**Indefinites: An argument for Skolemization with World Variables**

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# 1 Outlook

*Scope of talk*: Why skolemization of choice functions with world variables is needed.[1]

- The surface scope relation

  Negation … Intensional_Operator … Indefinite

  can yield the scope relation

  Intensional_Operator ≫ Indefinite ≫ Negation

  with **intermediate scope of the indefinite,** and without movement of either the negation or the indefinite.

- **Key example**

  *Context:* Rodica knows that Carl has to read the following books for his exam (A,B,C,D,E). Rodica also knows that it takes 1 hour for Carl to read a book. Rodica learns that Carl has started reading books 3 hours ago. Considering Carl's speed in reading a book, Rodica knows that there are two books that he didn't have time to read but she doesn't know which of these books.

  (1) Rodica doesn't think that Carl read some of the books.
  THINK ≫ SOME OF THE BOOKS ≫ ¬
  *Rodica thinks there are some books that Carl didn't read. (But she doesn't know which books).*
  (non-specific indefinite, with wide scope over negation)

- **Proposal**: Skolemize choice functions with a world variable.

## 1.1 Roadmap

- Section 2 provides the background on choice functions and introduces the puzzle.
- Section 3 explores the unique behavior of indefinites *w.r.t.* negation in the complement of Neg-raising predicates.
- Section 4 contains the proposal of this paper.
- Section 5 concludes.

# 2 Indefinites as Choice Functions

- The scope of quantifiers is clause-bounded. The example in (2) illustrates this:

[1] I first observed the intermediate scope of indefinites between intensional operators and negation in Farsi. However, as my English consultants reported that such a reading also exists in English, I will present only English data but the facts are the same for Farsi:

(i) Rodica fekr ne-mi-kon-ad Carl čand-ta ketabo xunde bash-ad.
Rodica thought NEG-IMPF-do-3SG Carl some-CL book-RA studied SUB.be-3SG
*Rodica doesn't think that Carl read some of the books.* THINK≫ SOME OF THE BOOKS ≫ ¬.

(2) A colleague believes that every paper of mine contains an error.
# 'For every paper of mine there is a potentially different colleague who believes that it contains an error.'

- Indefinites are special.
- The famous example by Fodor and Sag (1981) in (3) shows that indefinites can scope out of islands.

(3) Each teacher overheard the rumor that a student of mine had been called before the dean.
'There is a student of mine, say Zahra, and each teacher overheard the rumor that Zahra was called before the dean.'

- A successful account of island-free scope of the indefinites with the help of *choice function* was proposed by Reinhart (1997), Winter (1997), Kratzer (1998) and Matthewson (1999), among others.
- A *choice function* is a function that maps any non empty set onto an element of that set.
- It is a function of type $\langle\langle e,t\rangle, e\rangle$, which applies to the property denoted by the nominal predicate of type $\langle e,t\rangle$ and returns an individual of type e that has that property.

(4) $f(\{\text{Andrew, Katie, Kimberly, Leah, Zahra}\}) \rightarrow$ Zahra

**Reinhart (1997) & Winter (1997).** According to Reinhart (1997) and Winter (1997), an indefinite determiner may introduce a variable over *choice functions*. Such a variable may be bound by an existential quantifier which may appear at any level.

- Since the existential quantifier may appear at any level, their analysis predicts that an indefinite may have narrow, intermediate, or wide scope reading with no sensitivity to scope islands.

(5) Every linguist studied every solution that some problem might have.
a. $\forall$x [ linguist (x) $\rightarrow \exists f \forall$z [ solution to (z, $f$ (problem)) $\rightarrow$ (x,z) ]]
b. $\exists f \forall$x [ linguist (x) $\rightarrow \forall$z [ solution to (z, $f$ (problem)) $\rightarrow$ (x,z) ]]

**Kratzer (1998).** Unlike Reinhart (1997) and Winter (1997), Kratzer (1998) does not posit existential quantifier to bind choice functions. Choice functions are interpreted as free variables, with values to be provided by the context.

- They always act as if they get maximal scope. The intermediate scope is not freely available.
- To account for the intermediate scope of indefinites, she proposes to use *Skolemized choice functions* which are Skolem functions that have **both set and individual-variable arguments.**
- Skolem function applies to the binary relation *some problem* and *the linguist variable x* and returns a problem that linguist x had studied every solution to. This is basically the same as the intermediate construal of indefinite.

(6) $\forall$x [ linguist (x) $\rightarrow \forall$z [ solution to (z, $f$ (x, problem)) $\rightarrow$ (x,z) ]]

- The skolemization of choice functions with an individual variable will also help to solve a problem that has been mentioned for choice functions. When the set of elements that choice function applies to is fixed, the choice function, being a function, always picks out the same elements which might not be the intended reading (Kratzer 1998, Chierchia 2001 and Abels & Luisa Martí 2010, among others). Consider example (7), for instance.

(7) Every linguist studied every solution that some problem that intrigued him/her might have.

- In a situation in which the set of problems that intrigued the two linguists (A and B) is the same {Weak Crossover and Donkey Sentences}. Without skolemization, the choice function $f$ applies to the set {Weak Crossover, Donkey Sentences} and since it is a function, it has to give a unique value. Therefore, it would go wrong either for linguist A or for linguist B. Skolemization solves this problem.

(8) a. $f$ (A, {Weak Crossover, Donkey Sentences}) = Weak Crossover
b. $f$ (B, {Weak Crossover, Donkey Sentences}) = Donkey Sentences

### 2.1 A problem

*Context:* Rodica knows that Carl has to read the following books for his exam (A,B,C,D,E). Rodica also knows that it takes 1 hour for Carl to read a book. Rodica learns that Carl has started reading books 3 hours ago. Considering Carl's speed in reading a book, Rodica knows that there are two books that he didn't have time to read but she doesn't know which of these books.[1]

(9) Rodica doesn't think that Carl read some of the books.
THINK$\gg$ SOME OF THE BOOKS $\gg \neg$
*Rodica thinks there are some books that Carl didn't read. (But she doesn't know which books).*

- The indefinite in this example doesn't have widest scope, it has to remain under the scope of the attitude verb *think*. To clarify this reading, the sentences can be continued with "*but She doesn't know which books.*"
- To get the intended reading, we need:
  - Intermediate scope of indefinites between *think* and negation. ➢ Choice Functions
  - Variation in the output of the choice function even though the set is fixed. ➢ Skolemization
- As there's just one individual "Carl", the skolemization with an individual variable doesn't help.
- The choice function, being a function, always picks out the same book.
  (10) $f$(Carl, {A,B,C,D,E}) = A
- There are two important ingredients:
  (i) the negated predicate is *think,* which is a **neg-raising** predicate
  and (ii) **only indefinites** participate in this particular scopal interaction.
- I first explain what Neg-raising is and then establish the second point.

## 3 Indefinites in Neg-raising environments

### 3.1 Neg-raising

- Certain negated predicates (e.g. think, believe, want) have a reading in which the negation is interpreted in the embedded clause. For example, (11a) implies (11b).
  (11) a. John doesn't think Bill left.
  b. John thinks Bill didn't leave.
- Most other predicates do not have such readings. (12a) cannot be interpreted as (12b):
  (12) a. John doesn't claim Bill left.
  b. John claims Bill didn't leave.

  Two Approaches: the 'syntactic account' and the 'semantic-pragmatic account'.

### 3.2 Syntactic Account

- Negation is base-generated in the embedded clause and then raises to the higher clause via syntactic movement (Fillmore 1963, Horn 1971 and Collins & Postal 2014).
- The lowest copy of NEG is semantically interpreted and the highest copy of NEG is phonologically realized. The syntactic structure of (11a) would then be as in (13).
  (13) John NEG think Bill <NEG> left.

[1] Thanks to Ekaterina Vostrikova for the context.

### 3.3 Semantic-pragmatic Account

- Neg-raising predicates (NRP) come with an *Excluded middle* or *homogeneity* presupposition (Bartsch 1973, Horn 1989, Gajewski 2005, 2007, Homer 2012, 2015 and Romoli 2013, among many others).
- *Excluded middle presupposition*: The speaker is opinionated about the truth or falsity of the embedded proposition.
- Neg-raising reading is a logical consequence of this presupposition and the literal meaning of the sentence, as shown in (14).

(14) not [ NRP [S]]
Assertion: ¬ NRP (S)
Presupposition: NRP (S) ∨ NRP ¬(S) (Gajewski 2005; p.14).

In (15), this account is applied to (11). The speaker thinks either Bill left or Bill didn't leave. Together with this homogeneity presupposition, (11a) entails (11b).

(15) Assertion: It's not the case that John thinks Bill left. (11a)
Presupposition: John thinks Bill left ∨ John thinks Bill didn't leave.
∴ John thinks Bill didn't leave. (11b)

☞ I will assume that the semantic approach is correct (but will also discuss the predictions of the syntactic approach in Section 4.1).

## Indefinites are special

### 3.4 Universal Quantifiers

- Universal quantifiers "all" and "every" usually scope under negation. However, by adding a post-nominal modifier or focus, they can take wide scope over negation.

(16) All the students didn't come.
*No student came* ALL THE STUDENTS ≫ ¬

(17) Every student that I knew didn't come. EVERY STUDENT THAT I KNEW ≫ ¬

- When embedded under a Neg-raising predicate, however, universal quantifiers necessarily scope under negation.

(18) I don't think all the students came.
**I think no student came* *THINK≫ ALL STUDENT ≫ ¬
*I think not all of them came* THINK≫ ¬ ≫ ALL STUDENT

(19) I don't think every student that I knew came. *THINK≫ EVERY STUDENT ≫ ¬

### 3.5 Modals

- In simple sentences, *must*, being a PPI, cannot stay under the scope of negation.

(20) John must not jog.
*It's necessary for John not to jog.* MUST ≫ ¬
**It's not necessary for John to jog.* *¬ ≫ MUST

- Homer (2011) argues that *must*, when embedded under an epistemic neg-raiser, cannot scope both below the embedding predicate and over negation, as shown in (21) and concludes that *must* is not a Neg-raiser.

(21) The doctor doesn't think that John must jog.
**The doctor thinks that it's necessary for John not to jog.* *THINK≫ MUST ≫ ¬
*The doctor thinks that it's not necessary for John to jog.* THINK≫ ¬ ≫ MUST

### 3.6 Adverbs

- Adverbs enter a scopal interaction with negation in the simple sentences and can take either wide or narrow scope, as shown in (22).

  (22) He didn't do it intentionally.
  *He did it but it wasn't intentional.* ¬ ≫ INTENTIONALLY
  *He didn't do it and it was intentional.* INTENTIONALLY ≫ ¬

- When embedded under Neg-raising predicates, however, they can't take scope above negation. This has been shown in (23).

  (23) I don't think he did it intentionally.
  *I think he did it but it wasn't intentional.* THINK≫ ¬ ≫ INTENTIONALLY
  **I think he didn't do it and it was intentional.* *THINK≫ INTENTIONALLY ≫ ¬

### 3.7 Indefinites

- As far as I know, the scope of indefinites under Neg-raising predicates is only briefly discussed in Homer (2011).
- Homer (2011) argues that the conditions under which *some* can be interpreted under a negation is parallel to deontic *must*. Both *some* and deontic *must* can be interpreted under a superordinate negation

  (24) Sue doesn't think that Jean-Paul understands something. ¬ ≫ SOME

- He doesn't, however, discusses the cases where *some* can be interpreted above negation in the embedded clause of negated Neg-raising predicates.
- The examples in (25) show that such a reading is in fact available for *some* and other indefinites.

  *Context:* Rodica knows that Carl has to read the following books for his exam (A,B,C,D,E). Rodica also knows that it takes 1 hour for Carl to read a book. Rodica learns that Carl has started reading books 3 hours ago. Considering Carl's speed in reading a book, Rodica knows that there are two books that he didn't have time to read but she doesn't know which of these books.

  (25) a. Rodica doesn't think that Carl read some of the books.
  THINK≫ SOME BOOKS ≫ ¬
  b. Rodica doesn't think Carl read (at least) two of the books.
  THINK≫ (AT LEAST) TWO BOOKS ≫ ¬
  c. Rodica doesn't think Carl read several of the books.
  THINK≫ SEVERAL OF THE BOOKS ≫ ¬
  d. Rodica doesn't think that Carl read a few of the books.
  THINK≫ A FEW OF THE BOOKS ≫ ¬
  e. Rodica doesn't think that Carl read many of the books.
  THINK≫ MANY OF THE BOOKS ≫ ¬

- Indefinites in these cases don't take widest scope and they have to remain under the scope of attitude verb *think*. To clarify this reading, the sentences can be continued with "*but She doesn't know which books.*"

- Indefinites are unique in outscoping negation in the embedded clause of Neg-raising predicates. This suggests that they achieve wide scope over negation because they are unique in being interpreted as **choice function** variables.

## 4 The proposal

*Context:* Rodica knows that Carl has to read the following books for his exam (A,B,C,D,E). Rodica also knows that it takes 1 hour for Carl to read a book. Rodica learns that Carl has started reading books 3 hours ago. Considering Carl's speed in reading a book, Rodica knows that there are two books that he didn't have time to read but she doesn't know which of these books.

(26) Rodica doesn't think that Carl read some of the books.
THINK ≫ SOME OF THE BOOKS ≫ ¬
*Rodica thinks there are some books that Carl didn't read. (But she doesn't know which books).*

- I assume the semantic account of Neg-raising is correct.
  ➢ Negation doesn't move under *think,* it doesn't end up being c-commanded by *think.*
  ➢ Since negation is in a superordinate clause, it is by the choice function route that the indefinite takes **pseudo-scope** over negation (and below *think:* THINK≫ SOME OF THE BOOKS ≫ ¬).

  *Should we use existential closure?* Answer: no.

- Given the denotation of the Neg-raising predicate *think* and the negation of the embedded proposition as the result of the excludded middle presupposition, we will have either (27a) or (27b), depending on where the choice function is existentially closed:

  (27) a. $\forall$w" $\in$ Think(R,w):$\neg\ \exists f$ [ $\text{read}_{w''}$ (Carl, $f$ ({A,B,C,D,E }))]
  b. $\exists f$ ( $\forall$w" $\in$ Think(R,w):$\neg$[ $\text{read}_{w''}$ (Carl, $f$ ({A,B,C,D,E }))]

- None of these gives us the intended reading. Note that we can't close below *think* and above negation, since negation is not syntactically below *think*.

- Clearly, (27a) is ruled out because negation scopes over the existential closure of choice function and gives the reading that Carl didn't read any books.

- (27b) doesn't yield the intended reading either, as the choice function always picks out the same element from the set of book {A,B,C,D,E }, thus gives rise to the wide-scope (*de re*) reading of the indefinite.

- Skolemizing the choice function with an individual argument doesn't help to give rise to the intended reading for (26). As the individual argument of choice function is filled with a constant, the choice function $f$ will always gives the same value (say A).

  (28) a. $\forall$w" $\in$ Think (I,w):$\neg$[ $\text{read}_{w''}$ (Carl, $f$ (Carl, {A,B,C,D,E }))]
  b. $f$ (Carl, {A,B,C,D,E }) = A

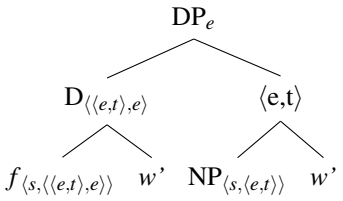
  *How can we capture the **variation** of books across doxastic alternatives (cross-world variation)?*

➢ *My proposal is to Skolemize with a world variable:*

- Choice functions are functions of type ⟨s, ⟨⟨e,t⟩, e⟩⟩.

- They take as their first argument a world variable, then they apply to a set of type ⟨e,t⟩ and return an individual of type *e*.

  (29)




- The world variable argument of the choice function can be bound by an intensional operator.

- The function $f$ can pick **different values for different worlds** (cross-world variation):

  (30) a. $f$ ($w_1$, {A,B,C,D,E }) = A
  b. $f$ ($w_2$, {A,B,C,D,E }) = C
  c. $f$ ($w_3$, {A,B,C,D,E }) = E

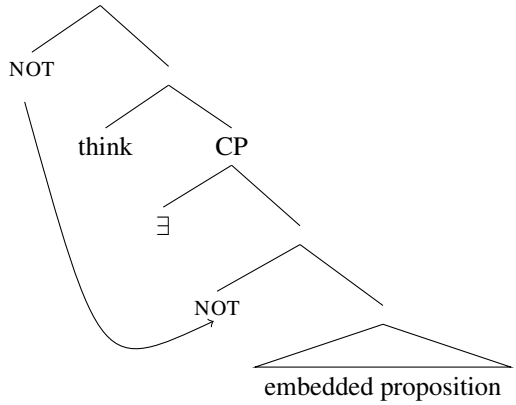
- (31) will give us the intended reading for (26)

  (31) $\exists f$ ( $\forall$w" $\in$ Think(R,w):$\neg$[ $\text{read}_{w''}$ (Carl, $f$(w",{A,B,C,D,E }))])

- When the world variable of the choice function is set to the actual world, the world argument is constant and the effect will be as if there is no Skolemization.
- This will give rise to the wide scope interpretation of the indefinite with respect to the attitude verb.
  (32) $f$ ($w_0$, {A,B,C,D,E}) = A

## 4.1 Objection

- Assuming a syntactic analysis of Neg-raising, there might be a way to make the classic non-skolemized choice functional account of indefinites work for the intended reading of (26).
- It can be assumed that the negation can **only reconstruct to the top** of the clause and the choice function is existentially closed at the highest position in the embedded clause and above the negation (adverbs would thus be predicted to scope under negation, since they are lower than the reconstructed position; quantifiers that achieve wide scope by QR will also take scope under negation, as QR is a short movement, see Johnson & Tomioka 1998).
  (33) $\forall$w" $\in$ Think(R,w): $\exists f$ $\neg$readread$_{w''}$ (Carl, $f$(Book$_{w''}$))]




N.B.: *The above is a charitable interpretation of the syntactic approach.* Current syntactic accounts would not predict that negation can reconstruct under existential closure. Collins & Postal (2014) give a revised version of Seuren's highest operator generalization:

***The Highest-Operator Constraint*:** If a NEG raises from clause B to clause A, and NEG originates in a unary-NEG structure W= [NEG X], then W is the highest operator in B.

Neither Seuren nor Collins & Postal (2014) define the concept *operator*. They just assume that this concept covers quantificational DPs and adverbs as well as modal auxiliaries.

- However, there are cases where the movement of negation doesn't help. In other words, we can show that Skolemization with world variables is independently needed, outside of Neg-raising contexts.

## 4.2 Negated Modals

- My account predicts that non-specific wide scope readings of indefinites are not limited to Neg-raising contexts.
- Modal operators scoping over negation $\Box\neg/\Diamond\neg$ are predicted to provide the environment for an intermediate scope of indefintes i.e indefinite scopes under the intensional operator but above negation.
- (34)-(36) show this prediction is borne out true .
- ***Duality:*** $\neg\Box \Longleftrightarrow \Diamond\neg$ & $\Box\neg \Longleftrightarrow \neg\Diamond$
- *Duality* is a logical equivalence and it doesn't arise via a syntactic movement.

(34) I'm not sure he read two of the books.
$\Diamond \gg$ TWO OF THE BOOKS $\gg \neg$
*It's possible that there are two books that he didn't read.*

(35) You can't see two of the cards.
$\Box \gg$ TWO OF THE CARDS $\gg \neg$
*It's necessary that there are two cards that you don't see.*

(36) *Bonus questions:* There are five questions on the exam. Each question has 10 points. To get the full points on the exam (30 points), you only need to answer three questions. You can pick any three questions to answer.
You don't have to answer two of the questions. $\Diamond \gg$ TWO OF THE QUESTIONS $\gg \neg$
*It is allowed for two questions not to be answered.*

## 4.3 Solving the fixed sets Problem

- The skolemization of choice functions with a world variable can solve the problem of fixed sets that has already been mentioned for choice functions in the literature (see Winter 1997, 2001; Kratzer 1998; Geurts 2000; Abels & Martí 2010; among others).
- Abels & Martí (2010) give a unified analysis to the split scope readings of negative indefinites using choice functions.
- Quantificational noun phrases that are not upward monotonic give rise to truth conditionally distinct, so-called split scope readings across intensional verbs.
- Consider the sentence (37), for instance:

(37) Zu dieser Feier musst du keine Krawatte anziehen.
to this party must you no tie wear
*To this party you don't have to wear a tie* (Abels & Martí 2010)

- The formalization of the truth-conditions of this sentence with the help of choice function is given in (38).

(38) $[\![(37)]\!] = 1$ iff $\neg \exists f$ CH($f$) & $\forall$w' R($w_0$), you wear $f$(tie$_{w'}$) in w' (Abels & Martí 2010)

- This sentence is true if and only if there is no choice function that in all relevant worlds w' picks a tie from w' that you wear in w'. So you don't wear a tie in every world.
- *Problem*: if you are wearing a tie in all worlds and that the tie worn in $w_1$ is different from that worn in $w_2$, but the set of ties is exactly the same in all worlds, then for all choice functions $f$, the same tie is picked in all worlds: $f(\text{tie}_w 1) = f(\text{tie}_w 2)$

| | $w_1$ | $w_2$ | $w_n$ |
|---|---|---|---|
| $f_1$ | ✓[t1,t2]→ t1 | ✗ [t1,t2] → t1 | ... |
| $f_2$ | ✗ [t1,t2]→ t2 | ✓[t1,t2]→ t2 | ... |
| $f_m$ | ... | ... | |

- According to the truth-conditions given in (38), (37) is predicted to be true. You cannot find a choice function that in every relevant world picks a tie that you wear.
- That is because $f_1$, for example, picks $t_1$ in all the worlds under consideration, but this tie is not actually worn in the world $w_2$ .
- But (37) may be actually false, since what we just said is compatible with wearing a tie in every world.
- The problem would not arise if the choice function is skolemized with a world variable. Then, for all choice function $f$, a different tie will be picked in different worlds. So, $f(w_1, \text{tie}_{w_0}) \neq f(w_2, \text{tie}_{w_0})$.

| | $w_1$ | $w_2$ | $w_n$ |
|---|---|---|---|
| $f_1$ | ✓[t1,t2]→ t1 | ✓[t1,t2] → t2 | ... |
| $f_2$ | ✗ [t1,t2]→ t2 | ✓[t1,t2]→ t2 | ... |
| $f_m$ | ... | ... | |

- You can find at least one choice function, namely, $f_1$, that in every relevant world picks a different tie that you wear, making (38) false as needed.

# 5 Conclusion

- Choice functions need to be skolemized with world variable.
- This provides a way to get variation in the output of choice function over a fixed set in modal enviroments.

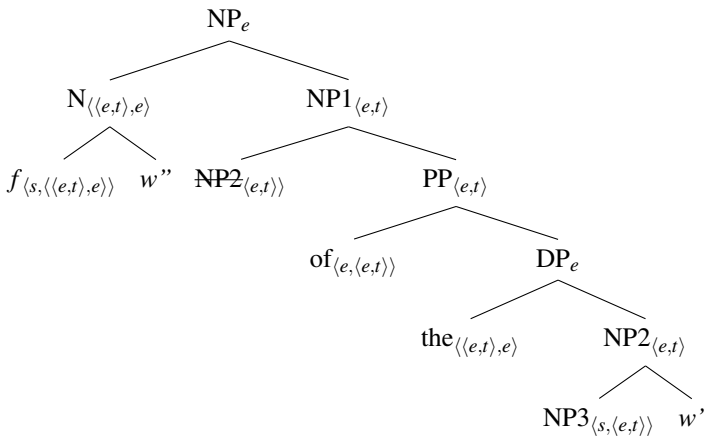
## Appendix: Indefinites as Generalized Quantifiers

- Indefinites are existential quantifiers and go through quantifier raising.
- To get the intended reading, the existential operator simply needs to be placed on top of the embedded clause and above negation which is interpreted in its base-generated position in the embedded clause.
  (39) I NEG think ∃x. <NEG> $\text{readread}_{w''}$ (Carl,Book (x)).
- This violates *The Highest-Operator Constraint*. It's not clear why there should be a difference between indefinites and other quantifiers.
- In the intended readings of sentences in (26), indefinites has to remain under the scope of *think*.
- There is no position which indefinite can move to in order to scope above negation which comes as a result of excluded middle presupposition, while still remaining in the scope of *think*.

- A generalized quantifier approach to indefinites creates problems for both syntactic and semantic approaches to Neg-raising:
  - Semantic-pragmatic runs into problem accounting for low scope of negation with respect to indefinites.
  - Syntactic account of Neg-raising fails to account for the variation among scope-taking elements in giving rise to wide scope over negation.

## 5.1 A note on Partitives

- The question is why only partitives can be used in this context.
- Remember in order to get the intended reading of PP is transparent but the head of the partitive is opaque.
- Inspired by the constraint proposed by Percus (2000) and Keshet (2008), I assume that specifiers of a DP must agree in transparency with the NP.
  Intersective Predicate Constraint: Keshet (2008)
  All intersective modifiers of a DP must agree in transparency with the NP
- Partitive add more structure to DP making the mismatching transparency possible.

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