

Scope without Syntax

Towards a Game Theoretic Approach

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Quantifiers

- Languages have what are called *quantifiers*, which are words which delineate particular quantities of nouns that they modify.
 - ▶ **Universal quantifiers** – all, each, every (\forall)
 - ▶ **Existential quantifiers** – a, one, some (\exists)
 - ▶ **Negation** – not, no (\neg)
 - ▶ Many others – numerals, much, many, few, etc.
- For the purposes of sentence interpretation, quantifiers are quite a puzzle. Especially when there are multiple quantifiers in a sentence, a sentence may become ambiguous.

Scope Ambiguity

(1) Everyone loves someone.

- This sentence has two quantifiers, a universal (\forall) 'every' and an existential (\exists) 'some.'
- This sentence has two different interpretations:
 - ▶ For each person, there exists some other person they love.
 - ▶ There exists one particular person who everyone loves.
- In the first possible reading, we say that the \forall takes 'wide scope' over the \exists , which is said to have 'narrow scope.'
- In the second, we say that the \exists takes wide scope over the \forall .

Traditional View

- Scope was traditionally dealt with in terms of ‘movement’ and ‘logical form.’ An ambiguous sentence had to go through some kind of post-syntactic change to yield an unambiguous representation in the mind.
- Different languages were discovered to have different availabilities of scope ambiguity. This was dealt with with formal and syntactic parameters.
- Over wide enough data sets, few generalizations were robust.
- Scope ambiguity is difficult to account for because it is:
 - ▶ Highly context sensitive (Chomsky’s aphasia)
 - ▶ Sensitive to linear order

Game Theoretic Scope

- **My statement:** Scope ambiguity is totally paralinguistic. Scope ambiguities fall out from listeners' evaluation of the intentions of the speaker.
- We don't need "syntax", we don't need "logical form", we don't need any linguistic machinery whatsoever.
- This can partially be modeled in Game Theory, seeing that speakers are mutually evaluating the others' behavior and choosing how to word or interpret sentences based on that.
- This can allow us to formally analyze an apparent "functional" alternation.

Game Theory Abridged

- Theoretical framework for analyzing decision-making, conflict and cooperation.
- The gist:
 - ▶ Have a set number of players.
 - ▶ Each player has a set of possible behaviors “strategies” .
 - ▶ Players are awarded payoffs based on the strategies taken by each player.

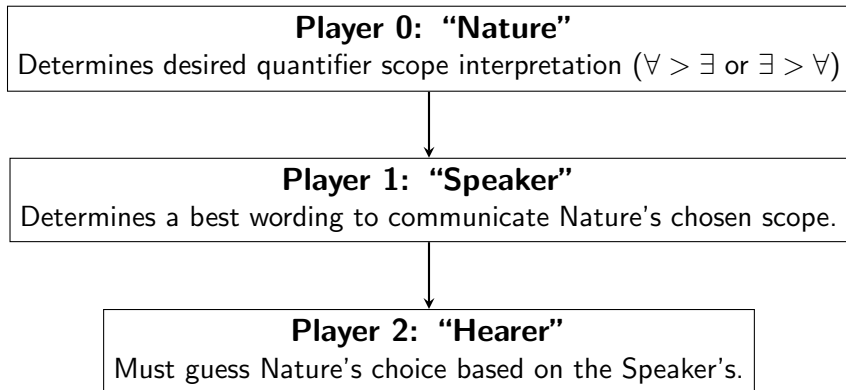
Precedents in Linguistics

- Game Theory has been similarly employed in linguistics, particularly semantics to deal with implicatures.

(2) Billy ate most of the chocolates.

- Sentences like this in actual language are inferred to mean that Billy ate most *but not all chocolates*, although the sentence is logically still true if he did.
- However speakers *assume* Billy didn't eat *all* the chocolates because if that were true, a speaker probably would've said so.
- Normal human:
 - ▶ "If he wanted to say 'Billy ate all the chocolates', he would've said just that!"

Our Quantifier Scope Game



Assumptions and Constraints

- It is generally preferable if quantifiers occur in the order they are supposed to be interpreted in (surface scope).
- Moving around nouns via 'transformations' (passivization, clefting, etc.) is costly/marked/undesirable.
- Scrambling (to be discussed later), as opposed to transformations are not similarly costly.

English Data

- Typical English sentences show scope ambiguity if there is more than one quantifier:

(3) Two men dug each hole.

- There can be two particular men who dig all the holes ($\exists > \forall$) or, each hole can be dug by a different pair of men ($\forall > \exists$).
- Ambiguity will usually disappear or become highly dispreferred if the sentence undergoes a 'transformation:'

(4) Each hole was dug by two men.

- Here, the strongly preferred reading is the one where there is a pair of men for each hole ($\forall > \exists$), while the case where there is two specific men for each hole is harder to get out of the blue.

English Data

- (5) Everyone loves someone.
- (6) Everyone loves someone, and that person is Billy.
- (7) Everyone loves someone. Don't pretend like you don't have someone special.
- (8) Someone is loved by everyone.
- (9) Someone is loved by everyone, and that person is Billy.
- (10) ?? Someone is loved by everyone. Don't pretend like you don't have someone special.

Generalization in English

- Unmarked active sentences tend to be ambiguous.
- Passive sentences tend to be unambiguous, preferring only surface scope.

Now Onto the Game...

- Both Players receive a payoff when the sentence is correctly communicated, represented by x .
- If the more marked inverse scope is employed, both players suffer a slightly diminished payoff. We refer to this amount as i .
- If the Speaker employs passive voice, he suffers a slight loss p .
- $|p + i| < |x|$ That is, even if we have to passivize and get inverse scope interpretation, it's always most preferable to get the intended interpretation.
- This game is **non-zero sum Coordination Game**, meaning that both active players' interests are aligned.
- The players **do not** have perfect information. While the Hearer knows what the Speaker's strategy is, he does not know what Nature has chosen.

The Decision Tree

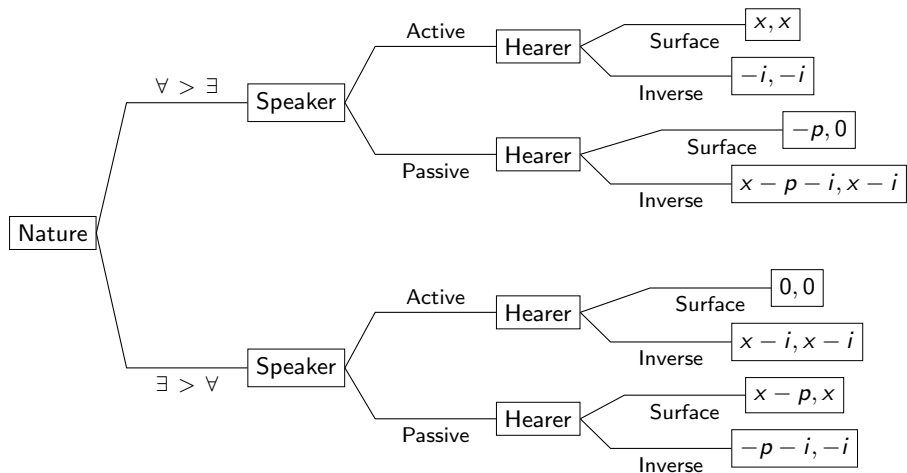


Figure: Decision Flow of the Game of “Everybody loves somebody”

Matrix for when Nature chooses $\forall > \exists$

		Speaker	
		Active	Passive
Hearer	Surface	x	$-y$
	Inverse	$-i$	$x - p - i$
		x	$x - i$

Figure: Decision Flow of the Game of “Everybody loves somebody”

Matrix for when Nature chooses $\exists > \forall$

		Speaker	
		Active	Passive
Hearer	Surface	0	$x - p$
	Inverse	$x - i$	$-p - i$

0	x
$x - i$	$-i$

Figure: Decision Flow of the Game of “Everybody loves somebody”

Results and Intuitive Explanation

- **Passivization is a kind of signalling.** If a speaker passivizes, which is costly, *he does it for a reason*, probably to get a more preferable quantifier order.
 - ▶ This kind of signalling make the passive sentences *unambiguous*.
- If the speaker *does not* passivize, there are two options for the Hearer to choose from:
 - ▶ Either the active sentence is already in the right order. . .
 - ▶ or it is not, but the Speaker didn't want to accrue the passive penalty (p).

Scope in Scrambling Languages

- English has relatively rigid word order (subject-verb-object), but many languages have what is called ‘scrambling’ which is free linear movement of nouns without the cost of transformations.
- Scope is systematically different in languages like these.

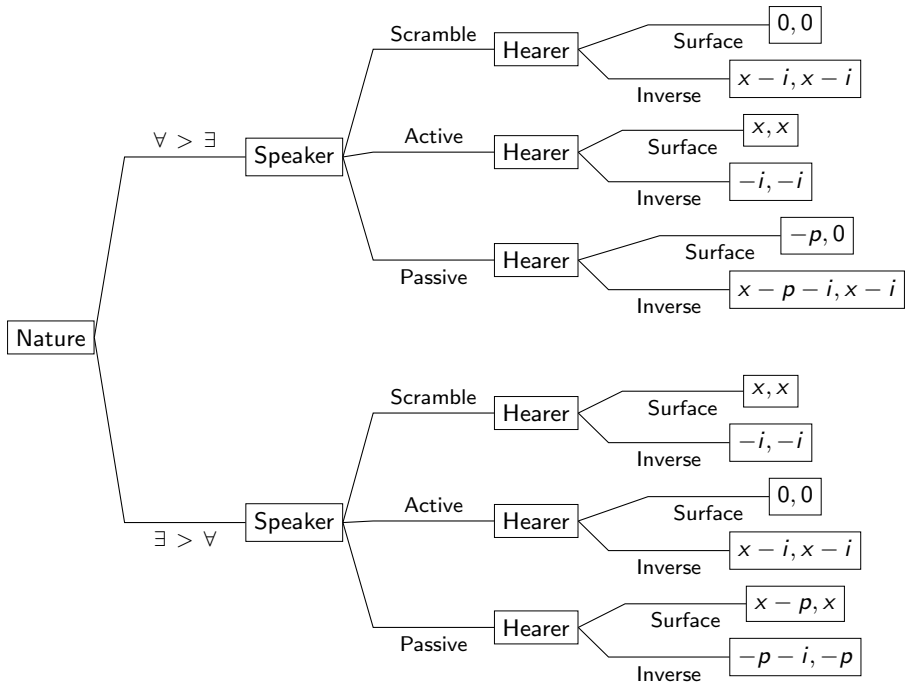
(11) Har dāneshjui ye kitābi-ro mixune.
all student a book-OBJ reads
“Every student is reading a book.”

(12) Ye ketābi-ro har dāneshjui mixune.
a book-OBJ all student reads
“Every student is reading a book.”

- However, both of these sentences *must have surface scope*. They cannot be ambiguous.

A Game Theoretic Account

- Given our previous suggested constraints, we can predict these scope availabilities.
- Remember, **surface scope** is preferred and **transformations** are costly.
- However, **scrambling** is not similarly costly... so it's a new strategy.



Optimal Strategies with Scrambling

- First, Scramble is a **dominant strategy** over Passivization.
- Since there is no longer cost to reordering for the Speaker, the focal strategies are to use whatever strategy avoids the need for inverse scope.
- Seeing this, the Hearer's best strategy should always be to assume **surface scope**.
- Therefore, for each sentence (active or scrambled), there should only be only one unambiguous interpretation.

Formal Terms

- In all situations, we narrow down scope possibilities with *Schelling Points*/focal points.
- The “markedness” of inverted scope or passivization are *vital* to communication, as they signal the Speaker’s intention and indirectly create the focal points.

In an English-like language. . .

- As assumed speakers *want* to interpret quantifiers in linear order.
- When a speaker produces a costly transformation (like a passive) the listener assumes that the new surface word order is the intended scope order.
- If a speaker produces an untransformed sentence, the listener has two possible hypotheses: (1) the speaker intended surface scope, or (2) that the speaker intended inverse scope, but didn't want to undergo a costly transformation.
- These two possibilities produce scope ambiguity.

In Scrambling Languages

- In scrambling languages, since speakers have greater flexibility in ordering, listeners make different assumptions about intended scope.
- If the speaker wants the object to scope over the subject, he can easily scramble it leftward.
- Since he can do this, the unscrambled sentence has an unambiguous surface scope interpretation.
- **Sidenote:** Potentially related, languages with scrambling/flexible word order, usually rely on things like passivization less often.

Just a random difference?

- In addition to this correlation between rigid word-order and scrambling languages, we see that this theory still hold in rigid constructions in scrambling languages.
- In Persian, for example, although nouns are flexible, negation must always be on the same part of a verb.
- We should expect negative quantifiers to work similar to English sentences in that they produce ambiguity. This is the case:

(13) Billy ye ketābi-ro na-xund.

Billy a book-OBJ not-read

“Billy didn’t read a (particular) book.” ($\exists > \neg$) or “Billy didn’t read any book.” ($\neg > \exists$)

- This holds in similar languages with scrambling and stable negation location (e.g. Korean).

Rigidity = Ambiguity; Flexibility = Unambiguousness

- The general theorem that arises from this analysis is that *wherever* we have syntactic flexibility, we have ambiguity (and *vice versa*.)
- This difference, in agreement with our theory, is true *across constructions*, not necessarily *across languages*.
- “Scrambling” languages are unambiguous in normal sentences, but are in more rigid constructions, ambiguity arises.
 - ▶ This is because the ambiguity is not a language-specific parameter, but a result of the strategies employable in any given context.

Local Rigidity

In scrambling languages, generally we have syntactic flexibility accompanied by unambiguous surface scope.

- (14) a. Meigeren dou zhuazou yige nüren.
everyone all arrest a woman
“Everyone arrested a woman.” ($\forall > \exists$)
- b. (You) yige nüren meigeren dou zhuazou.
(have) a woman everyone all arrest.
“A woman was arrested by everyone.” ($\exists > \forall$)

But in syncactically inflexible constructions, ambiguity arises.

- (15) a. Meigeren dou bei yige nüren zhuazou.
everyone all PASS a woman arrest
“Everyone was arrested by a woman.” ($\forall > \exists, \exists > \forall$)
- b. *Bei yige nüren meigeren dou zhuazou.
PASS a woman everyone all arrest

Local Rigidity in English as well

English negation placement is *rigid* with only one modal, as a result, the negation can take either wide or narrow scope.

(16) Billy can not go. ($\forall > \exists, \exists > \forall$)

On the other hand, where there are multiple modals, the negation can appear in multiple locations. This results in non-ambiguous sentences. (Note, the ambiguity is not with the *could* modal, but *have gone*.)

(17) Billy could not have gone before we arrived.

(18) Billy could have not gone before we arrived.

But in languages where negation is *always* flexible...

... like Chinese, we *always* have a lack of ambiguity!

(19) Shujuan keyi **bu** gen Guorong tiao wu.

Shujuan may not with Guorong dance

“Shujuan is permitted not to dance with Guorong.” (*may* > \neg)

(20) Shujuan **bu** keyi gen Guorong tiao wu.

Shujuan not may with Guorong dance

“Shujuan can’t dance with Guorong.” (\neg > *may*)

Empirical summary

Rigid constructions

English main clauses

Persian negation

English negation with auxes

Chinese passives

All of these are ambiguous.

Flexible constructions

Main clauses in scrambling languages

Chinese negation

English negation without auxes

English Passives*

All of these are non-ambiguous.

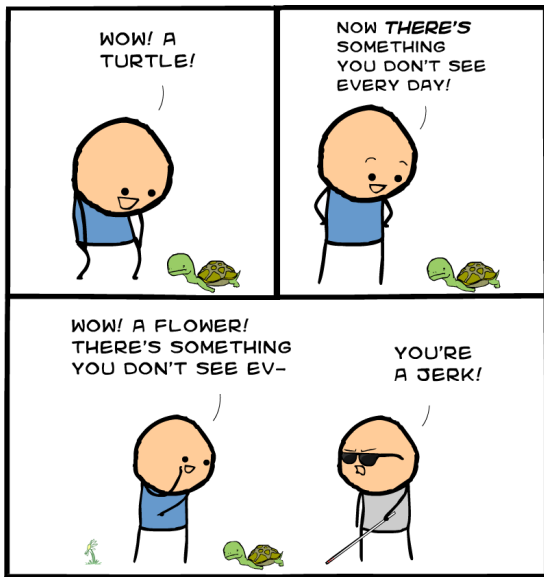
The General Theory

- Quantifier scope interpretations are not so much syntactically *licensed* so much as they are **pruned** from the all possible combinations of scopes ($q!$ where q = number of quantifiers).
 - ▶ That is, *all* quantifier scope interpretations are possible in the abstract (hence Chomsky's aphasia) . . .
 - ▶ but the pragmatics of the structure of a language (what other constructions we have available) determine what are actually plausible interpretations.
- Without any syntactic machinery, we have already done a lot of the work of narrowing in on what interpretations are possible.
- But the story is not done yet!

Project Extension

- Replace generative notions of syntactically-determined quantifier scope ambiguities with more plausible, externally-driven factors.
- Unify this account with other scope alternations (say, the unavailability of semantically implausible scope interpretations) into a general theory of scope where possible interpretations are *pruned*, rather than derived by some syntactic engine.
- Similar accounts for related phenomena? C-command? Cross-over?
- Extensive Game Theory w.r.t different quantifiers and remodelling given data.

The End



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