How children learn "some," "all," and "most," words

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Number words and quantifiers

‘seven dots are black’

-

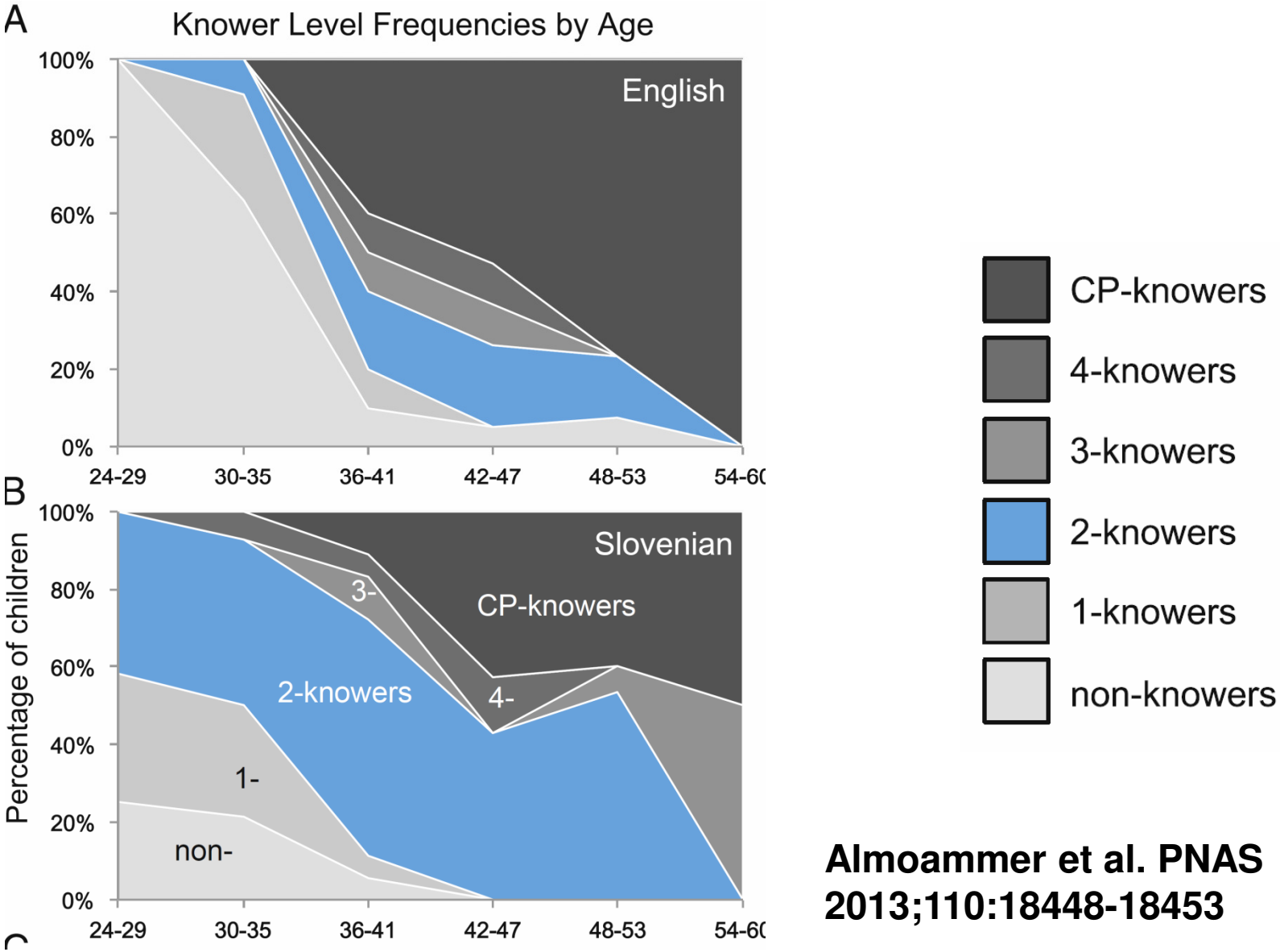
‘all of the dots are black’

Number word acquisition:

- Object-tracking system
- Analogue magnitude system
- Language

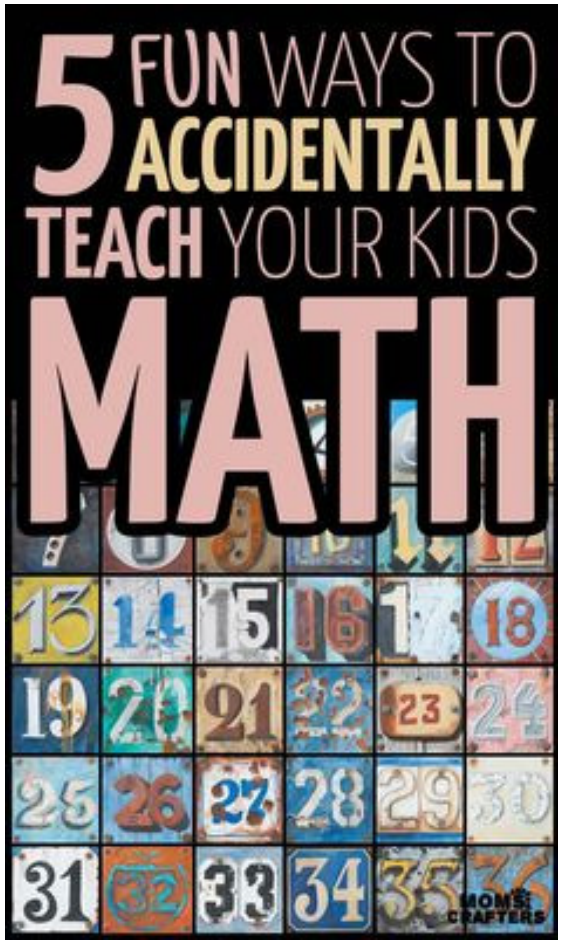
Feigenson, Dehaene & Spelke (2004),
Sullivan & Barner (2011)

Frequency of non-, one-, two-, three-, four-, and CP-knowers in (A) English, (B) Slovenian



Almoammer et al. PNAS 2013;110:18448-18453

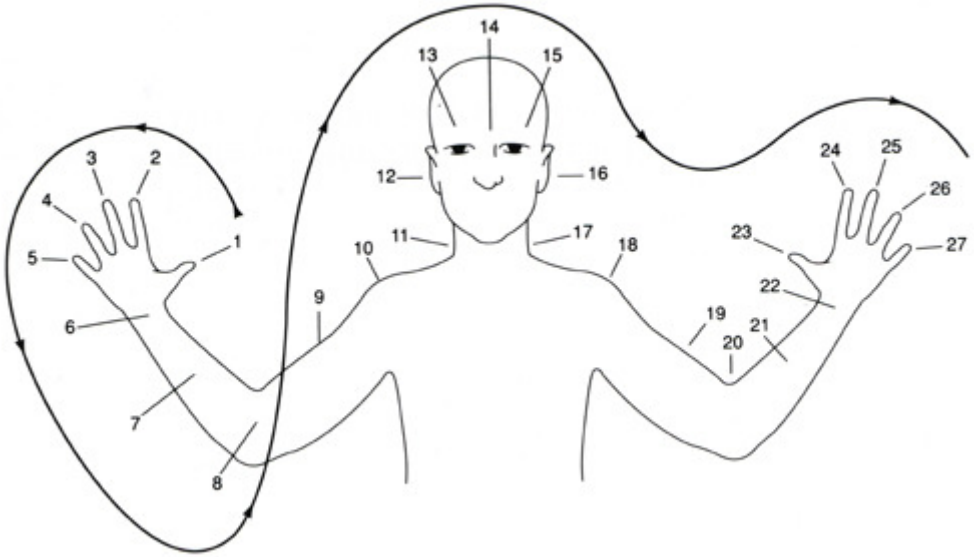
Number word learning: culture and ‘technology’



- Verbal count line ‘one, two, three…’
- Extensive training (family and early education)

Number word learning: culture and ‘technology’

- Embodied ‘technology’, finger- and body-part counting



Oksapmin counting system, based on 27 body parts (Saxe, 1982).

Number word learning

- A universal order of acquisition of the meaning of number words, starting with ‘one’ and proceeding in line with increasing cardinality

- What about “**some**," "**all**," and "**most**," words? In what order are they learned?

Acquisition of quantifiers and number words: only partially related

- Restricted role for object-tracking and analogue magnitude systems:

  3, 6, 9…, n Xs are just as likely to be ‘all Xs’ as ‘some Xs’

- No embodied technology
- No culture/education system teaches quantifiers
- No known verbal quantifier line (e.g. ‘some, many, most, all’)
- What would a verbal quantifier line even include? (‘a few’, ‘not all’, ‘none’, ‘more than half’?)
- If quantifiers are acquired in line with increasing overlap between two sets (compare: increasing cardinality for numerals), ‘a few’ would be one of the easiest and ‘most’ and ‘all’ hardest.

- Rich and varied semantics and pragmatics of quantifiers:

'All', 'kol', 'todos', 'wszystkie'…As are Bs: $A \cap B = A$

Some As are Bs: $A \cap B \neq \emptyset$

Most As are Bs: $|A \cap B| > |A - B|$

No As are Bs: $A \cap B = \emptyset$

Some As are not Bs: $A \cap B \neq A$

Not all As are Bs: $A \cap B \neq A$

- Subtler similarities: 'all', 'each', 'every'; 'oli', 'kaθe'

Constraints on the acquisition of quantifiers?

- Crosslinguistic similarity in the *meaning* of quantifiers might lead to crosslinguistic similarities in the *order of acquisition* (Katsos, et al., 2016, *PNAS*)

Similarities in meaning – Similarities in the order of acquisition?

Predictions from the prior work (Geurts et al, 2010; Just & Carpenter, 1971; Musolino, 2004; Noveck, 2001; i.a.)

Positive > negative: (‘all’, ‘some’) > (‘none’, ‘some…not’)

Upward-monotone > downward monotone: (‘all’, ‘some’) > (‘none’, ‘some…not’)

- **All** the children are playing football

  ⇒ **All** the children are playing a sport

  ≠> **All** the children are playing football in the rain

- **None** of the children are playing football

  ≠> None of the children are playing a sport

  ⇒ None of the children are playing football in the rain

Similarities in meaning – Similarities in the order of acquisition?

Predictions from prior work (Geurts et al, 2010; Just & Carpenter, 1971; Musolino, 2004; Noveck, 2001; i.a.)

1. Positive > negative, (‘all’, ‘some’) > (‘none’, ‘some…not’)

   Upward-monotone > downward monotone

2. Totality > Partiality

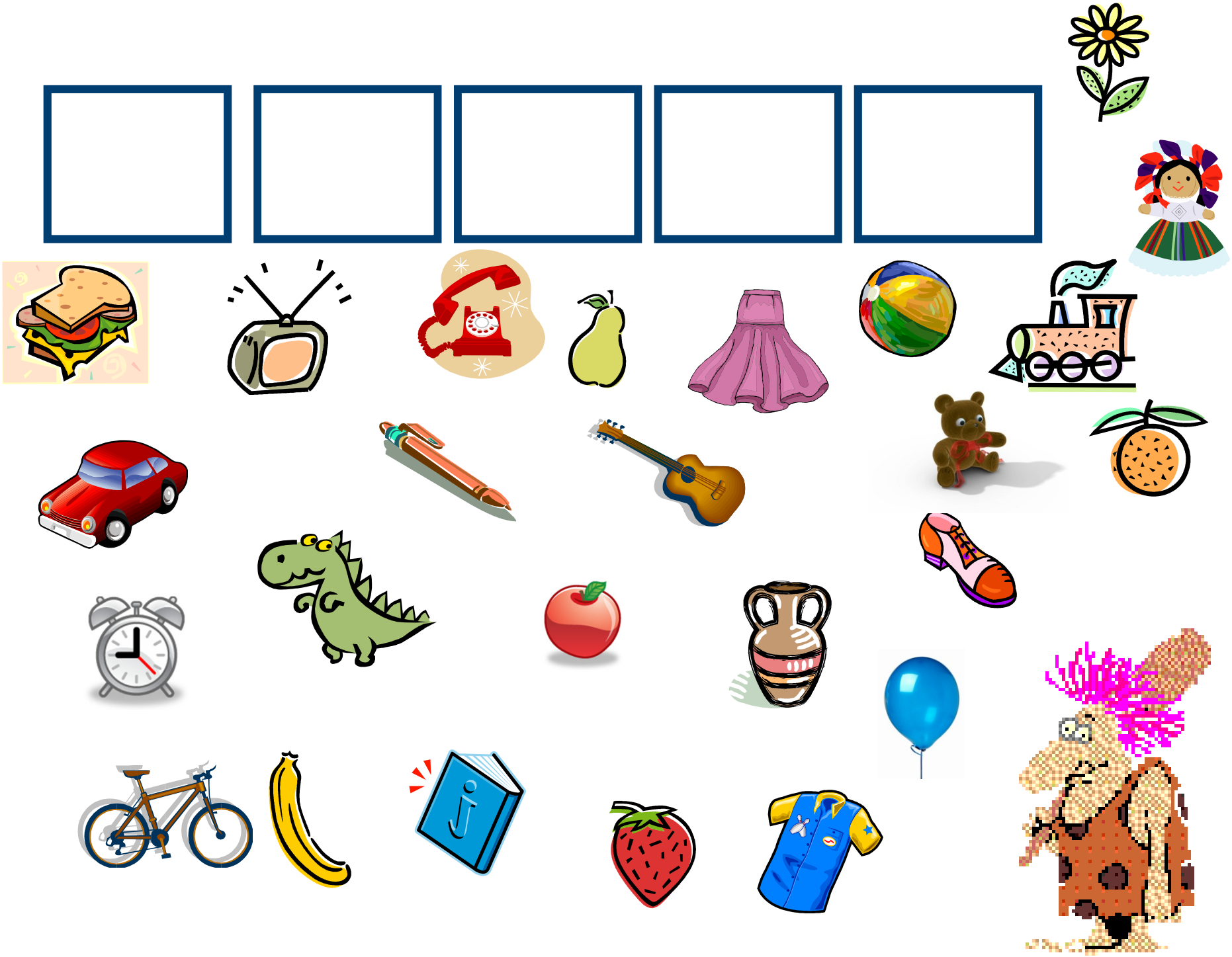
   (‘all’, ‘none’) > (‘some’, ‘some…not’, ‘not all’)

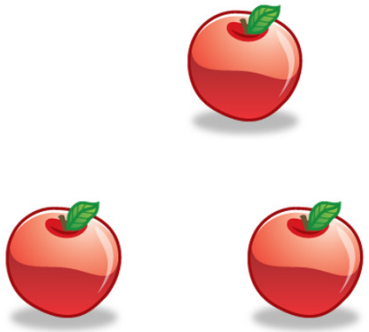
3. Complexity ‘some’ > ‘most’

4. Logical falsity > under-informativeness

Language- or population- specific effects

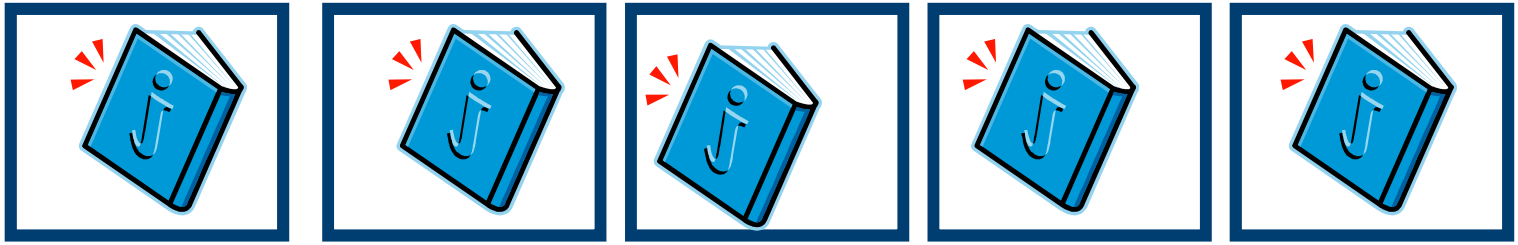
- Syntax
  - Concord: ‘None of the apples are in the boxes’ - ‘**Aucune** pomme **n**'est dans les boîtes’
  - Quantifier-Noun order
  - Partitivity ([Quantifier] “of the”)
- Lexical
  - Quantifier or Noun (‘most’ vs ‘la plupart’, ‘la mayoría’)
  - Quantifier syllable length
- Participants
  - Attending formal education, Socio-economic background (didn’t test), Age, Gender





All the Fs are in the boxes
None of the Fs…
Some of the Fs…
Most of the Fs…
Not all the Fs…
Some of the Fs are not…

If participant says ‘WRONG’
Experimenter asks ‘Why?’



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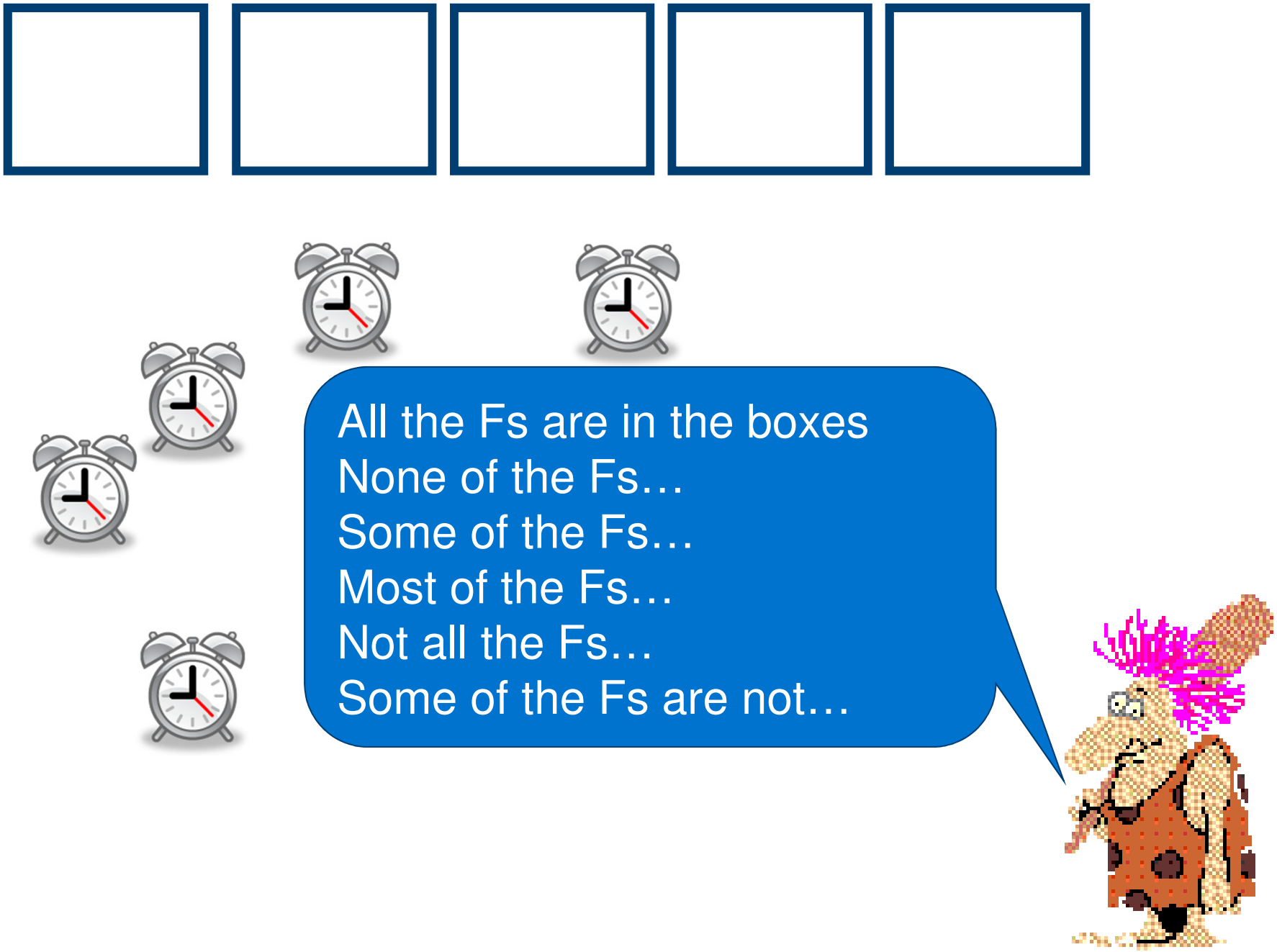
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None of the Fs…
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Language	Genus	Language type
Finnish	Finnic	Uralic/ Finno-Ugric
Estonian		
Mandarin	Chinese	Sino-Tibetan
Cantonese (Yue)		
Korean	Korean	Korean
Georgian	Karto-Zan	Kartvelian
Japanese	Japanese	Japanese
Slovak	Slavic	Indo-European
Serbian		
Russian		
Polish		
Croatian		
Spanish	Romance	
Italian		
French		
Catalan		
Urdu	Indic	
Greek	Greek	
Cypriot Greek		
Norwegian	Germanic	
German		
English		
Dutch		
Danish		
Lithuanian	Baltic	
Tamil	Southern Dravidian	Dravidian
Basque	Basque	Basque
Malay	Malay-Sumbawan	Austranesian
Turkish	Turkic	Altaic
Maltese	Semitic	Afro-Asiatic
Hebrew		

- 31 languages, 15 genera, 11 types (families and isolates) classified according to WALS.
- Participants: 5- to 6-year-old children (n=768) and adults (n=536)
- Task took 25-30 minutes, 3 pseudorandomised orders of presentation.
- Rejections were justified on the grounds of the quantity of objects inside the boxes

Let’s have a look…

- Adult correct responses in 99% of true and false conditions, 84% rejections of under-informative conditions
- Child responses range widely

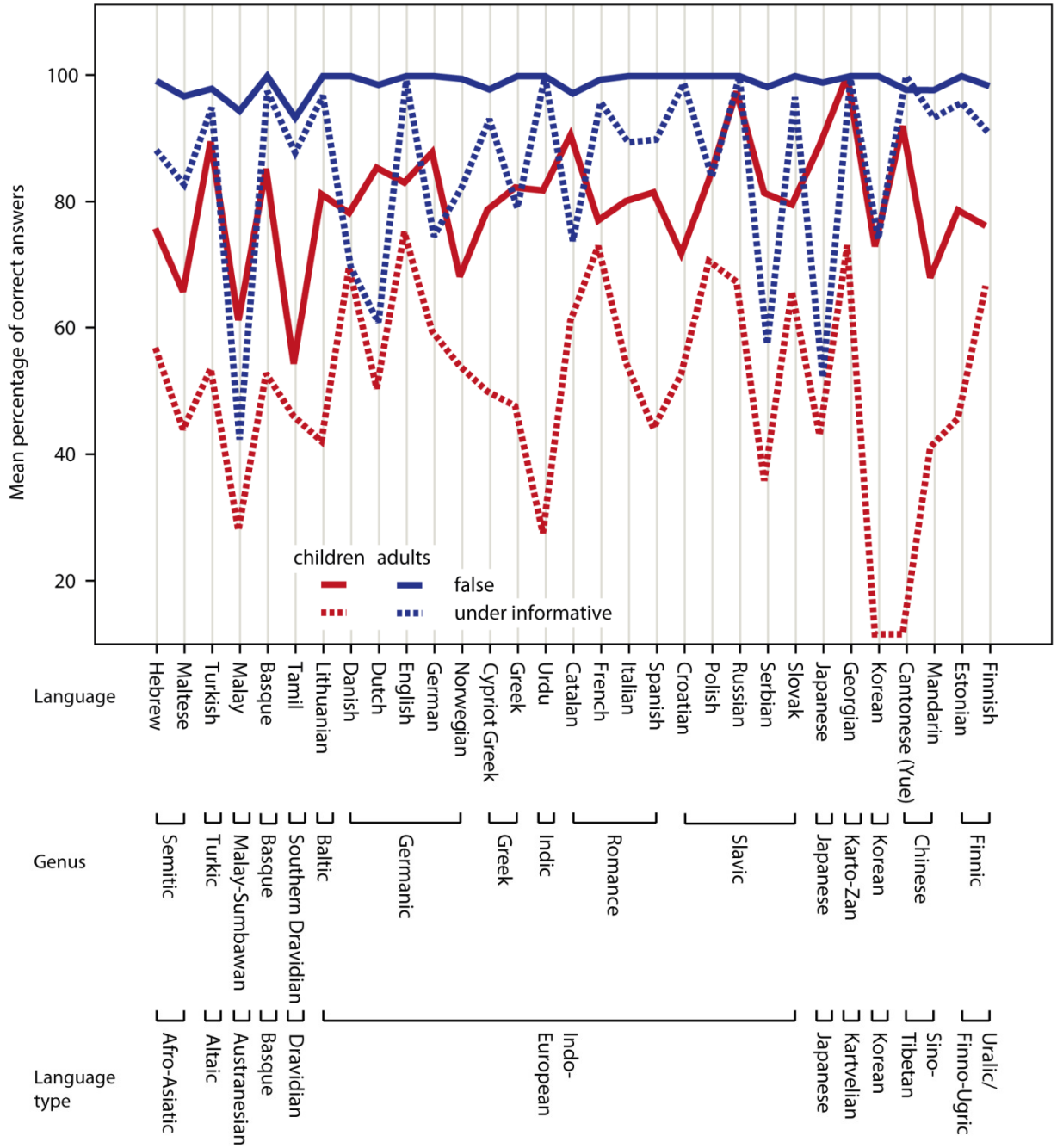
Percentage of correct responses for each quantifier by 5-year-old children

Predictions and Results

1. Positive > negative, (‘all’, ‘some’) > (‘none’, ‘some…not’)
   Upward-monotone > downward monotone
2. Totality > Partiality
   (‘all’, ‘none’) > (‘some’, ‘some…not’, ‘not all’)
3. Complexity ‘some’ > ‘most’

- Multivariate analyses with each Constraint 1-3, Language/Genus/Type, Gender, Schooling, Age as well as relevant grammatical features
- Main effects of Language/Genus/Type but model comparison with AIC suggest models with Language/Genus/Type (including their interactions with the Constraints) are **over-fitted** compared to model without any language variable

Percentage of rejections of false and under-informative conditions for the average of 'some', 'some ... not' and 'most' by 5-year-old children and adults



Results: under-informativeness

- Multivariate analyses with Constraint 4, Language/Genus/Type, Gender, Schooling, Age as well as relevant grammatical features
- Main effects of Language/Genus/Type but model comparison with AIC suggest models are over-fitted compared to model without any language variable
- For both children and adults

Crosslinguistic similarities in language acquisition

- Four constraints upheld through multivariate analyses and model comparison
- No language or language type violated more than one constraint, except Georgian, which violated two.
- Georgian (as well as other exceptions), the violations were evidenced in cases of ceiling performance.

Additional analyses

Language-specific factors

- use of negative concord ($p<.001$),
- expressions with a partitive marker in the case of ‘some’ ($p<.05$)

Social-, biological factors

- Attending formal school at the time of testing ($p<.001$),
- A gender effect, boys outperformed girls in the acquisition of the true or false meaning, but no differences in informativeness

Search for ‘deeper’ explanations

Search for ‘deeper’ explanations

1. Polarity / Monotonicity

(‘all’, ‘some’) > (‘none’, ‘some…not’)

- Linguistic underpinning: markedness of negation
- Cognitive underpinnings: representation of absence vs existence, difficulty with creating subsets (subtraction?)

‘Deeper’explanations-2

2. Totality

(‘all’, ‘none’) > (‘some’, ‘some…not’)

- Maximality, whole-object preference in word learning

‘Deeper’explanations-3

3. Complexity: Set size comparison ‘some’ > ‘most’, working memory

Some As are Bs: $A \cap B \neq \emptyset$

Most As are Bs: $|A \cap B| > |A - B|$

$|A \cap B| > |1/2\ A|$

‘Deeper’explanations-4

4. Logical falsity > under-informativeness

Linguistic, cognitive, meta-cognitive underpinnings:

- Access to alternatives
- Relevance of alternatives
- Processing resources
- Tolerance of pragmatic violations

Katsos, 2014

- Attending formal school at the time of testing, use of negative concord, expressions with a partitive marker in the case of ‘some’
- Gender effect: boys >> girls, in true or false only

Crosslinguistic similarities in the order of acquisition

While number word acquisition starts with ‘one’ and proceeds by cardinality, quantifier acquisition starts with ‘all’ and is guided by rich semantics and pragmatics

Positive > negative, Upward- > downward monotone

Totality > Partiality

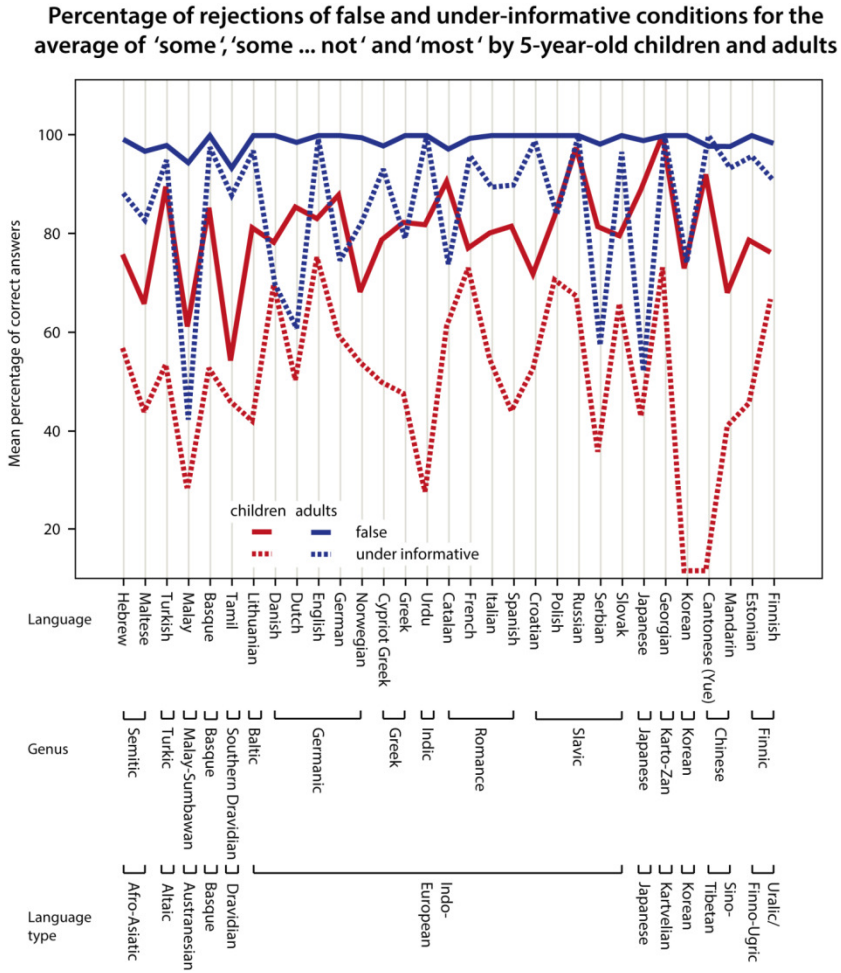
Complexity

Logical falsity > under-informativeness

In line with proposals that extensive universals can be found in the area of language meaning and use (Stivers et al., 2009, PNAS; Levinson, 2015, TiCS)

Explanation likely to include semantics and pragmatics, cognitive biases, cultural and educational practices as well as individual differences

Ways forward 1: cross-linguistic pragmatics



Where does the cross-linguistic variation in sensitivity to under-informativeness come from?

Structure of the lexicon?

Pragmatic norms?

Ways forward 2: typological prevalence hypothesis

Typological Prevalence Hypothesis:

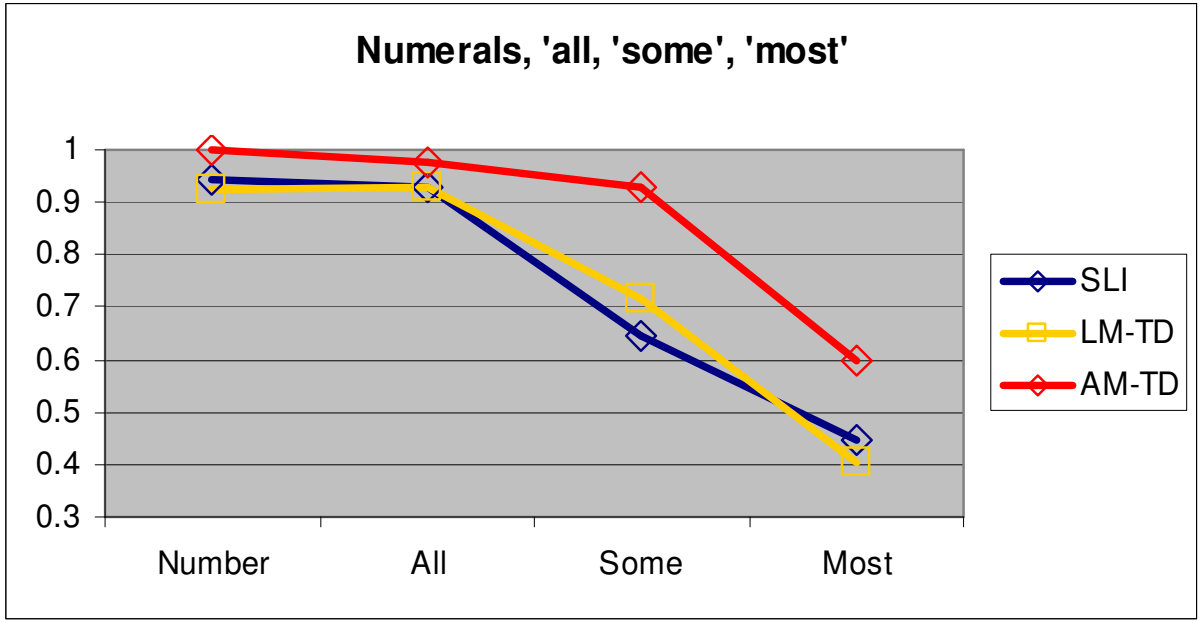
- Domain of space: the more frequent a given way of carving semantic space is, the easier it will be for children to learn it (Gentner & Bowerman, 2009).

  Piraha: "my bigness ate [at] a bigness of fish, nevertheless there was a smallness we did not eat" (Everett, 2005: 624)

- Eventually, link typology (and frequency), acquisition, processing

Ways forward 3: Cross-linguistically valid language assessment benchmarks

- 81 Spanish-speaking children, 27 SLI (mean age: 6;6, age range 4;0-6;9; 20 males; Katsos et al, 2011, *Cognition*)
- Two typically-developing (TD) control groups: Aged-matched (TD-AM) and Language-Matched (TD-LM)

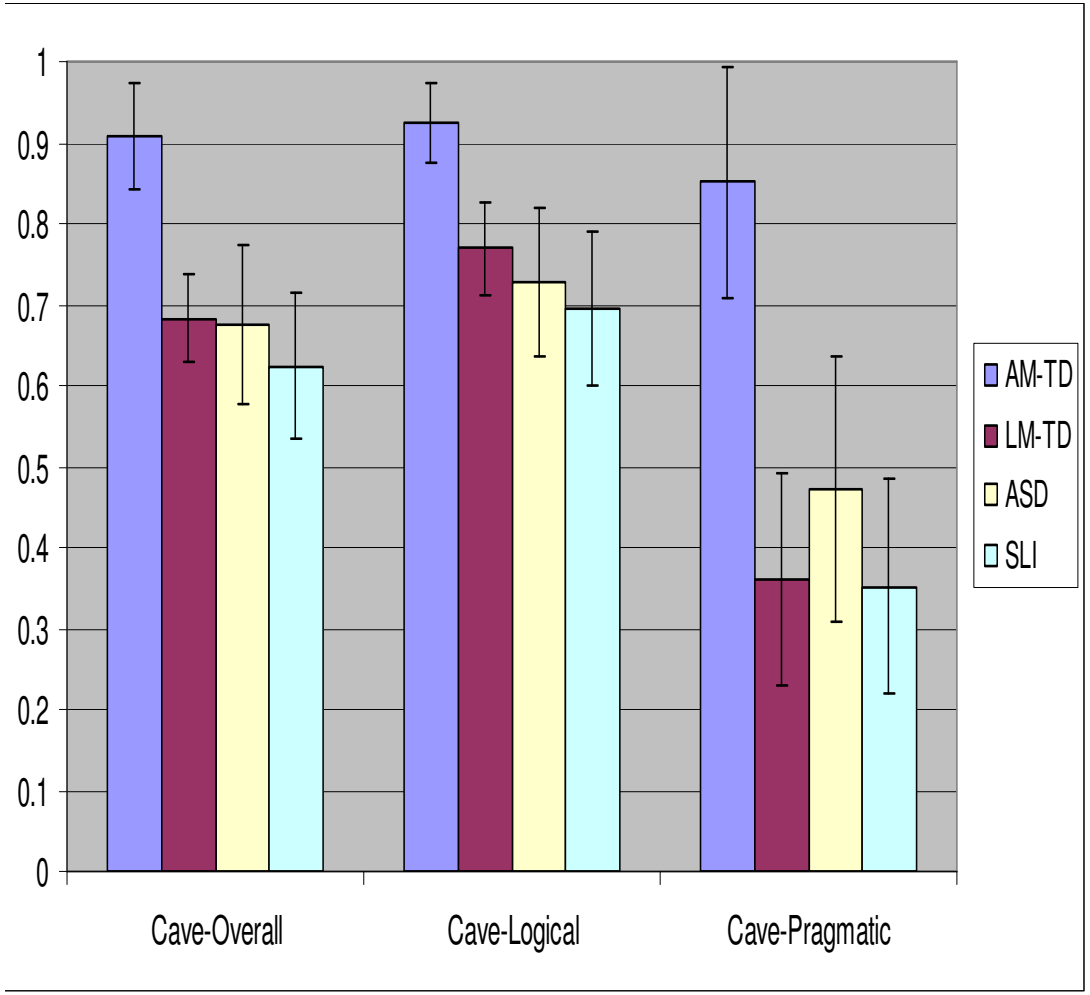


CwSLI & ASD on pragmatics
(Andrés Roqueta & Katsos, under review)

Spanish-speaking CwASD (diagnosis by psychologists, corroborated by ADI and IDEA)

- 20 CwASD (7;4, range 5;0 – 10;1; 17 males)
- 20 CwSLI (5;7, range 4;1 – 8;2; 15 males), language-matched to CwASD on receptive grammar (TROG)
- 20 LM-TD (4;3, range 3;4 – 6;3; 16 males), language-matched to ASD on receptive grammar (TROG)
- 20 AM-TD (7;2, range 5;1 – 9;8; 17 males)
- The Cavegirl task (Katsos, Andrés Roqueta et al, 2011)
- Strange Stories (Happé, 1994)

(Andrés Roqueta & Katsos, under review)
Results



AM-TDs > (ASDs ≈ SLIs ≈ LM-TDs)

TDs: regressions: Age in Months
CwSLI & CwASD: structural language

Ways forward 4: bilingual language assessment

- Ozturk, Katsos, Haman & Miekisz *in prep*
- 46 Polish-English bilingual children living in the East of England.
  - Age: 6;10 (4;11 – 7;10)
  - Age of onset of English: 2;3 (birth – 4;1)
  - Length of exposure to English: 3;10 (1;8 – 6;2)
- Between-language correlations for Quantifiers are stronger than correlations for vocabulary and morphosyntax

QC correlates better between languages

Correlations				
Method			**F**	
	r	p	z	p
QC Polish/English	0,86	0,001	4,03	0,001
TROG Polish/English	0,38	0,001		
TROG Polish/QC Polish	0,56	0,001	-0,28	0,38
TROG English/QC English	0,60	0,001		

r - Pearson's correlation coefficient; F -Fishers transformation test of signficance;

p - significance level

Thank you!

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For all quantifiers, *N* languages and types where children's performance with true and false was numerically higher ('>>').

Languages, out of 31				
	'All' >>	'Some' >>	'None' >>	'Some…not' >>
'All'	--	5	2	1
'Some'	26	--	14	3
'None'	29	15	--	2
'Some…not'	30	28	29	--

Language types, out of 11				
	'All' >>	'Some' >>	'None' >>	'Some…not' >>
'All'	--	3	1	0
'Some'	7	--	5	1
'None'	10	5	--	1
'Some…not'	10	10	9	--

N languages and types where children rejected false statements more often than underinformative (*UI*) ones.

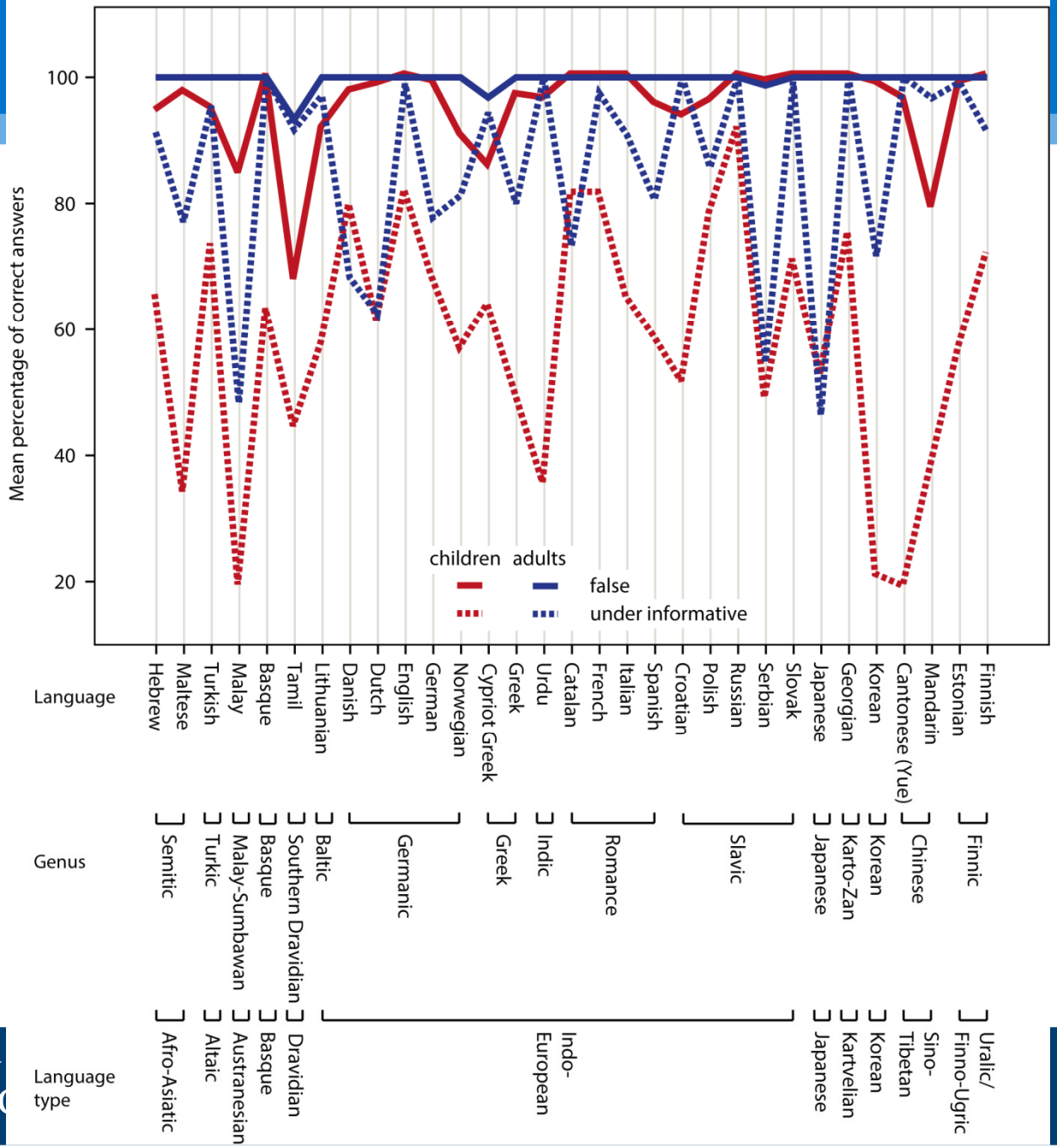
Languages, out of 31				
	‘Some’	‘Some…not’	‘Most’	All three
False >> UI	31	25	24	31
Language types, out of 11				
	‘Some’	‘Some…not’	‘Most’	All three
False >> UI	11	8	10	11

Bilingualism: Polish-English children

Ozturk, Katsos, Haman & Miekisz

		Version						
		Polish		English				
Method	mesure	M	SD	M	SD	t	df	p
QC	logical	0,81	0,17	0,73	0,17	4,16	44	0,000
	pragmatic	0,55	0,29	0,57	0,29	-0,43	44	0,671
	overall	0,74	0,16	0,70	0,16	3,72	44	0,001
TROG	Items passed	52	17,9	37	14	5,45	44	0,001
	Blocks passed	9	4,53	6	3,3	5,03	44	0,001

Percentage of rejections of false and under-informative conditions for 'some' by 5-year-old children and adults



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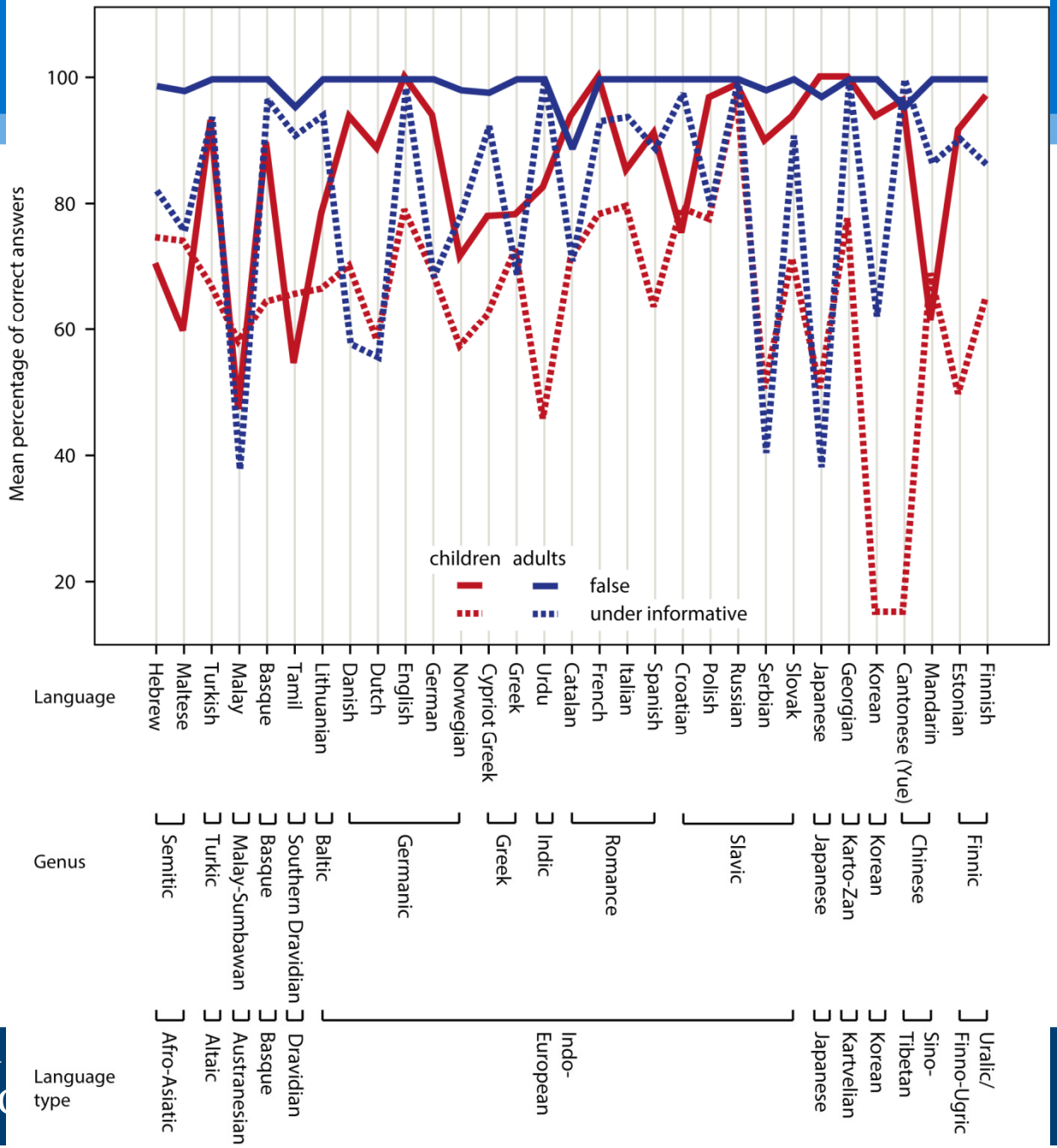
Percentage of rejections of false and under-informative conditions for ‘some ... not’ by 5-year-old children and adults



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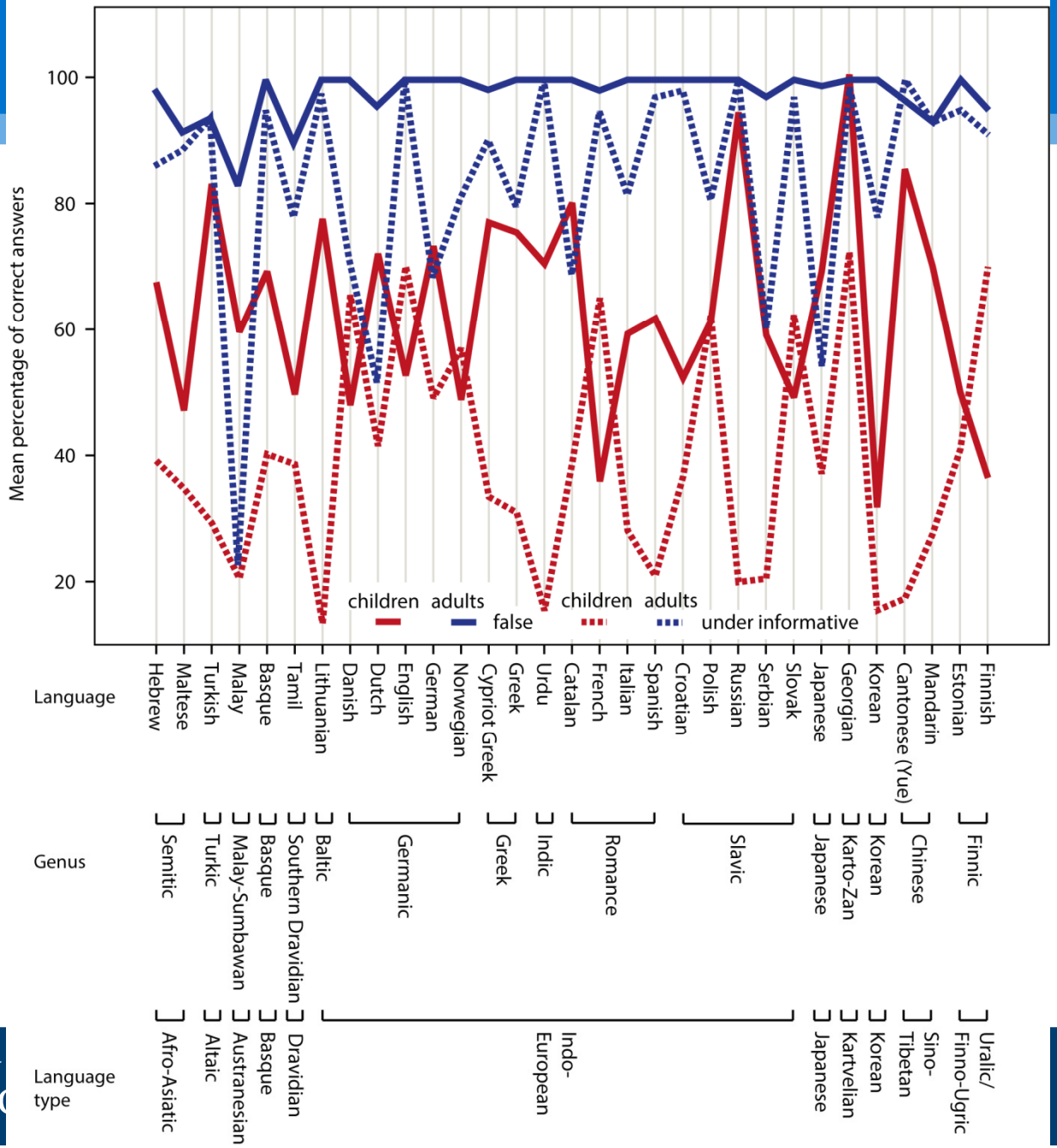
Percentage of rejections of false and under-informative conditions for 'most' by 5-year-old children and adults



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