with a scale



From plural scales to truth/falsity conditions

Let $P_S = \langle [P_S], [P_S]_+, [P_S]_- \rangle$ be the partition associated with a plural scale S.

Addressing an issue

S addresses an issue Q iff
a. every partition class in $[P_S]$ is a subset of some partition class in Q,
b. and no partition class in Q contains elements of both $[P_S]_+$ and $[P_S]_-$.

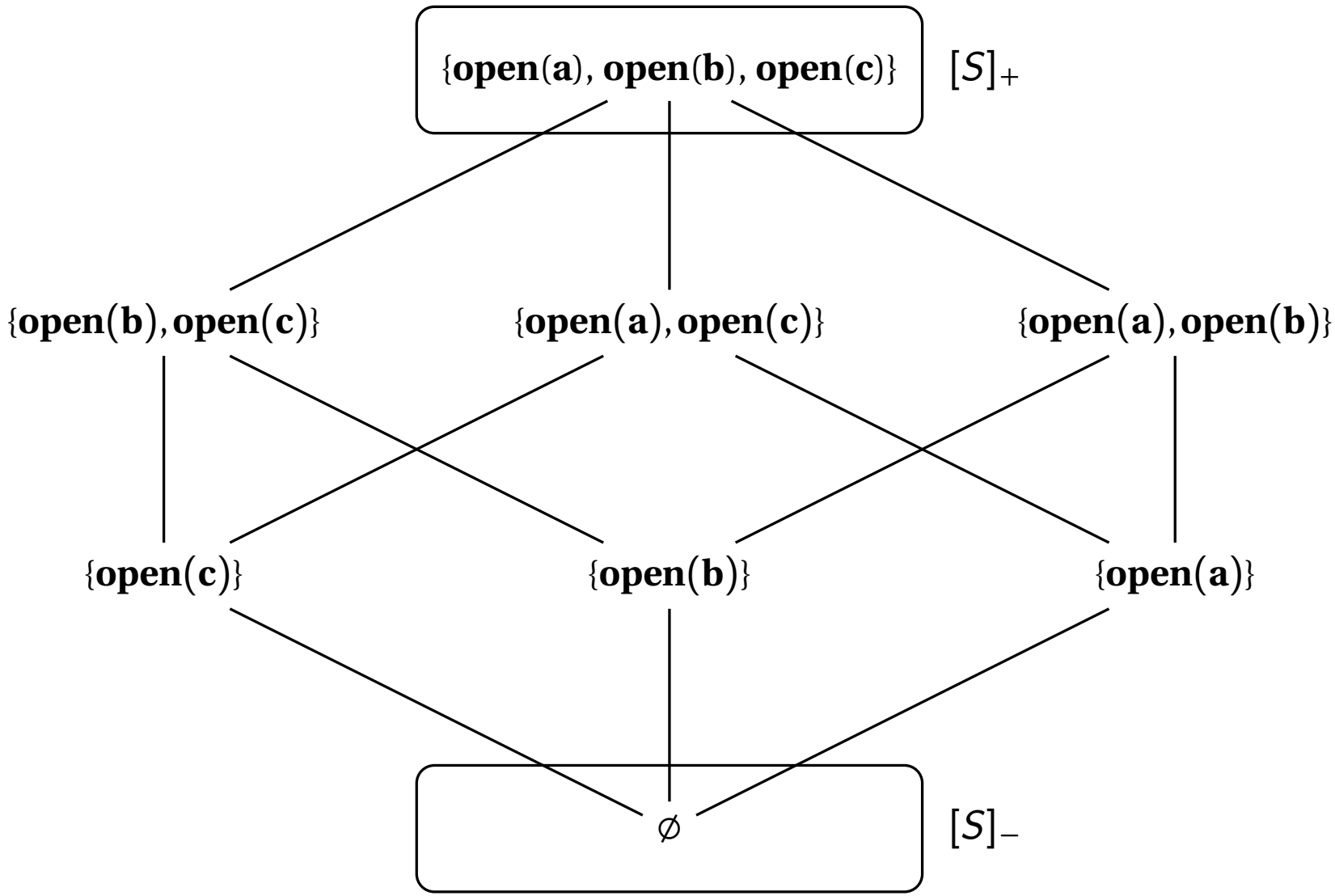
The notion of truth relative to an issue follows the basic idea from Križ (2015):

Truth and falsity conditions

- S is (context-independently) true in a world w iff there is a $p \in [P_S]_+$ such that $w \in p$.
- S is false in w iff there is a $p \in [P_S]_-$ such that $w \in p$.
  There may still be a 'gap' in the partition.
- Given an issue Q addressed by S, we define $[P_S]_+^Q$ as the set of all partition classes $p \in [P_S]$ that entail the same answer to Q as some partition class in $[P_S]_+$.
- Given an issue Q addressed by S, S is true relative to Q in w iff there is a $p \in [P_S]_+^Q$ such that $w \in p$.

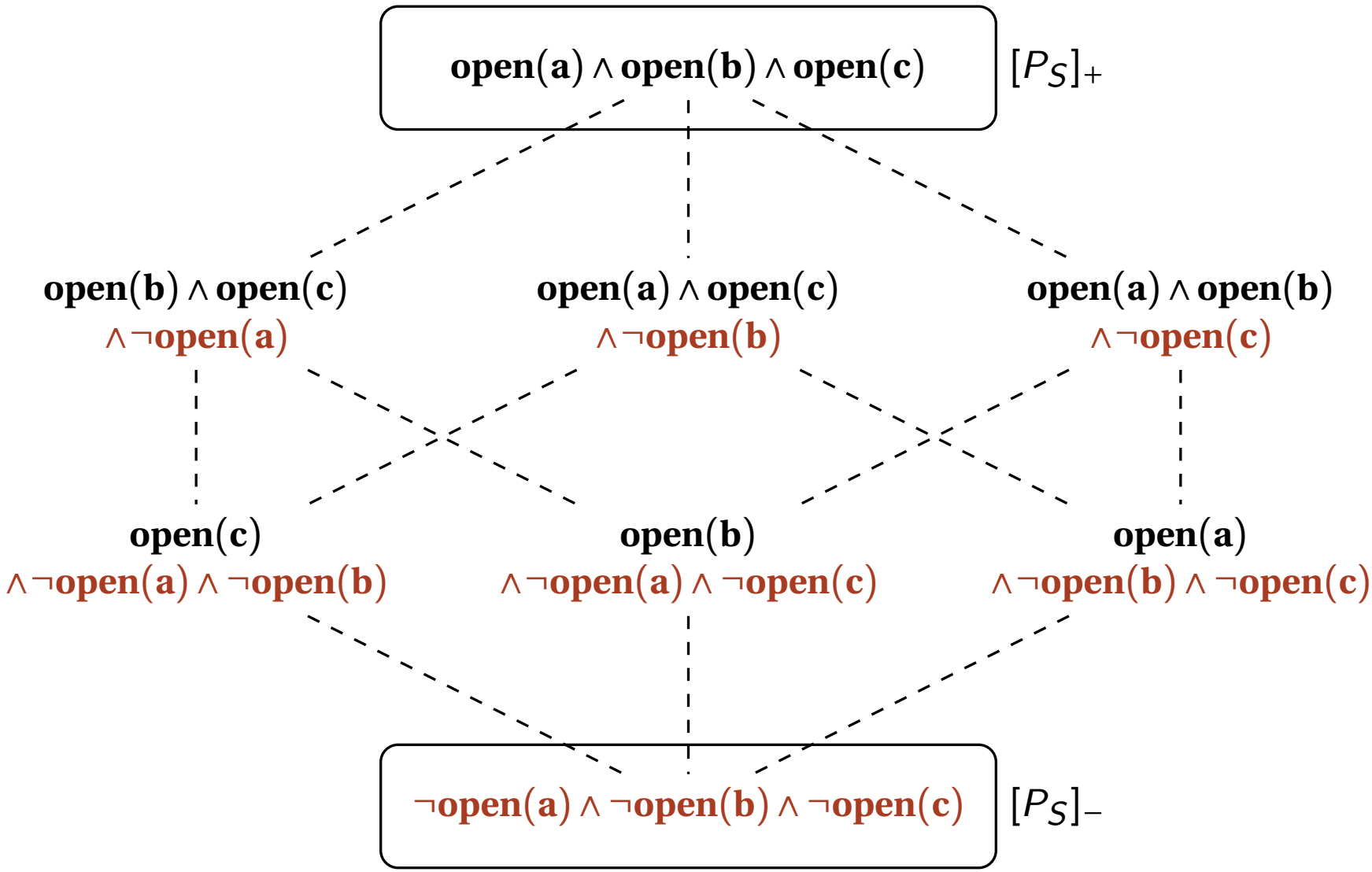
Truth and falsity: Illustration

If there are three doors **a**, **b**, **c**, *The doors are open* denotes the following scale:



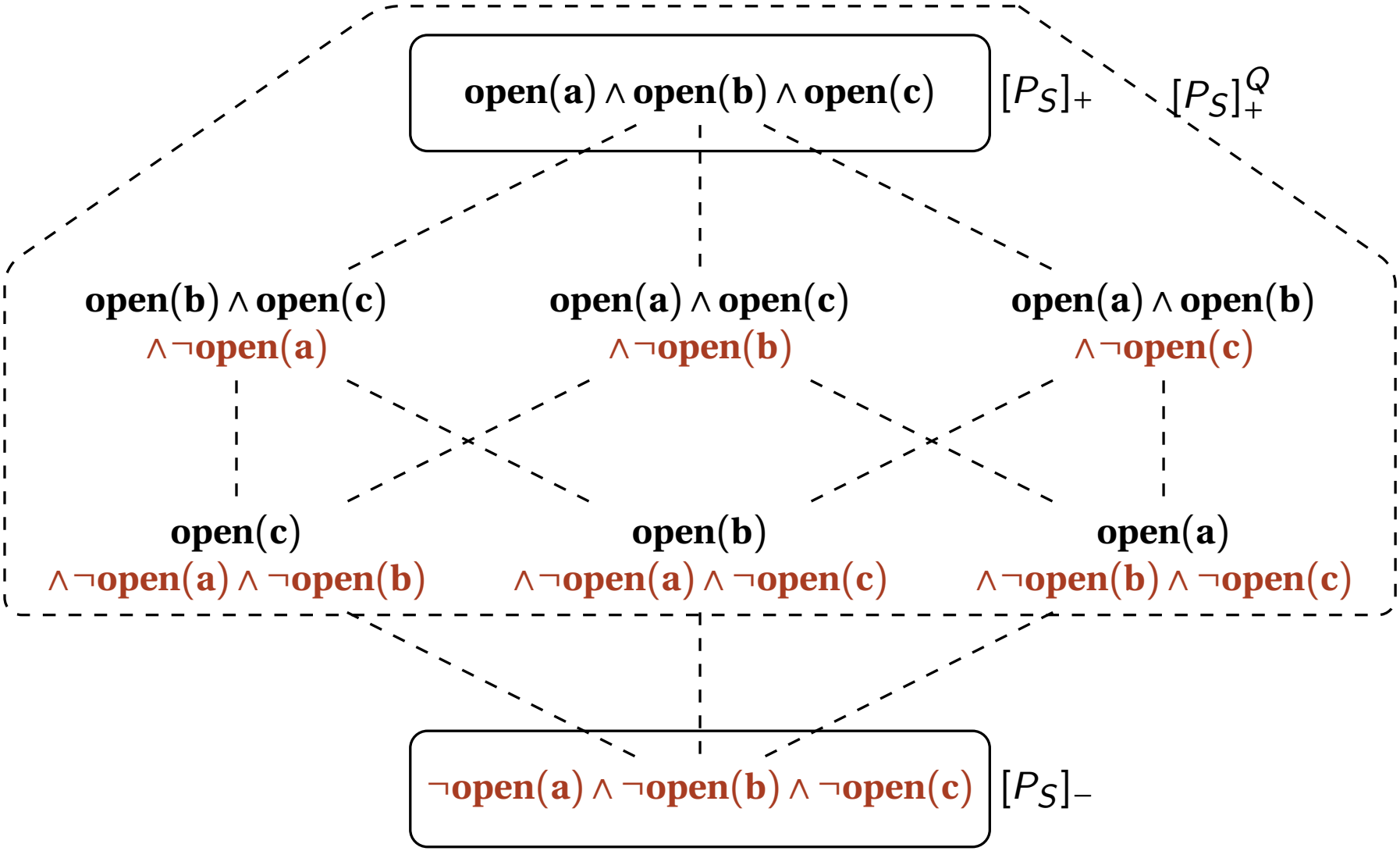
Truth and falsity: Illustration

This scale corresponds to the following partition:



Truth relative to an issue: Illustration

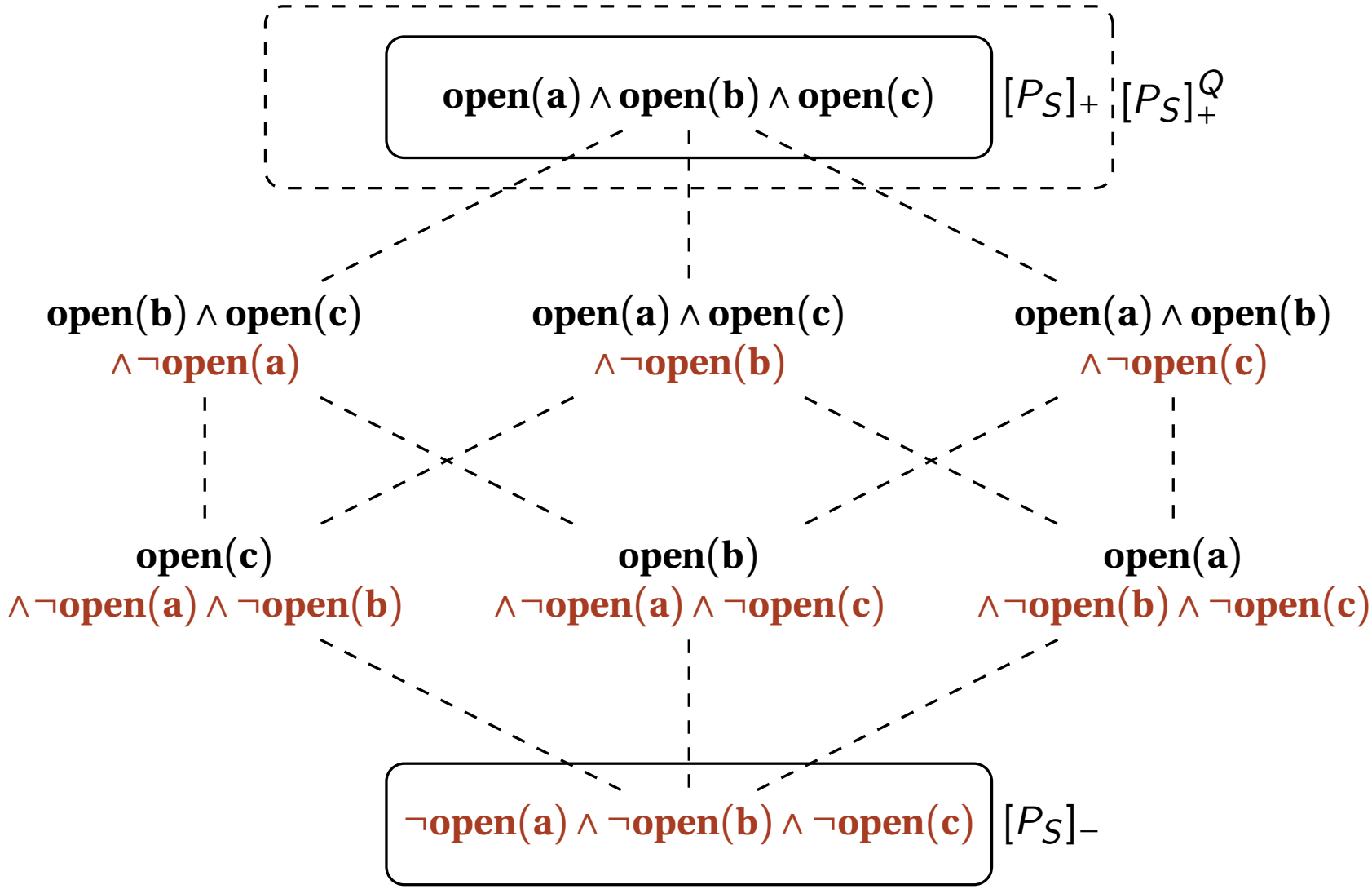
Given issue Q = 'Are any of the doors open?'



⇒ Sentence true relative to Q in non-maximal scenario.

Truth relative to an issue: Illustration

Given issue Q = 'Are all of the doors open?'



⇒ Sentence not true relative to Q in non-maximal scenario.

Interim summary

- Cumulative readings and non-maximal readings reflect the same semantic phenomenon.
- Following existing work on non-maximality, I took this phenomenon to be truth-value gaps.
- I argued that the gaps in cumulative sentences are not always due to a particular plural expression, but can also arise from the compositional mechanism.
- As a starting point, I partly introduced Schmitt's (2019) system, on which plural expressions can be of any type and denote sets of pluralities of that type.
- Since this system is two-valued, these 'plural sets' were replaced with scalar predicates of pluralities that come with a 'positive set' and a 'negative set'.
- Plural sentences were assumed to denote scalar predicates of propositions. I showed how this accounts for non-maximality.

Next steps

- We will assign plural scales to subsentential constituents as well.
- Following previous work on the 'projection' behavior of cumulativity (Haslinger & Schmitt 2018), we will define a composition rule that combines plural scales.
- This composition principle captures the interaction between cumulativity and non-maximal interpretations of individual plurals.

1. Goals of this talk
2. Contextual constraints on cumulative construals
3. The puzzle: QUD-dependence and interacting sources of non-maximality
4. Plural sets and plural scales
5. **Cumulativity and composition-based truth-value gaps**

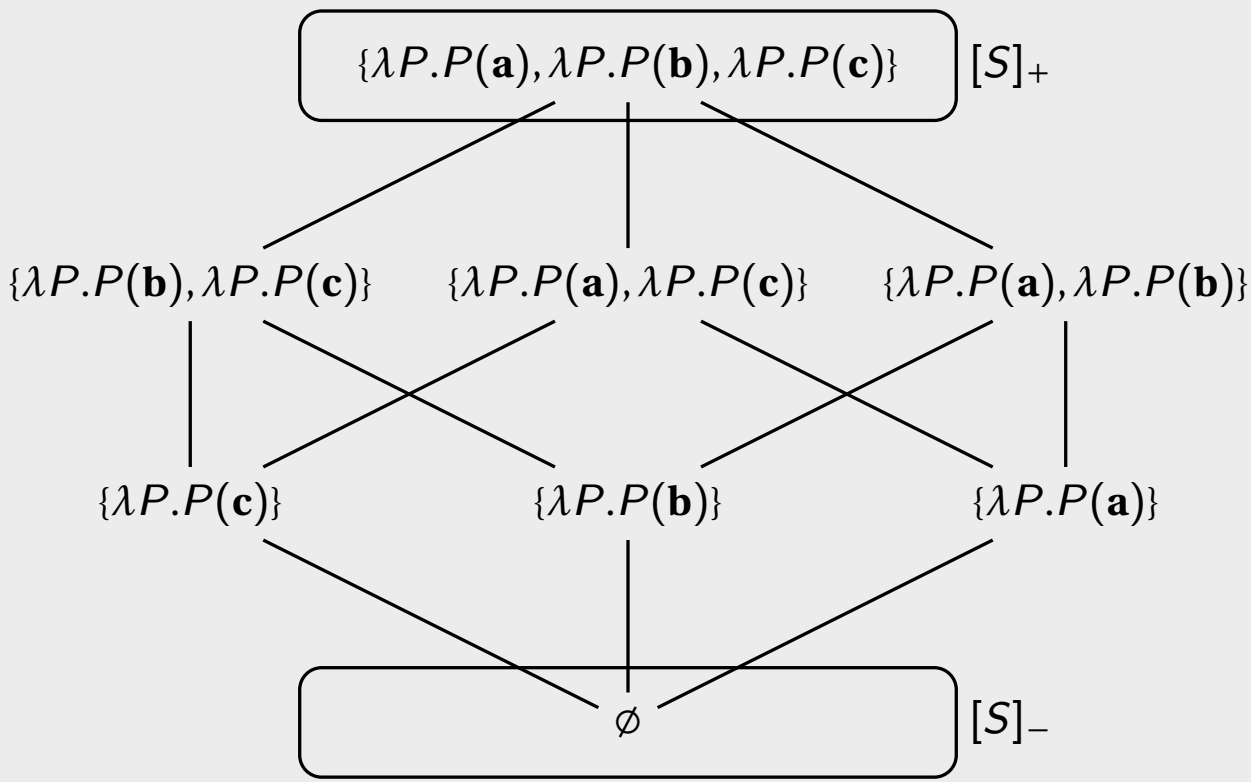
Plural scales across categories

We first need to say something about simple plurals like *the books* or *two books*.

We will assume that subsentential constituents containing a plural denote plural scales as well.

Since the ordering underlying plural scales is based on entailment, the atomic individuals in each plurality have to be shifted to quantifier type.

Scale for *the books* (for books **a**, **b**, **c**)



Composing two plural scales

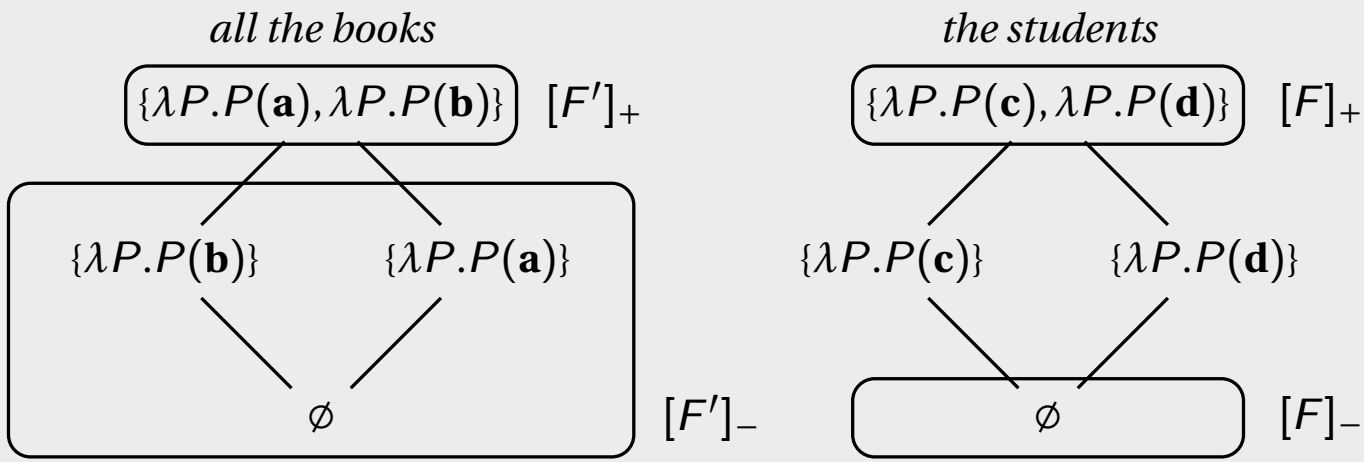
Goal

Define a composition principle that combines a functor scale $F = \langle [F], [F]_+, [F]_- \rangle$ with atoms of type $\langle a, b \rangle$ and an argument scale $A = \langle [A], [A]_+, [A]_- \rangle$ with atoms of type a to get a scale $\langle [S], [S]_+, [S]_- \rangle$ of type b.

Let's illustrate the mechanism with an example: *The students read all the books*, with books **a**, **b** and students **c**, **d**.

Plural scales for subject and object

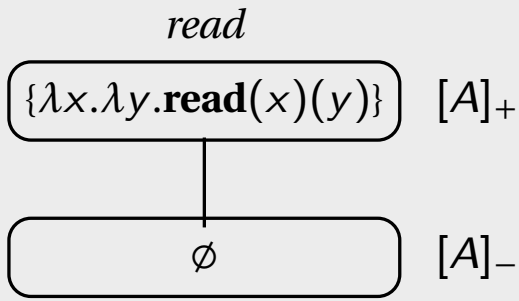
The students introduces a gap ($\rightsquigarrow$ non-maximality), *all the books* does not.



Composing two plural scales

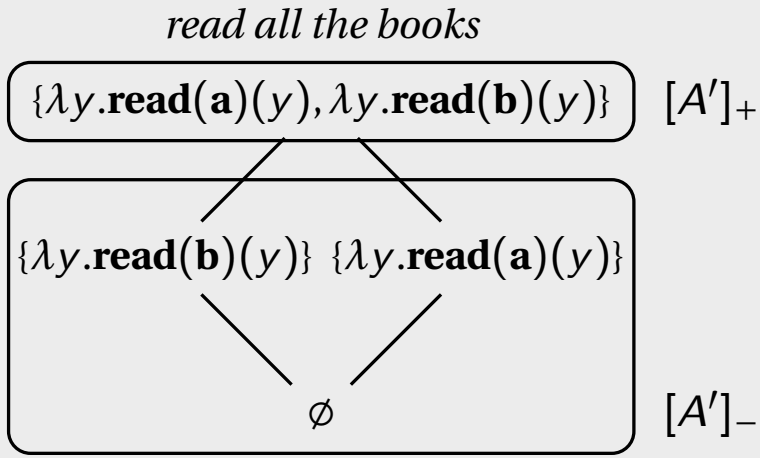
Trivial scales for non-plural expressions

The non-plural predicate *read* is associated with a scale containing a singleton set on the 'positive' and the empty set on the 'negative' side.



Scale for *read all the books*

The first 'trivial' composition step preserves the scale structure of *all the books*:



To see how this works, let's now consider the non-trivial step of composing this with the scale for *the students*.

Composing two plural scales

To compute the domain of the new scale, $[S]$, we take all the 'function-argument covers' derived from $[F]$ and $[A]$.

A function-argument cover is a mapping from atomic parts of a function plurality to argument pluralities.

Function-argument cover

A function-argument cover of two plural scales F, A is a partial function $C : \text{AT}(F) \rightarrow [A]$ such that the domain of C is a plurality in $[F]$.

For instance, $[F]$ and $[A']$ defined above have the following function-argument covers, among others:

(43) a. $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y)\}, \lambda P.P(\mathbf{d}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{b})(y)\}$
cumulative/'non-maximal' cover

b. $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y), \lambda y.\mathbf{read}(\mathbf{b})(y)\}, \lambda P.P(\mathbf{d}) \mapsto$
$\{\lambda y.\mathbf{read}(\mathbf{a})(y), \lambda y.\mathbf{read}(\mathbf{b})(y)\}$ distributive/'maximal' cover

For each cover, we compose each function in the cover with each part of its argument plurality using our usual composition rules (e.g. functional application) and collect the results in a set.

Composing two plural scales

(44) a. $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y)\}, \lambda P.P(\mathbf{d}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{b})(y)\}$
cumulative/'non-maximal' cover

b. $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y), \lambda y.\mathbf{read}(\mathbf{b})(y)\}, \lambda P.P(\mathbf{d}) \mapsto$
$\{\lambda y.\mathbf{read}(\mathbf{a})(y), \lambda y.\mathbf{read}(\mathbf{b})(y)\}$ distributive/'maximal' cover

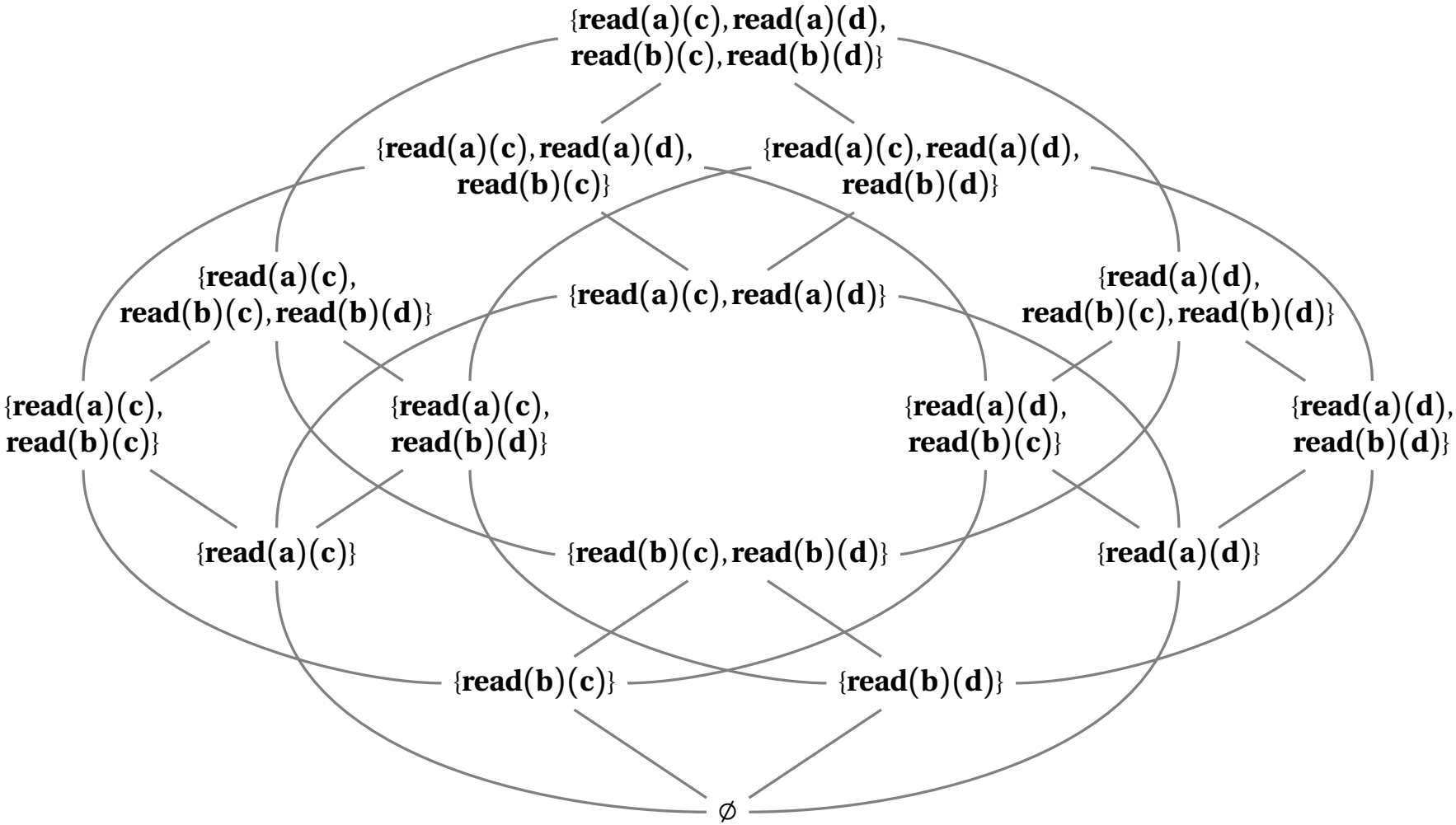
We compose each function in the cover with each part of its argument plurality using our usual composition rules (e.g. functional application) and collect the results in a set.

(45) a. $\{\mathbf{read}(\mathbf{a})(\mathbf{c}), \mathbf{read}(\mathbf{b})(\mathbf{d})\}$ corresponding to (44-a)/cumulative scenario

b. $\{\mathbf{read}(\mathbf{a})(\mathbf{c}), \mathbf{read}(\mathbf{a})(\mathbf{d}), \mathbf{read}(\mathbf{b})(\mathbf{c}), \mathbf{read}(\mathbf{b})(\mathbf{d})\}$
corresponding to (44-b)/distributive scenario

These sets will be the elements of our new scale.

Illustration: Composing two plural scales



Now we have an ordered set of propositions, but what about the positive and negative sets ($\rightsquigarrow$ truth and falsity conditions)?

Composing two plural scales: Positive set

The positive set $[S]_+$ reflects situations where the sentence is true in every context.

So, it encodes a maximal construal wrt. each individual plural and a distributive construal overall.

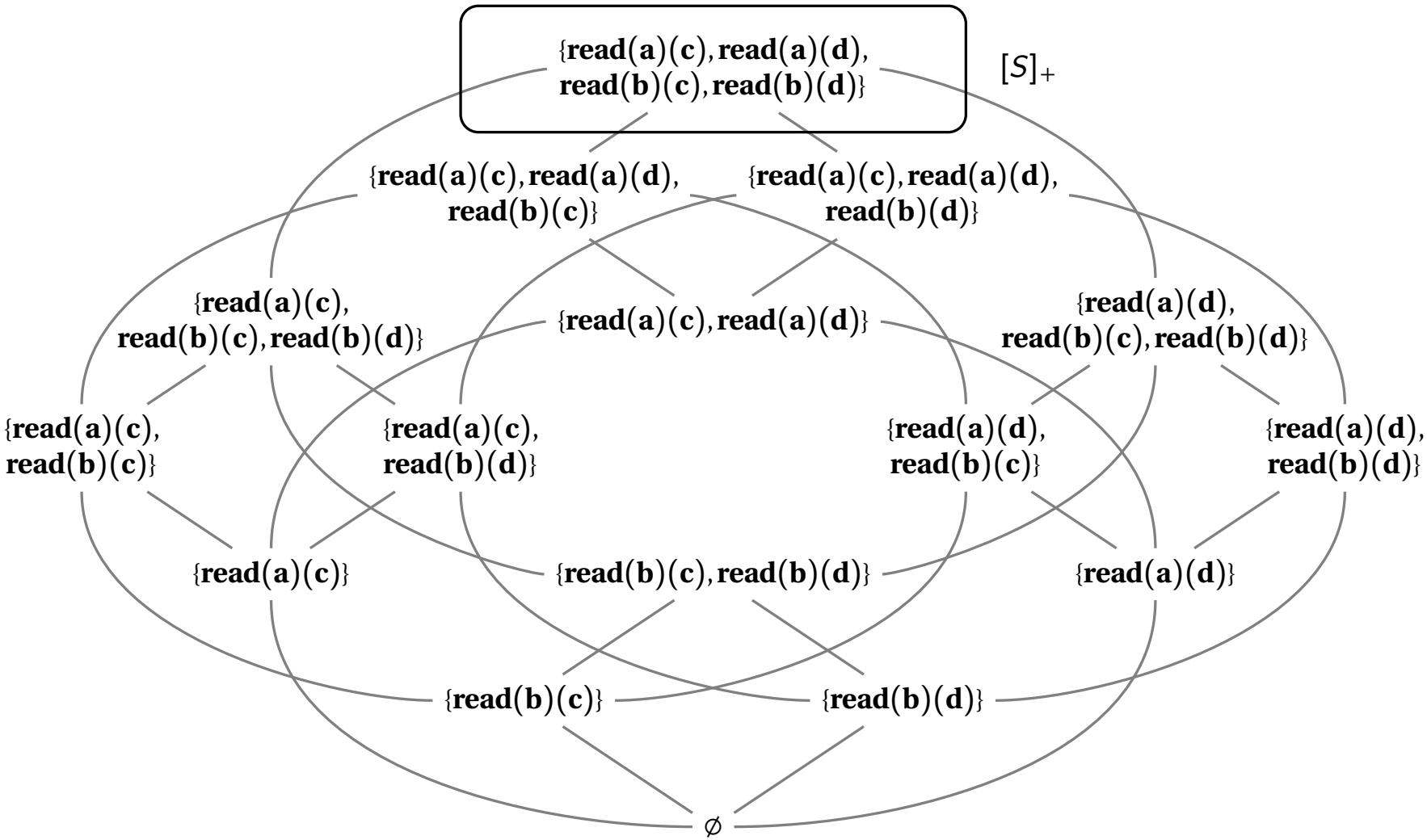
- We look at those function-argument covers in which one or more elements of $\text{AT}(F)$ are matched with pluralities $a \in [A]_+$, i.e. in the positive set of the argument scale.

  $\Rightarrow$ distributivity + maximal construal of each plural in the argument

  In our example: We consider atomic function-parts matched with the predicate plurality that corresponds to reading all the books.
- For each cover, we form the set of the elements of $\text{AT}(F)$ with this property. By definition, this set is in $[F]$.
- If this set is also in $[F]_+$, the resulting value plurality is in $[S]_+$.

  $\Rightarrow$ maximal construal of function plurality
  In our example: Each student is matched with the predicate plurality that corresponds to reading all the books.

Composing two plural scales: Positive set



Composing two plural scales: Negative set

The negative set $[S]_-$ reflects situations where the sentence is false in every context.

These are situations where it is false even under a non-maximal construal wrt. each individual plural and a cumulative construal overall.

- We look at function-argument covers whose domain is in $[F]_-$, i.e. the set of atomic function-parts 'used' in the cover is in $[F]_-$.
  For each such cover, the corresponding value plurality is in $[S]_-$.

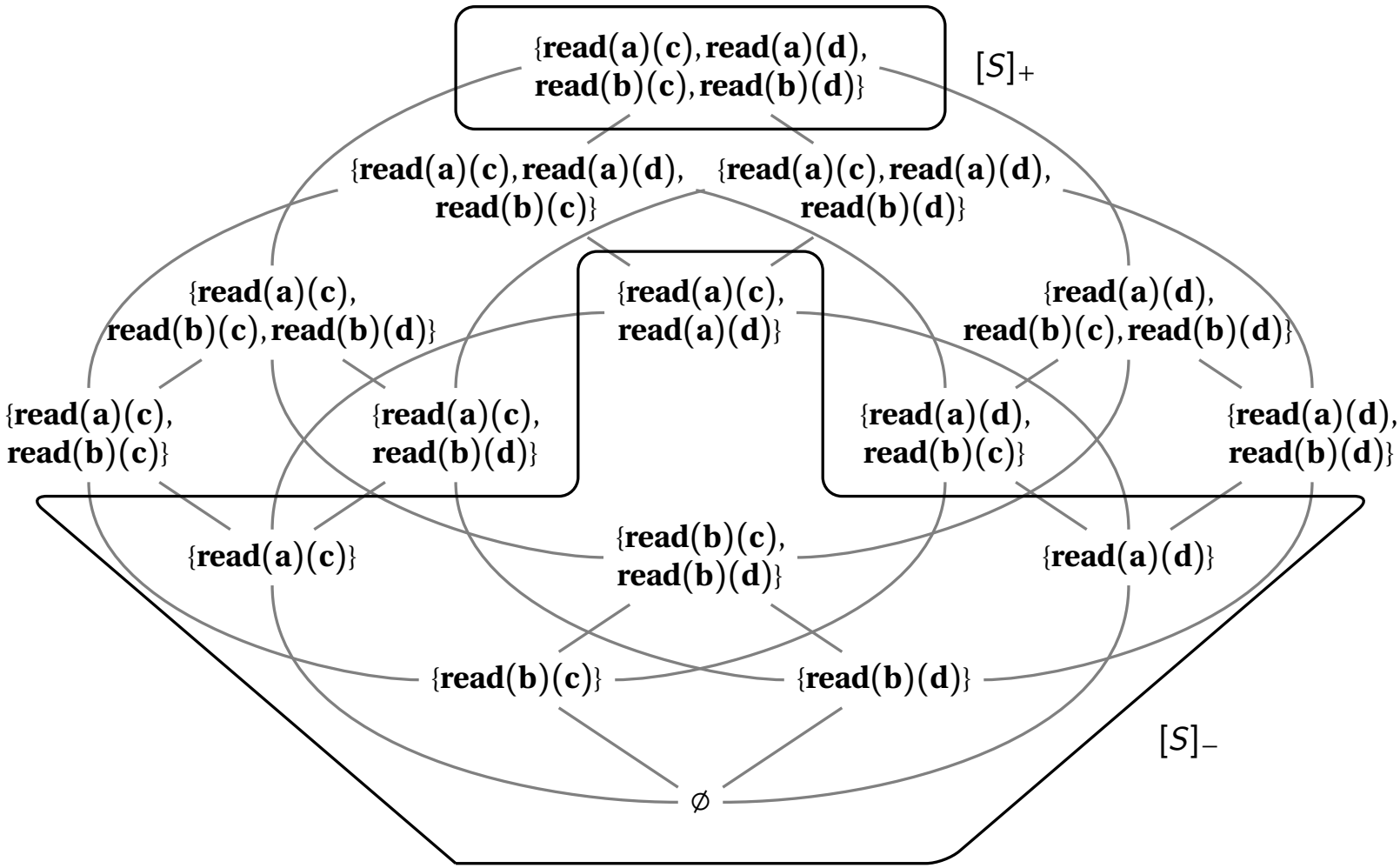
  $\Rightarrow$ non-maximal construal of function plurality

  In our example: We consider covers in which none of the students read any books.
- In addition, we look at function-argument covers where the set of all atomic argument-parts 'used' in the cover is in $[A]_-$.
  For each such cover, the corresponding value plurality is in $[S]_-$.

  $\Rightarrow$ cumulativity, non-maximal construal of plurals within the argument
  In our example: We consider covers in which not all books were read by a student.

Composing two plural scales: Positive and negative sets

(46) *The students read all the books.*



Composing two plural scales

(47) *The students read all the books.*

Context-independent truth and falsity conditions

(47) true iff each of the students read all of the books.
(47) false iff not all of the books were read by a student
⇒ We get non-maximality wrt. *the students* and global cumulativity.
⇒ We don't get non-maximality wrt. *all the books*.

Some noteworthy properties of this mechanism

- Lexical meanings of (non-collective) predicates need to be defined only for atomic arguments.
  Cumulativity due to compositional mechanism, not to individual predicates.
- Composition rule encodes a function-argument asymmetry.
  Fits with evidence that cumulative readings are not really 'scopeless'.
  Schein (1993), Kratzer (2003), Champollion (2010), Buccola & Spector (2016), Haslinger & Schmitt (2018, 2020)
- Combining a plural and a non-plural expression results in a plural. Schmitt 2019
- Homogeneity properties of individual plural expressions 'project'.
  cf. Križ 2015, although present system doesn't have the same empirical coverage yet (e.g. modified numerals, negative quantifiers)

Combining two plurals without gaps

Combining two plurals that do not show homogeneity/non-maximality effects still results in a denotation gap.

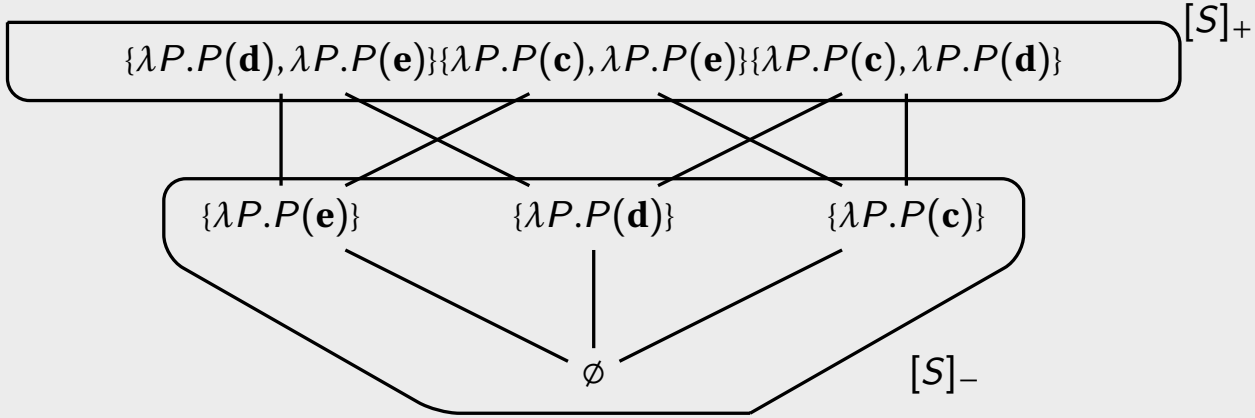
(48) *Two students* ***read*** *all the books*.

Predicted context-independent truth/falsity conditions

true iff there is some plurality of two students that each read all the books
false iff not all books were read by a student, or fewer than two students read any books

⇒ Truth conditions are distributive, but effect of cumulativity encoded in the falsity conditions.

Scale for *two students*



Combining two plurals without gaps

(49) *Two students read all the books.*

Here I won't give the full scale S for reasons of space, but illustrate the predictions with specific scenarios.

No non-maximality wrt. *all the books*

SCENARIO: Students **c** and **d** each read book **a**. Otherwise, no books were read.

- Function-argument cover:
  $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y)\}, \lambda P.P(\mathbf{d}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y)\}$
- Set of argument parts used: $\{\lambda y.\mathbf{read}(\mathbf{a})(y)\}$. This is in $[\![\textit{read all the books}]\!]_{-}$.
- Corresponding plurality $\{\mathbf{read}(\mathbf{a})(\mathbf{c}), \mathbf{read}(\mathbf{a})(\mathbf{d})\}$ in $[S]_{-}$. $\Rightarrow$ (48) false.

No non-maximality wrt. *two students*

SCENARIO: Student **c** read all the books. Otherwise, no books were read.

- Function-argument cover: $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y), \lambda y.\mathbf{read}(\mathbf{b})(y)\}$
- Domain of the cover: $\{\lambda P.P(\mathbf{c})\}$. This is in $[\![\textit{two students}]\!]_{-}$.
- Corresponding plurality $\{\mathbf{read}(\mathbf{a})(\mathbf{c}), \mathbf{read}(\mathbf{b})(\mathbf{c})\}$ in $[S]_{-}$. $\Rightarrow$ (48) false.

Combining two plurals without gaps

(50) *Two students read all the books.*

Cumulativity

SCENARIO: Student **c** read book **a**. Student **d** read book **b**.

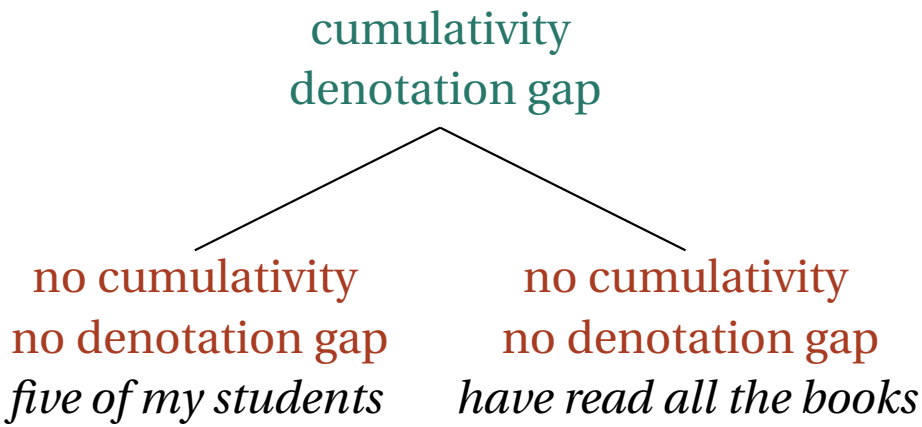
- Function-argument cover:
  $\lambda P.P(\mathbf{c}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{a})(y)\}, \lambda P.P(\mathbf{d}) \mapsto \{\lambda y.\mathbf{read}(\mathbf{b})(y)\}$
- Corresponding plurality $\{\mathbf{read}(\mathbf{a})(\mathbf{c}), \mathbf{read}(\mathbf{b})(\mathbf{d})\}$ not in $[S]_+$ or $[S]_-$.
- Cover doesn't associate any student-quantifier with an element of $[[\![\textit{read all the books}]\!]_+]$, so this is not in $[S]_+$.
- Domain of the cover, $\{\lambda P.P(\mathbf{c}), \lambda P.P(\mathbf{d})\}$, is in $[[\![\textit{two students}]\!]]_+$.
- Set of atomic argument-parts used in the cover, $\{\lambda y.\mathbf{read}(\mathbf{a})(y), \lambda y.\mathbf{read}(\mathbf{b})(y)\}$, is in $[[\![\textit{read all the books}]\!]]_+$.
- $\Rightarrow$ Sentence neither true nor false in the scenario, but true under some QUDs.

$\Rightarrow$ Sentence has a truth-value gap that is not introduced by either of the individual plurals.

Presence of a gap follows from the fact that the conditions on $[S]_+$ and $[S]_-$ introduced by the composition rule are not complementary.

Summing up the predictions of this system

- Cumulativity and non-maximality reduced to a common phenomenon: denotation gaps reflected in the structure of plural scales.
- These denotation gaps are not always attributable to either of the individual plural DPs.



- Assuming structured denotations (scalar predicates of pluralities) permits the system to account for complex cases of cumulativity:

(51) *The two girls* [*saw* [*Jenny* [*drink and* [*smoke* [***two cigarettes***]]]]

⇒ *Jenny drink and smoke two cigarettes* denotes plural scale of propositions, which can form the input to further cumulation

- Structured denotations (distinguishing between particular pluralities) also account for 'intermediate non-maximal readings'.

Further applications of the system

- The system can be extended to cover effects of alternative predicates on cumulativity/non-maximality:

  (52) SCENARIO: Two girls, Claire and Dora. Abe likes Claire and can't stand Dora. Bert likes Dora and hates Claire.
  Abe and Bert like the girls. ??not true

- At least for a plural semantics based on atomic individuals, we can actually get rid of the notion of a plurality (in my implementation, the 'inner level' of sets) and work with Boolean conjunctions.

  Atomic parts can be reconstructed from the entailment-based ordering.

  Non-Boolean conjunction can then be thought of as an extension of Boolean conjunction to plural scales.

- The structured denotations for plural sentences permit us to predict which definite plurals lack non-maximal interpretations (conjunctions, *the three books* etc.), based on contrasts with structural alternatives.
- QUD-dependency may (partly) explain the typicality effects on plural predication discovered by Poortman (2016) (experimental work in preparation).

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