Computational approaches to the explanation of universal properties of meaning

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https://thelogicalgrammar.github.io/ESSLLI22_langevo

Goals

- Overview of the thriving research area of **semantic universals**.
- Examples of concrete universals in content and logical vocabularies of Ls
- Different theoretical explanations
- Different computational modelling paradigms

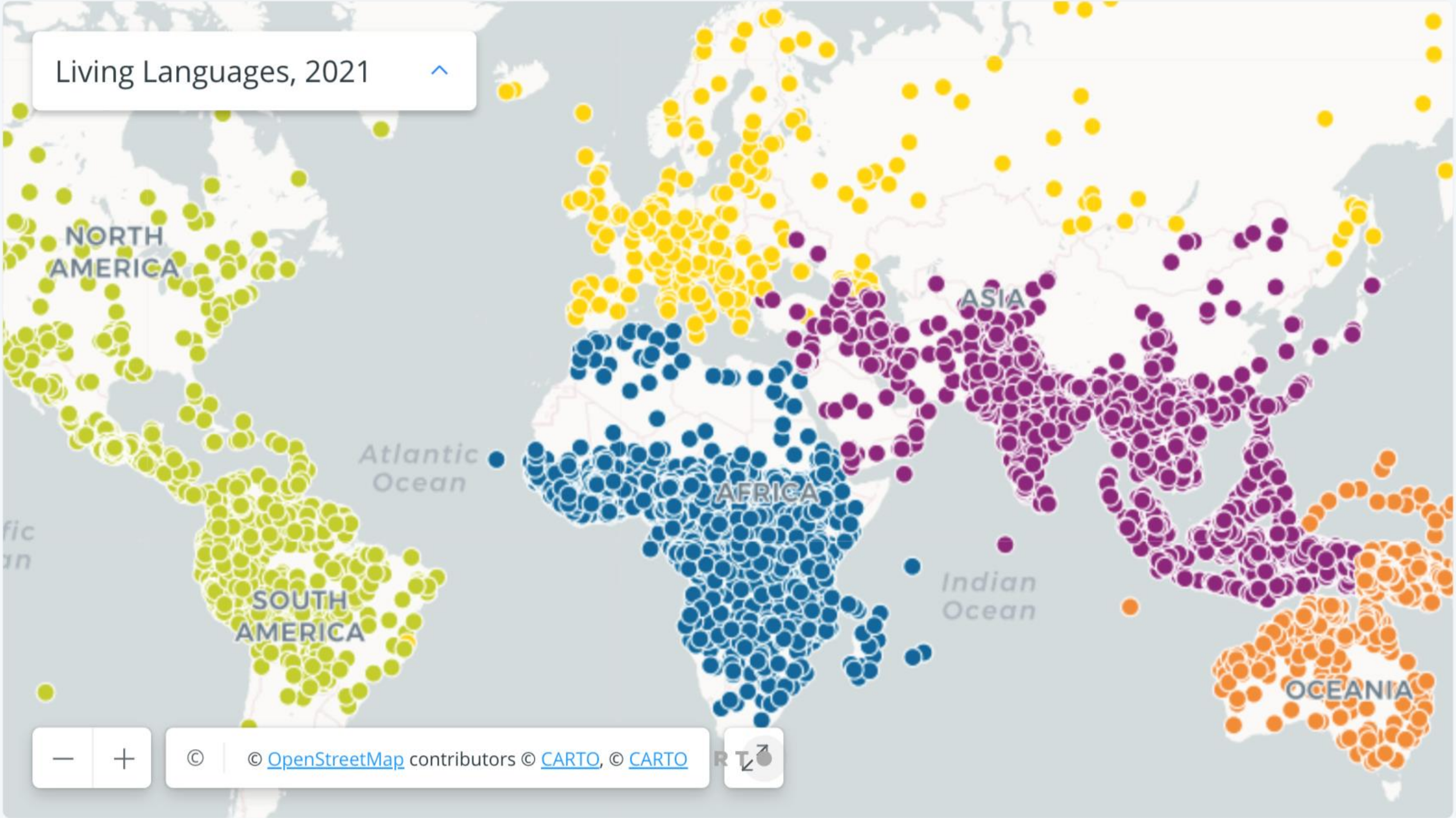
Course Outline

1. Introduction to linguistic universals
2. Learnability explanations
3. Cultural evolution explanations
4. Complexity explanations
5. Communicative efficiency explanations

Today's Outline

1. What are meaning universals?
2. Examples:
   1. Quantifier universals
   2. Convexity
   3. Boolean universals
   4. Gradable adjectives
   5. Modals
   6. Responsive verbs

Introduction



Map by Ethnologue by SIL International

Language variation and universals

1. Enormous variation **but** *common properties* across (almost) all Ls
2. Called **language universals**
3. Provide us with a window into our **cognition**
4. What are the limits of variation?
5. **What are the cognitive sources of such limits?**

Examples of linguistic universals

- **Phonology**: All *spoken* languages have consonants and vowels. All *spoken* languages have at least one unrounded and one back vowel (Hyman 2008).
- **Morphology**: All languages have pronominal categories involving at least three persons and two numbers (Greenberg 1966; Bauer 2010).
- **Grammar (syntax)**: All languages have verbs and nouns (Croft 1990). Grammatical rules are structure-dependent (Chomsky 1965)
- **Semantics**: …

Quantifiers

- Double click to open pdf document:

Literature

- Westerståhl, Generalized Quantifiers, SEP.
- Peters & Westerståhl, Quantifiers in Language and Logic, OUP, 2008.
- Handbook of Logic and Language, Van Benthem & Ter Meulen (Eds.), Elsevier 2011.
- Szymanik, Quantifiers & Cognition, Studies in Linguistics & Philosophy, Springer, 2016.

Convexity

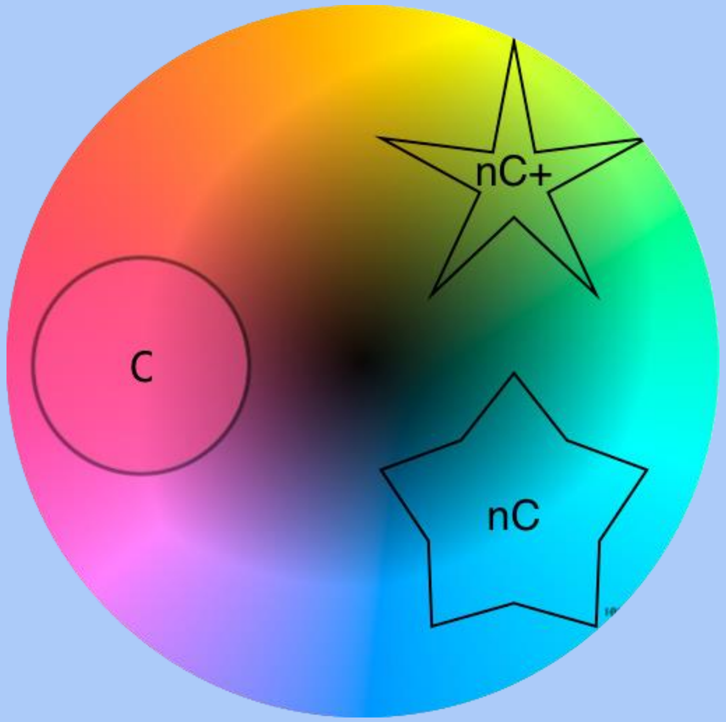
Convexity (Connectedness)

- Extending the notion of monotonicity
- No noun in English means ‘bottle or eagle’.
- No quantifier means ‘less than 5 or more than 10’.
- Informally, if two objects are blickets then, any object **in between** those two must also be a blicket.

Convex Quantifiers

- C is between A and B: if A ⊆ C ⊆ B (or vice versa)
- So: Q is connected: if A ⊆ C ⊆ B and Q(A) and Q(B), then Q(C).
- ‘Between 5 and 10’ or ‘5 to 10’ vs. ‘less than 5 or more than 10’.
- This property has also been called continuity by van Benthem (1984, 1986)
- **Theorem**. Q is monotone iff Q and $\neg Q$ are connected.

Convex Color Terms



Color terms across languages denote convex regions (Jaeger, 2010)

Convexity Universal

All lexical categories satisfy convexity (Gardenfors 2014)

Boolean Connectives

Boolean semantics

- Certain words in natural language can express Boolean functions
  - Functions from some n-product of {true, false} to {true, false}
- ‘Maria is in Galway *and* Maria is a linguist’
- We can reconstruct the input/output relations:

P	Q	Not P	P and Q
True	True	False	True
True	False	False	False
False	True	True	False
False	False	True	False

Boolean universals

- Suppose we restrict ourselves to Binary connectives
- Then, there are 16 possible operators
  - All the way of diving the 4 lines of a truth table with P and Q into true and false
- English has ‘and’, ‘or’, ‘nor’
- But they can in principle all be lexicalized!
- What about other languages?

{and}	Wari (Chapacuran)
{or}	Maricopa (Yuman)
{and, or}	Iraqw (Chusitic)
{and, or, nor}	English (Indo-European)

Boolean semantics

- Two distinct questions:
  - Why do we only see some operators and not others, e.g., ‘and’ but not ‘nand’?
  - Why do they come in certain combinations, e.g. never ‘nor’ alone?
- For some operators, there are some intuitively plausible answers
  - E.g., ‘left projection’ operator, which returns value of left argument
- However, others have received much discussion in the literature
  - E.g., why is there no ‘nand’?

Gradable Adjectives

Adjectival semantics

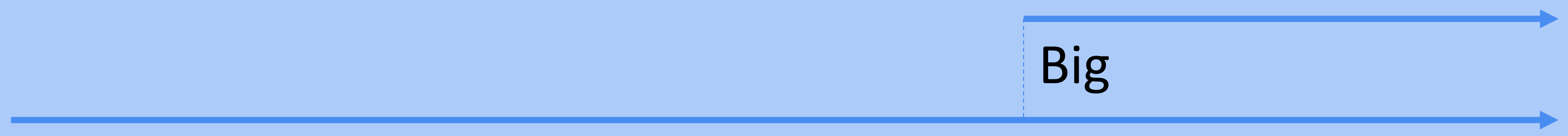
- Adjectives: Italian, red, tall, square
- *Gradable* adjectives:
  - *Very Italian, *very square
  - Very red, very tall
- Two big types of gradable adjectives:
  - Relative-standard: tall, short, cold, warm
  - Absolute standard: empty, full, straight, bent

Uses of gradable adjectives

- Gradable adjectives occur in two main contexts:
  - Measure uses: Roberta is 180 centimeters tall
  - Bare uses: Roberta is tall
- Relative-standard adjectives have some peculiarities:
  - Sorites paradox
    - If Chiara is tall, then someone 1mm shorter than Chiara is also tall.
  - Context sensitivity:
    - Chiara is tall (context: Italians) while Chiara is not tall (context: basketball players)
- The universal we consider applies to bare uses of gradable adjectives in a fixed context.

Monotonicity for gradable adjectives

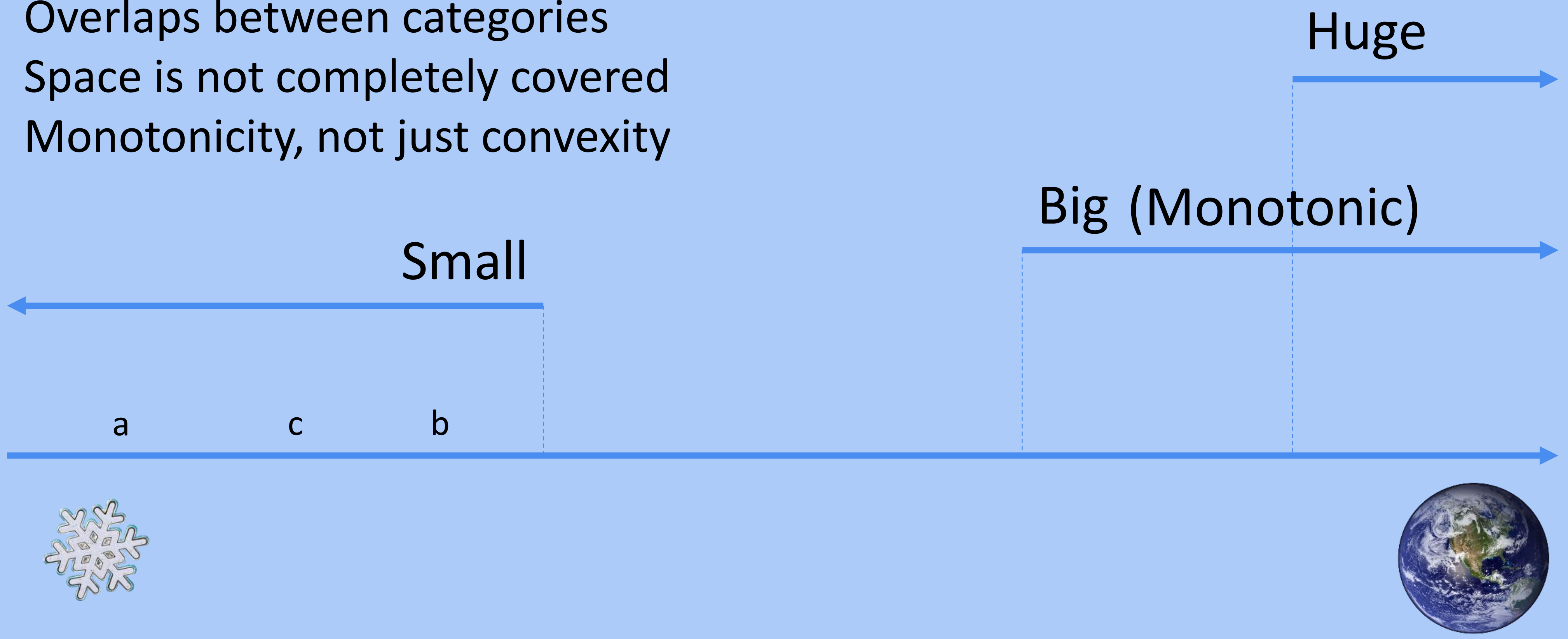
- General definition of monotonicity:
  - A function *f* is *monotonically increasing* iff
  - for all *x* and *y* such that $x \leq y$, $f(x) \leq f(y)$
  - And *monotonically decreasing* if whenever $x \geq y$, then $f(x) \leq f(y)$
- Intuitively, monotonically increasing functions preserve the order, and decreasing reverse it.
- Gradable adjectives (in a context) can be thought of as functions from degrees (which is an ordered set) to Booleans (which is an ordered set).



Monotonicity for gradable adjectives

Conceptual spaces? No, because:

1. Overlaps between categories
2. Space is not completely covered
3. Monotonicity, not just convexity



*Pictures not to scale

Modality

Modal semantics

- Modals are expressions such as ‘might’, ‘must’, ‘could’, ‘should’, ‘can’
- Attempting an exact definition is very hard, but roughly they can be used to talk about non-actual situations
- Since Kratzer (1981), we distinguish two axes of variation in modal meaning: force and flavour. Examples:

	Strong (universal) force	Weak (possibility) force
Epistemic flavour	The keys must be on the table	It may be raining
Deontic flavour	You must do your homework	You may park here

Modal semantics

- There's other flavours:
  - Bouletic (desire)
  - Teleological (goals)
  - And so on
- There's other forces
  - Arguably, 'should' is a necessity, but weaker than 'must'
- In English, modal verbs come with a fixed *force* and variable *flavour*
- In other languages, modals vary wrt force and not flavour
  - St'át'icmets (Rullmann, Matthewson & Davis 2008), Nez Perce (Deal 2011), Old English (Yanovich 2016), and Pintupi-Luritja (Gray 2021).

Universals of modal meaning

- The single axis of variability universal (Nauze 2008):
  - If a modal can express more than one flavor, it can only express one force (and mutatis mutandis for force and flavor).
- Second proposal (Vander Klok 2013):
  - A modal system as a whole only has lexically encoded force or flavour
- However, two counterexamples:
  - Washo (Bochnak 2015): A verb can vary both wrt to force and flavour
  - Koryak (Mocnik & Abramovitz 2019): A verb that can be used both to mean ‘believe’ (strong force) and ‘allow for the possibility that’ (weak force), and multiple flavours (doxastic and assertive)

Universals of modal meaning

- Independence of force and flavour universal (Steinert-Threlkeld 2022)
  - All modals in natural language satisfy the independence of force and flavor property: if a modal can express the pairs (fo1;fl1) and (fo2;fl2), then it can also express (fo1;fl2) and (fo2;fl1).
- This universal includes the cases that contradicted previous proposals
- And it excludes some meanings:
  - A modal *mighst* which behaves like a mix of:
  - *Might:* it can be used in epistemic possibility contexts
  - *Must:* in that it can be used in deontic necessity contexts.

Responsive Verbs

Responsive verbs

Types of verbs:

- Jakub *believes* that he is in Ireland
- # Jakub *believes* where Ireland is

- # Jakub *wonders* that he is in Ireland
- Jakub *wonders* where Ireland is

- Jakub *knows* that he is in Ireland
- Jakub *knows* where Ireland is

	Declarative	**Interrogative**	**Example**
Rogative	No	Yes	Wonder
Anti-rogative	Yes	No	Believe
Responsive	Yes	Yes	Know Forget

Lahiri 2002; Theiler, Roelofsen, and Aloni 2018; Uegaki 2018

Veridicality

'Know' is veridical wrt declarative complements:

- Jakub knows ESSLLI is in Ireland
- → ESSLLI is in Ireland

'Know' is veridical wrt interrogative complements:

- Jakub knows where ESSLLI is
- & ESSLLI is in Ireland
- → Jakub knows that ESSLLI is in Ireland

- 'Know' is *veridically uniform*!

'Be certain' is **not** veridical wrt declarative complements:

- Jakub is certain that ESSLLI is in Ireland
- -\-> ESSLLI is in Ireland

'Be certain' is **not** veridical wrt interrogative complements:

- Jakub is certain about where ESSLLI is
- & ESSLLI is in Ireland
- -\-> Jakub is certain that ESSLLI is in Ireland

- 'Is certain' is *veridically uniform*!

Veridical uniformity

- Based on these observations, we can formulate a universal:
- All responsive verbs are veridically uniform
    - (Spector and Egre 2015; Theiler, Roelofsen, and Aloni 2018)
- Why is this a substantial universal?
- Because it's easy to think of meanings for responsive verbs that do not satisfy it!
- E.g. *knopinion*:
- 'John knopinions that it will rain'
    - → John knows that it will rain
    - Veridical!
- 'John knopinions whether it will rain'
    - → John has an opinion about whether it will rain
    - Non veridical!

Some concluding remarks

General strategy:

- Pick a semantic domain
  - Quantifiers, Boolean operators, nouns, modal verbs, responsive verbs
- Define the space of possible meanings
  - By semantic type (quantifiers, adjectives)
  - or cognitive model (conceptual spaces)
- Define a restriction that…
  - Includes attested meanings
  - Excludes non-attested meanings
- This restriction is a universal to be explained!
- In the rest of the course we'll see strategies to explain these universals

Questions time!