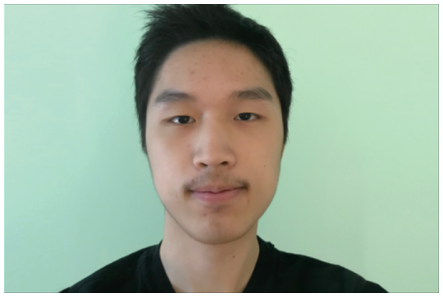
Granularity in the Semantics of Comparison

Helena Aparicio
Cornell University

joint work with



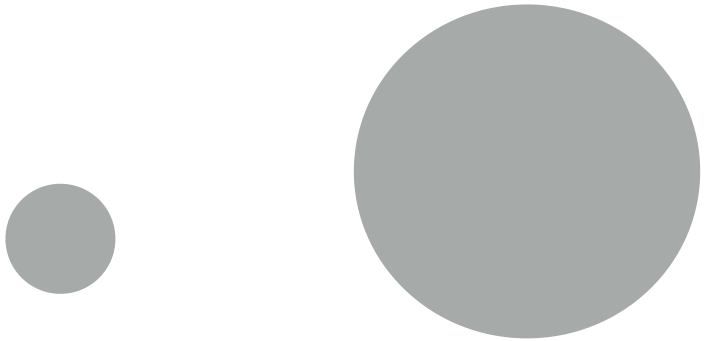
Curtis Chen (MIT)

Elizabeth Coppock (BU)

Roger Levy (MIT)

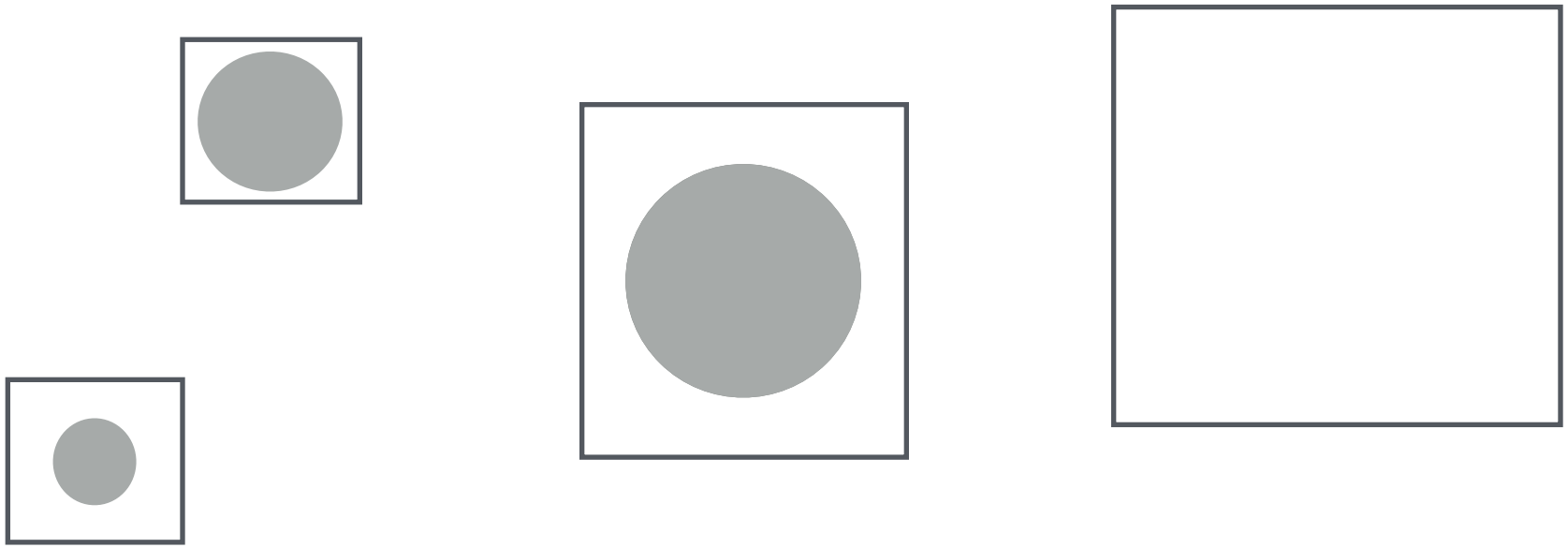
Definite Comparatives

The bigger circle.



Relative readings: superlatives

The circle in the biggest square.



Szabolcsi 1986, Heim 1999, Bumford 2017

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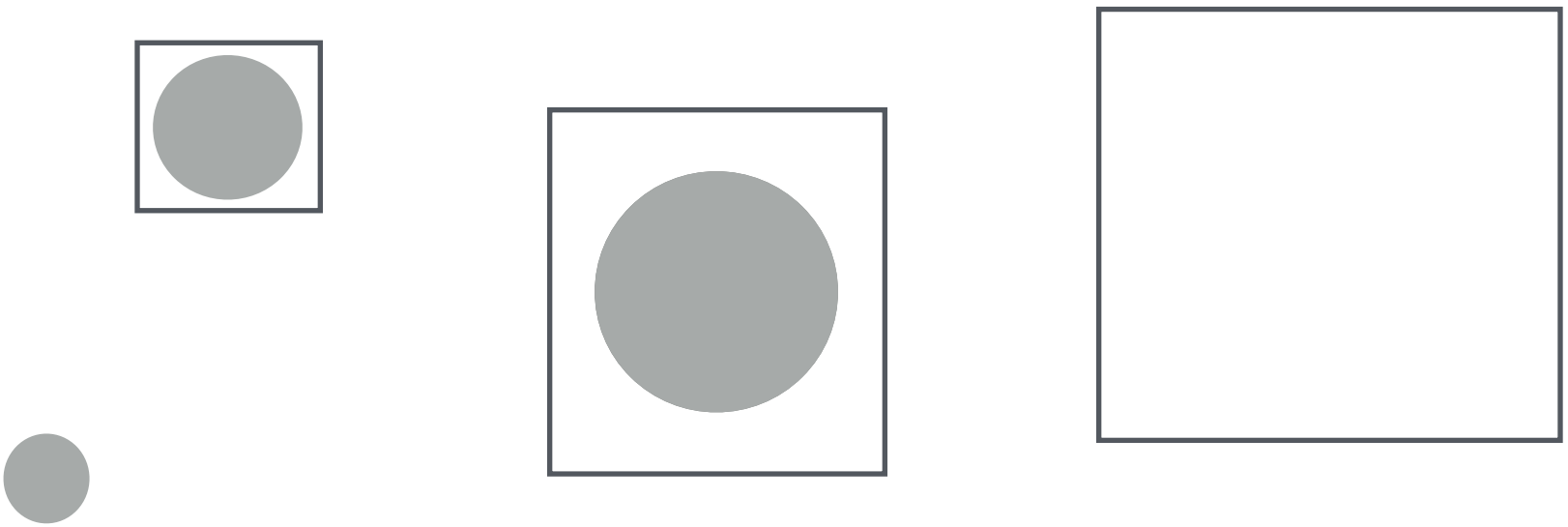

Szabolcsi 1986, Heim 1999, Bumford 2017

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(In)definites

The biggest circle.

?A biggest circle.

Cf. Herdan & Sharvit (2006), Coppock & Beaver (2014)

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Comparison Class

The biggest circle.

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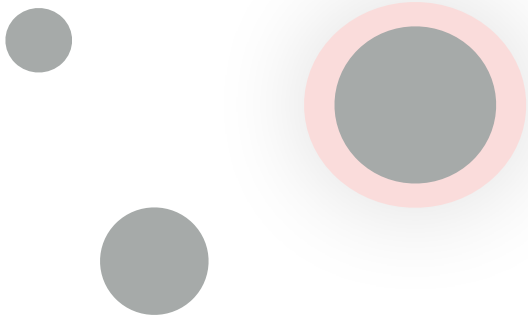

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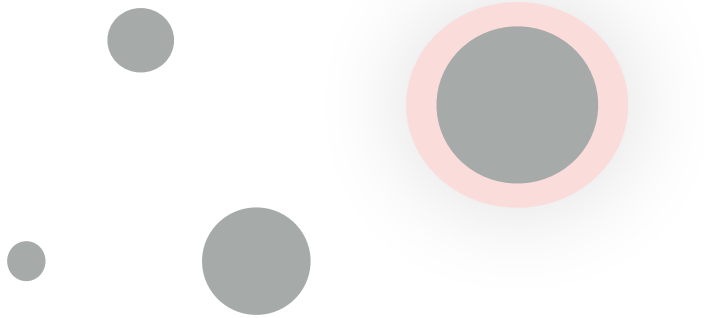

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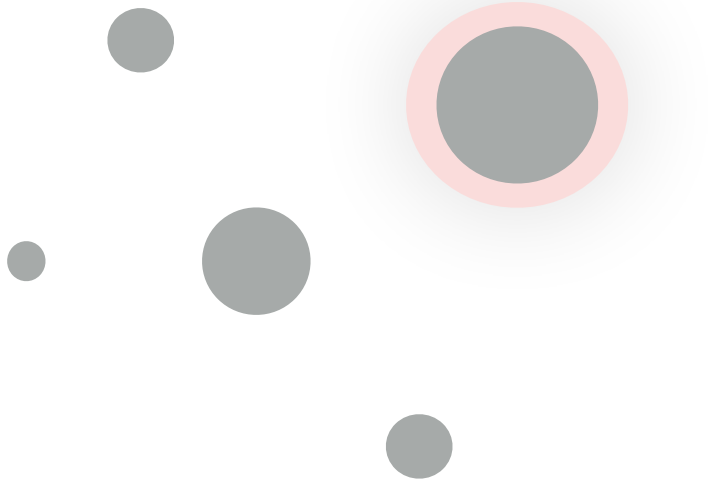

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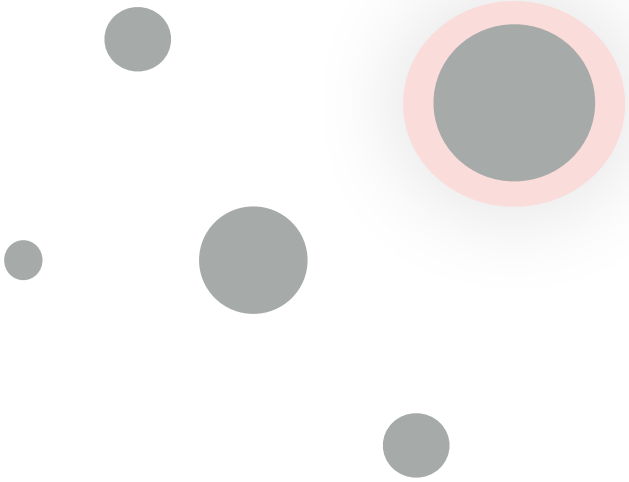

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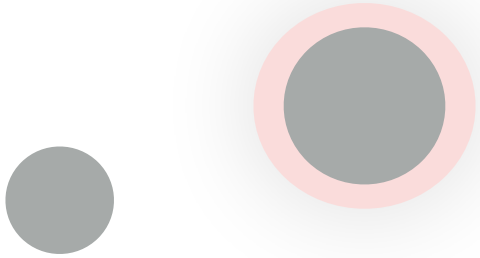

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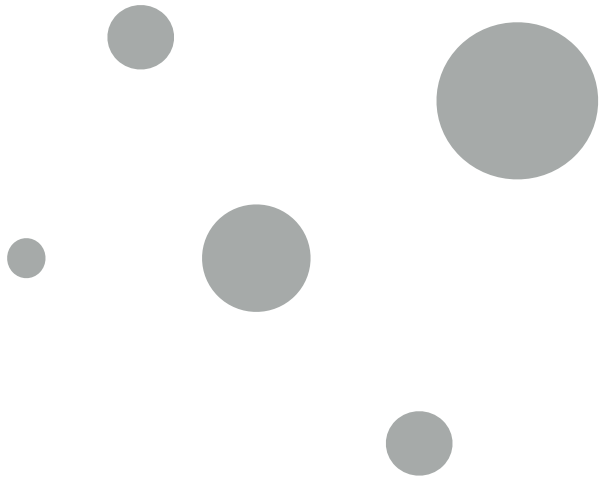

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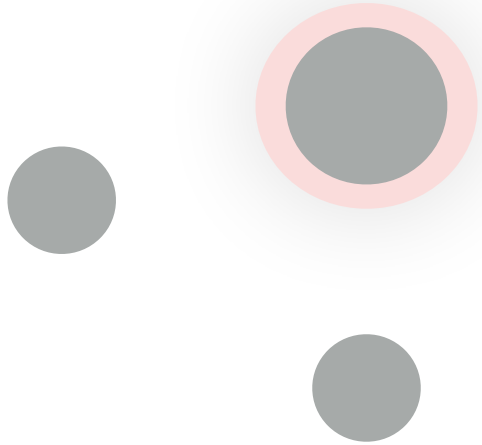

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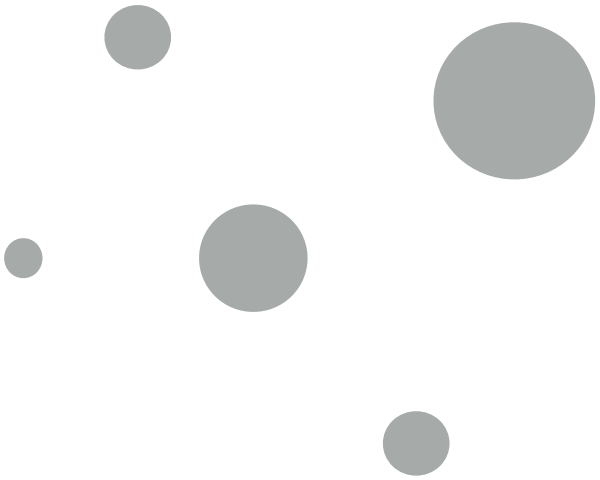

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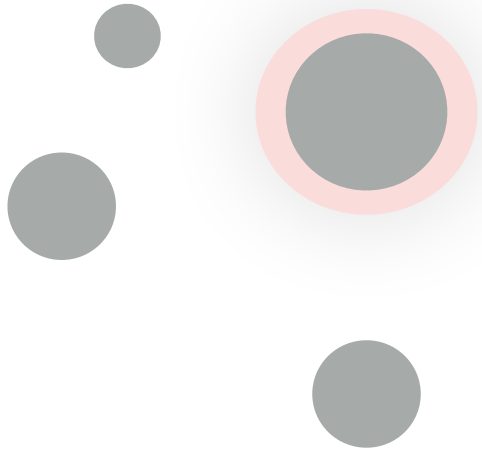

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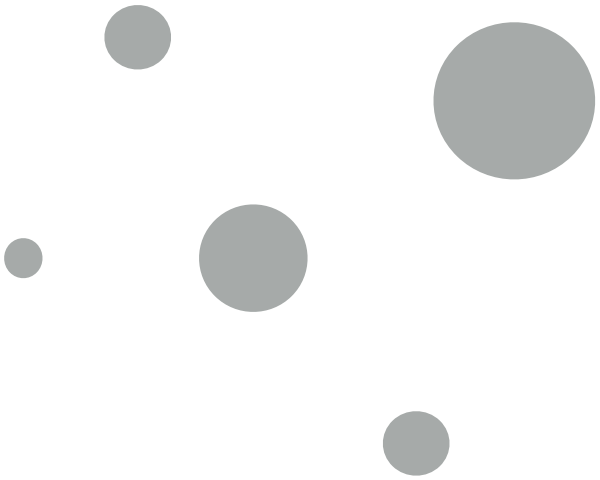

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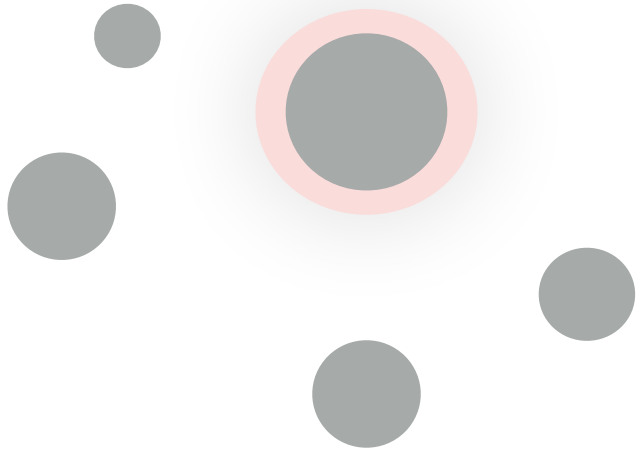

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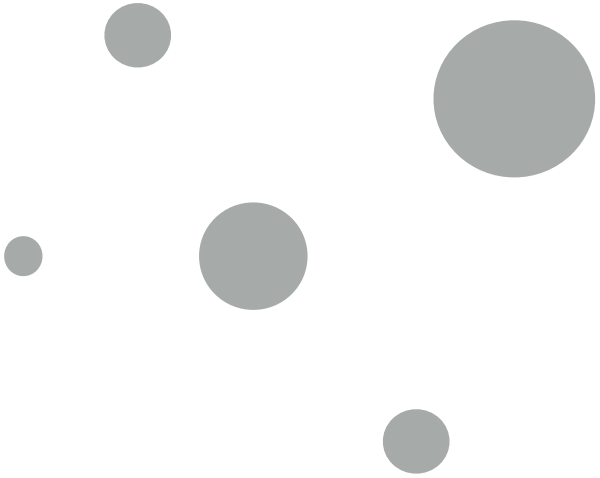

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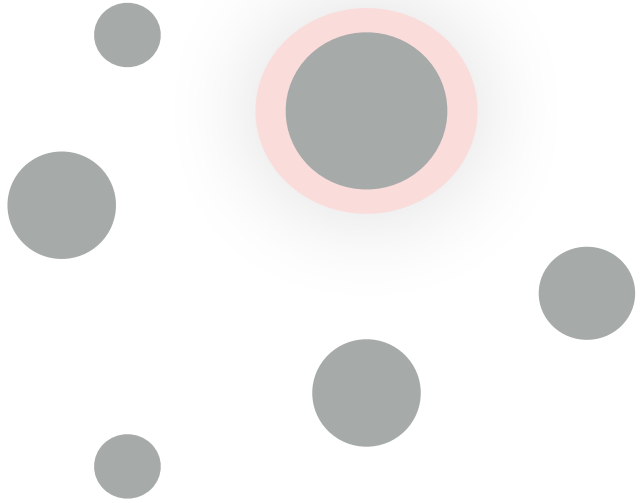
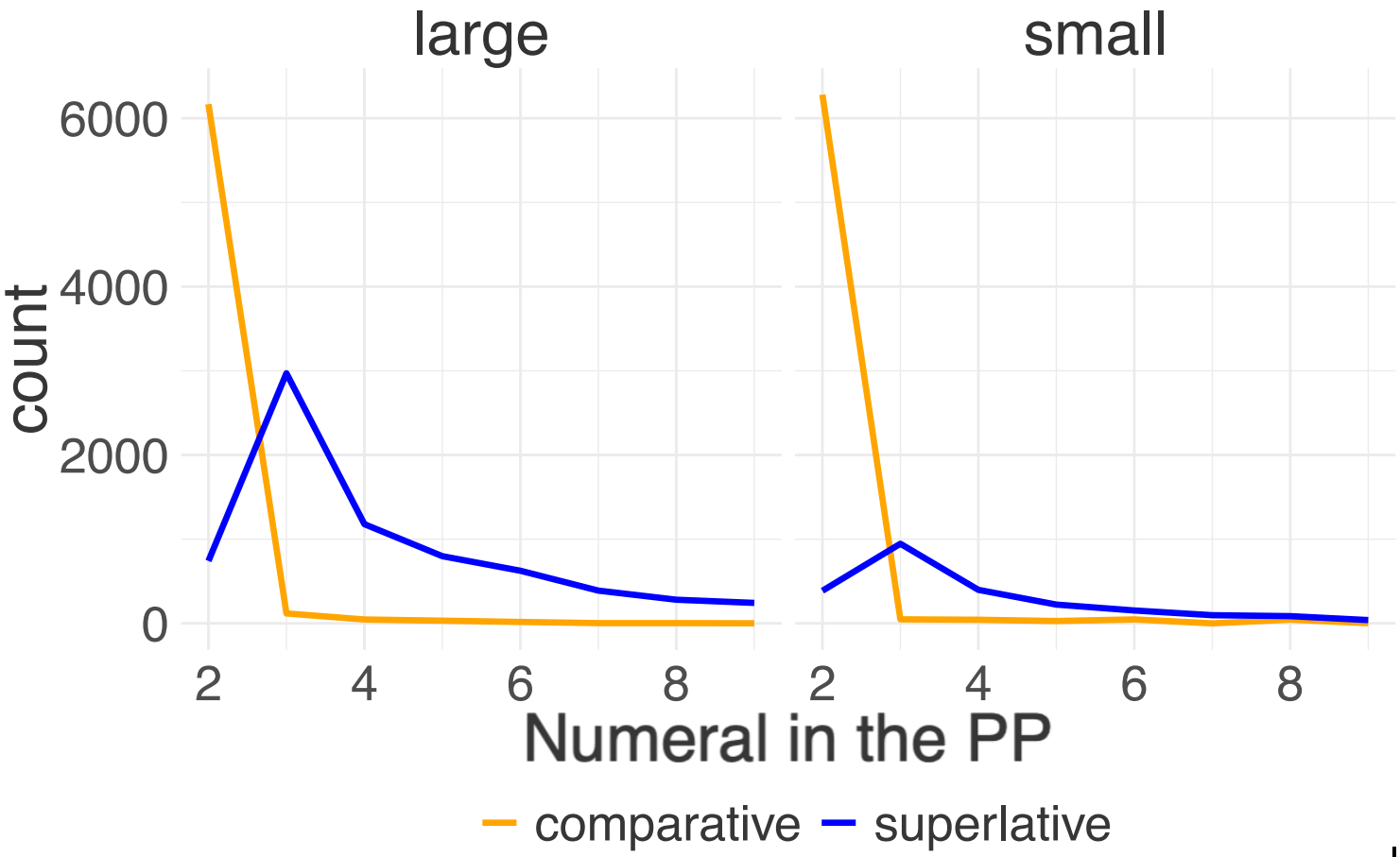


Corpus Data

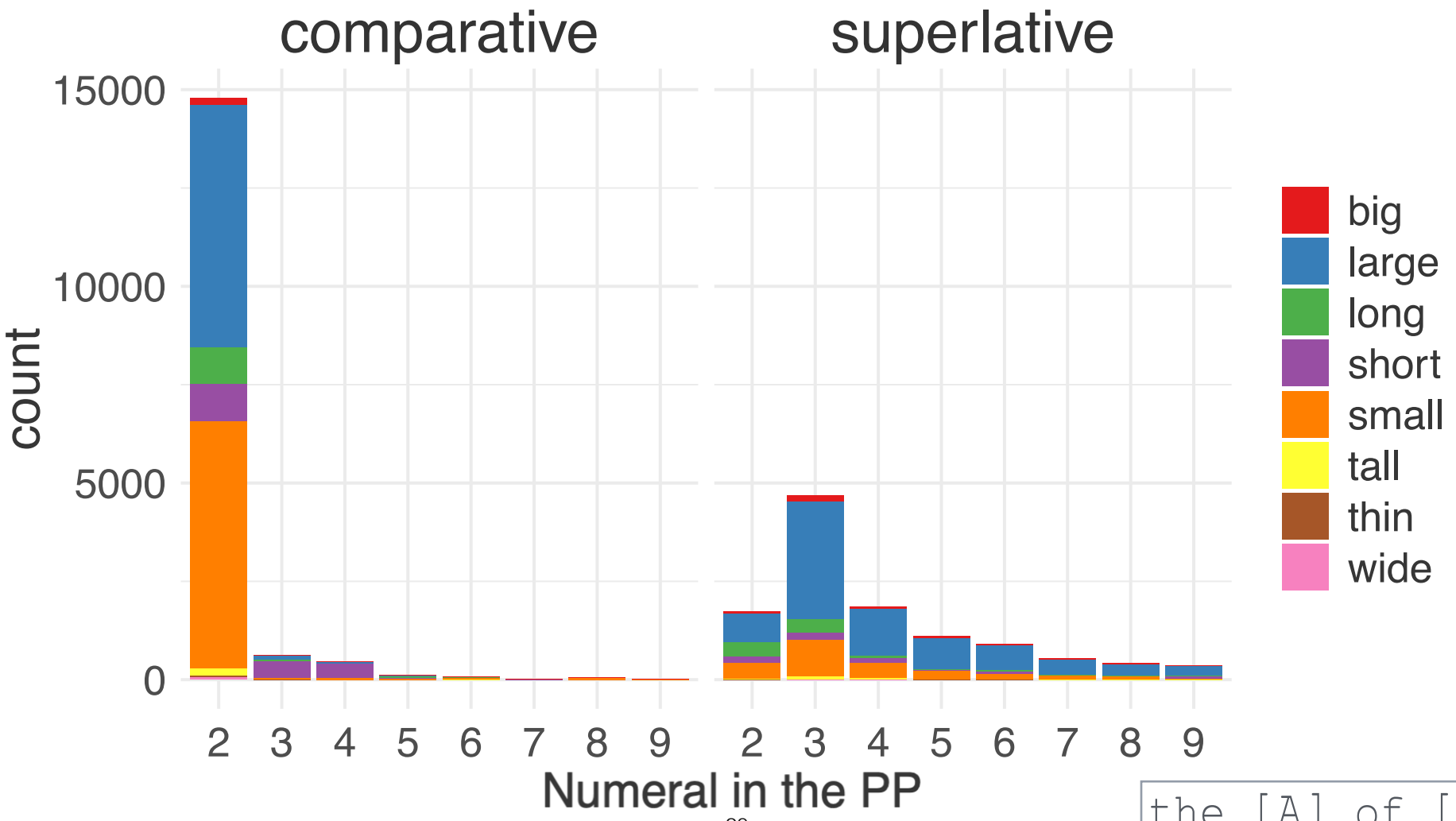


Query:

`the [A] of [Num]`

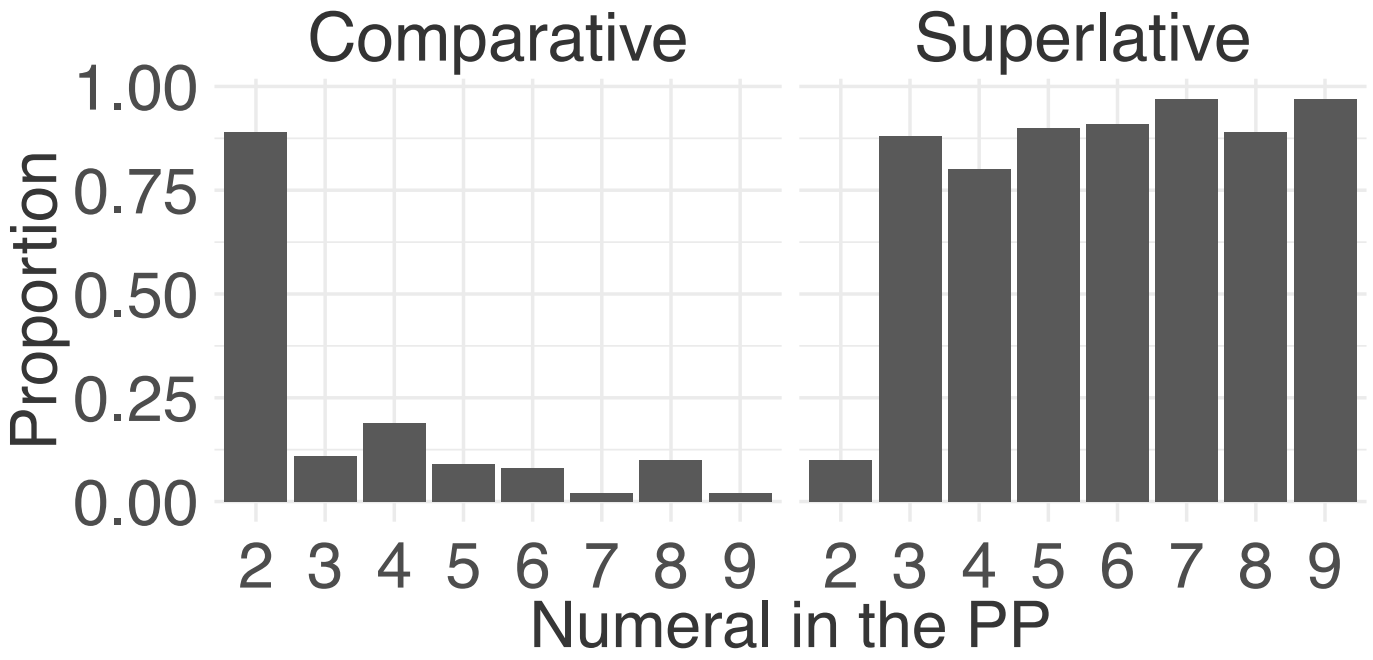
e.g., ‘the smaller of two’

Internet Archive Corpus (English)


comparative
superlative
15000
10000
5000
0
count
2 3 4 5 6 7 8 9
2 3 4 5 6 7 8 9
Numeral in the PP
big
large
long
short
small
tall
thin
wide

the [A] of [Num]

Corpus Data


Comparative
Superlative
1.00
0.75
0.50
0.25
0.00
Proportion
2 3 4 5 6 7 8 9
2 3 4 5 6 7 8 9
Numeral in the PP

Question

What constraints Comparison Class calculation of a definite comparative?

2 Individuals (2I) Theory

(1) $[\![\text{-}er]\!] = \lambda C_{\langle e,t\rangle} \lambda A_{\langle d,\langle e,t\rangle\rangle} \lambda x_e$:

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$$\exists x' \in C : max\{d|A(d)(x)\} > max\{d|A(d)(x')\}$$

2 Individuals (2I) Theory

(1) $[\![\text{-}er]\!] = \lambda C_{\langle e,t\rangle} \lambda A_{\langle d,\langle e,t\rangle\rangle} \lambda x_e : x \in C \wedge |C| = 2\,.$

$$\exists x' \in C : max\{d|A(d)(x)\} > max\{d|A(d)(x')\}$$

2 Degrees (2D) Theory

(2) $[\![\text{-}er]\!]^{\gamma} = \lambda C_{\langle e,t\rangle} \lambda A_{\langle d,\langle e,t\rangle\rangle} \lambda x_e : x \in C \wedge |\gamma_{A,C}| = 2\,.$

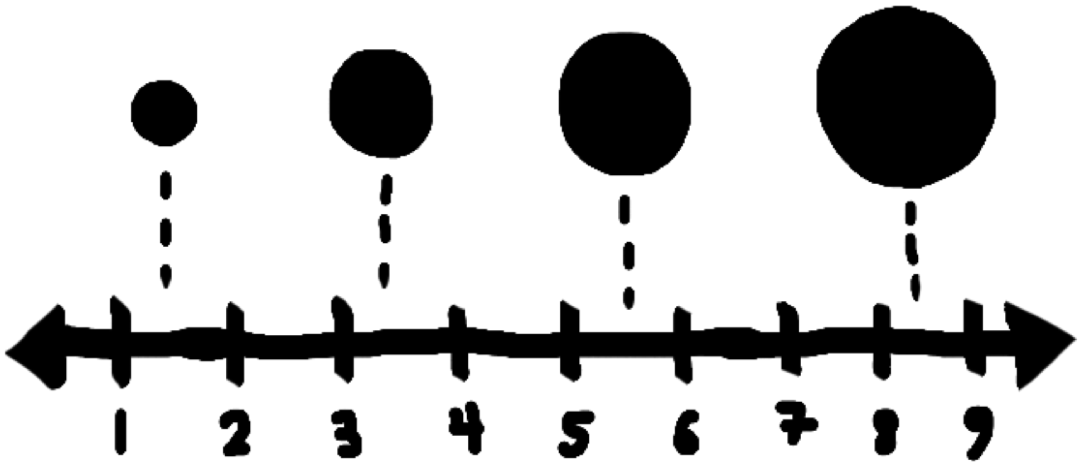
$$\exists d' \in \gamma_{A,C} : max\{d \in \gamma_{A,C} | A(d)(x)\} > d'$$

γ_A is a set of degrees of A-ness (a granularity of the A-scale)

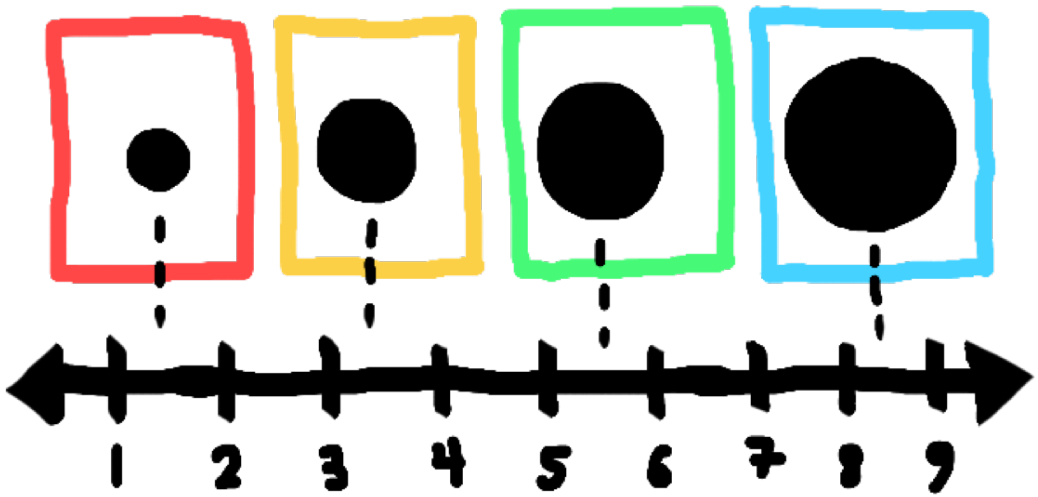
$$\gamma_{A,C} = \{d \in \gamma_A : \exists x \in C : \max\{d' \in \gamma_A | A(d')(x)\} = d\}$$

Krifka (2007)

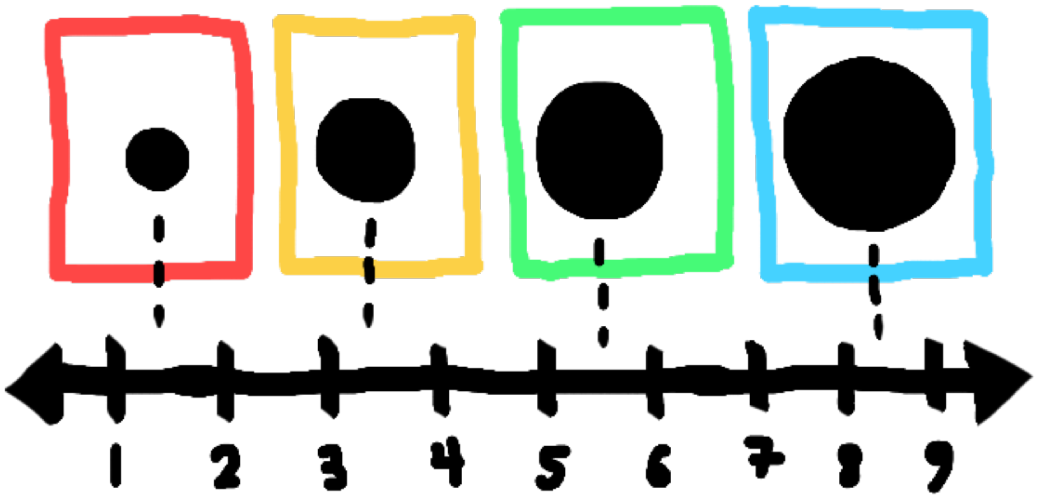
Granularity



Granularity

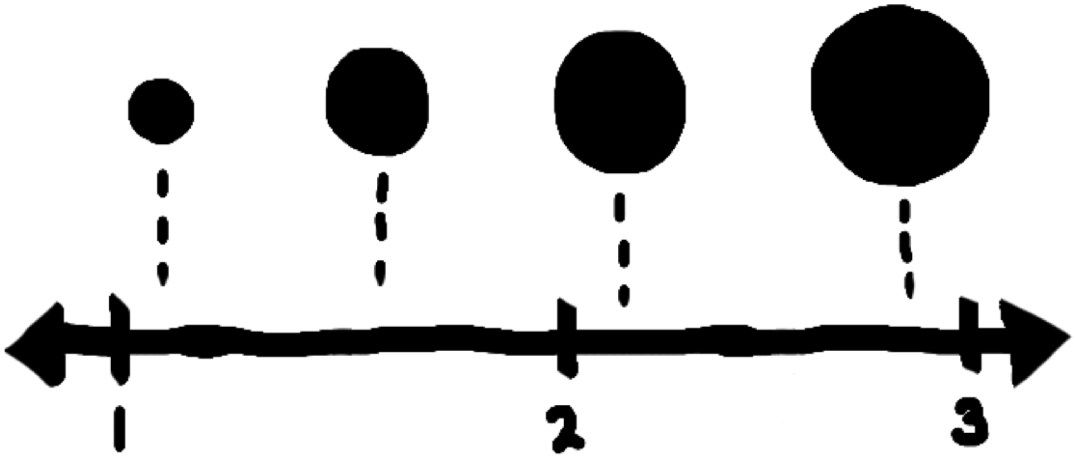


Granularity

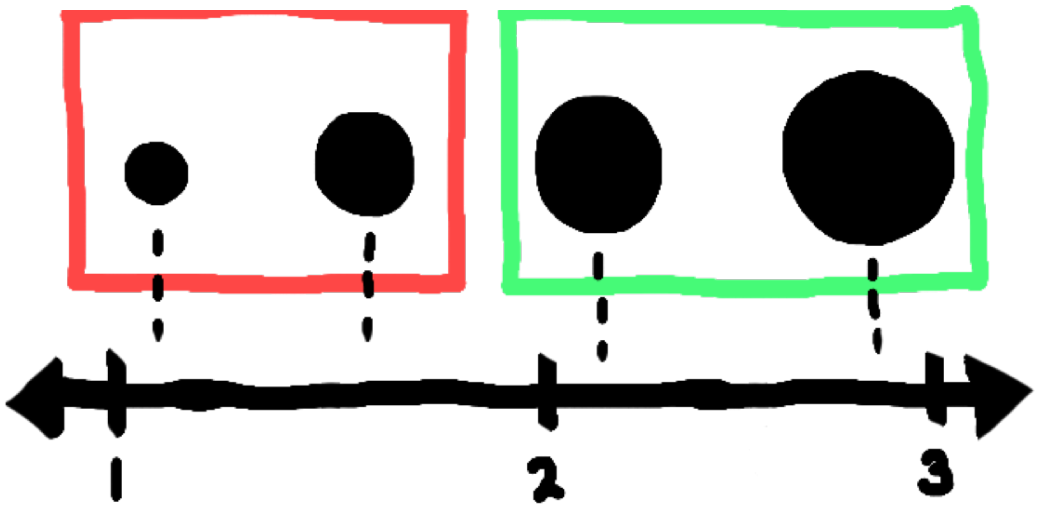


$|\gamma_{A,C}| = 2$

Granularity



Granularity

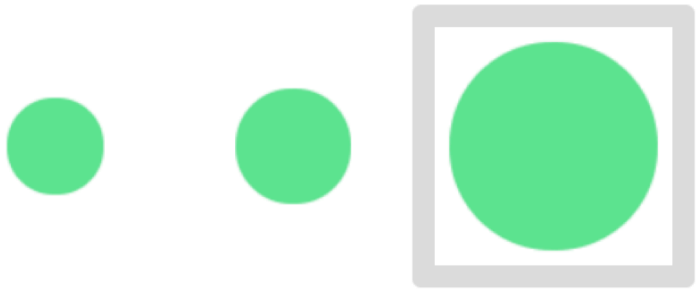


$|\gamma_{A,C}| = 2$

The Experiment

Experimental Task

This is the biggest circle.



How acceptable is the above description of the scene?

	1	2	3	4	5	**6**	7	
(Bad)	○	○	○	○	○	●	○	(Good)

Back *Next*

Study Design

comp & super

comp & super

Study Design

	comp & super	comp & super
card. 2		
card. 3		
card. 4		

Study Design

comp & super

comp & super

card. 2

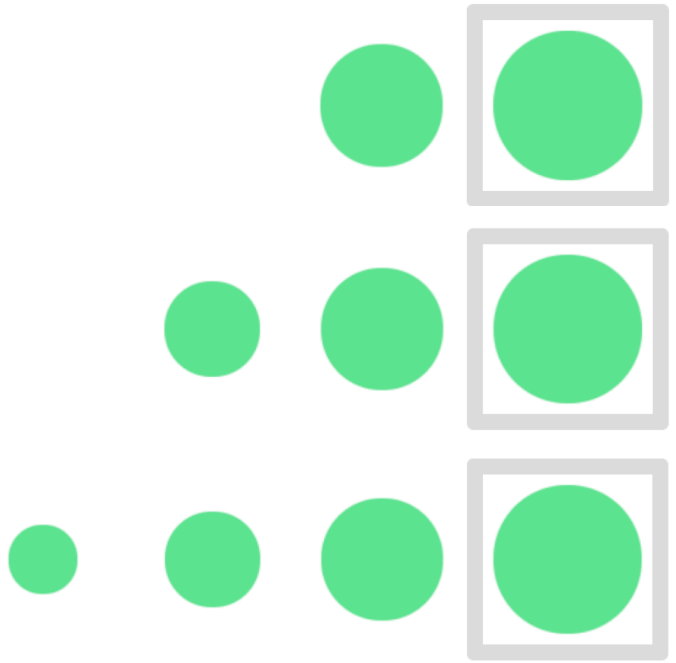
card. 3

card. 4

progressive

Study Design

	comp & super	comp & super
card. 2		
card. 3		
card. 4		



progressive

Study Design

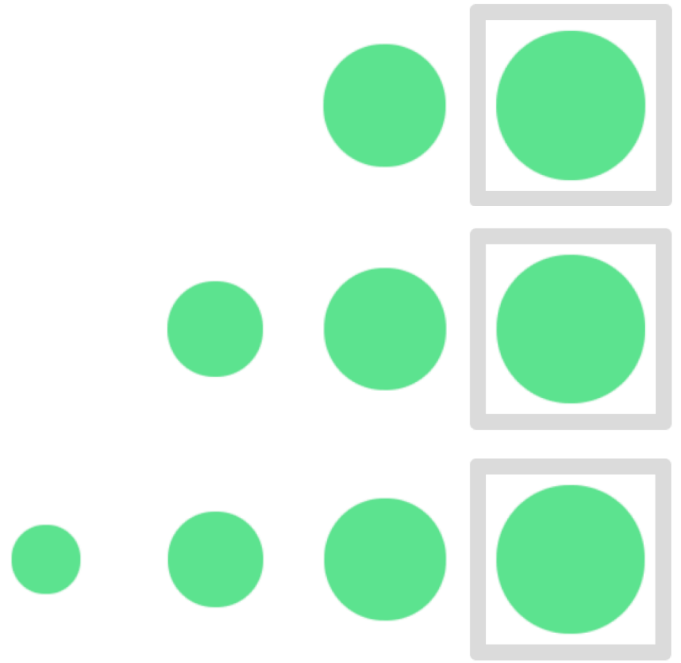
comp & super

comp & super

card. 2

card. 3

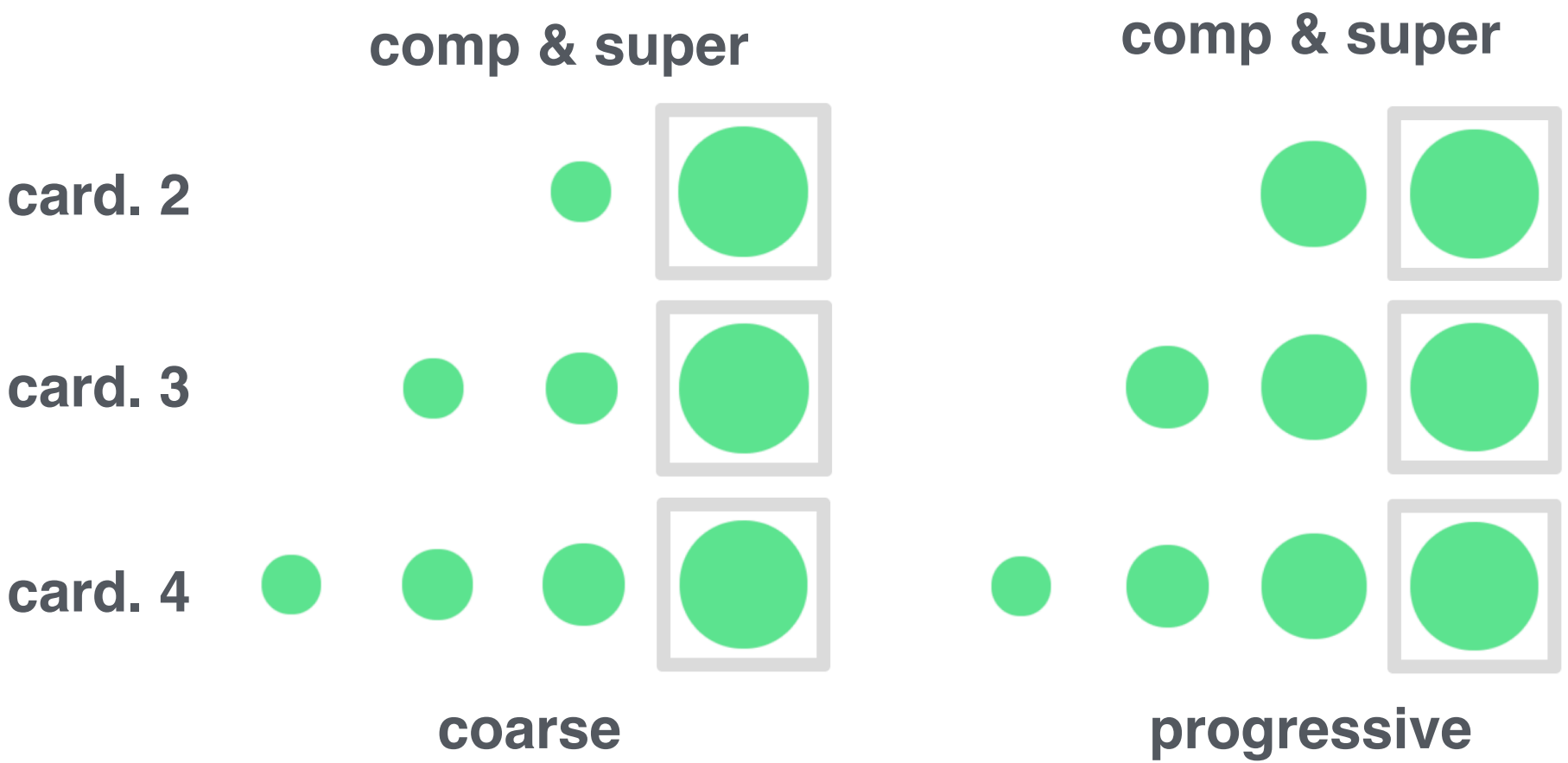
card. 4



coarse

progressive

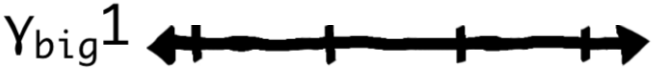
Study Design



Linking Function

Acceptability of a description is modulated by its reference failure potential

Linking Function



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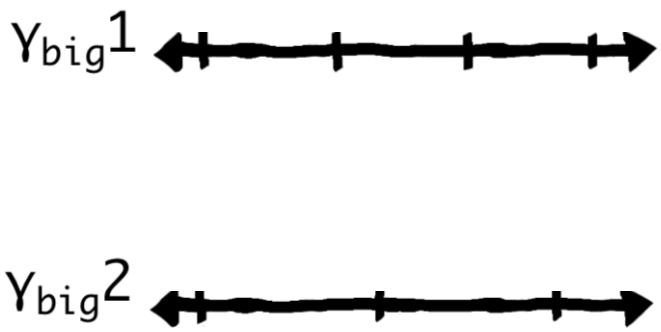

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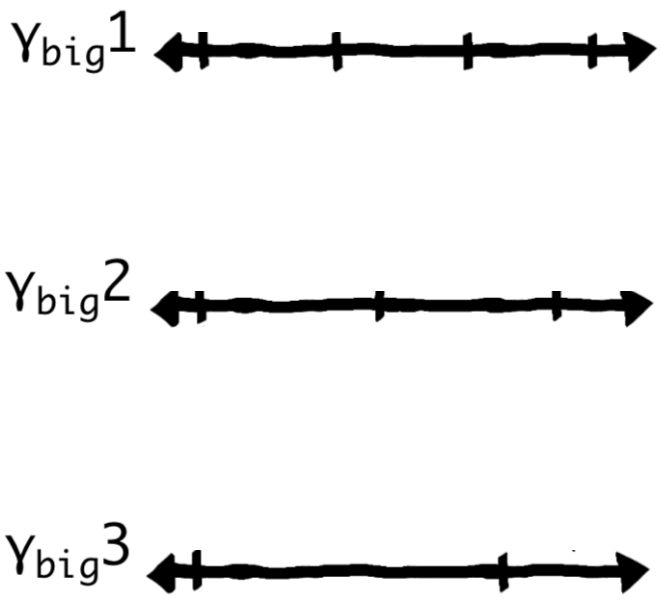

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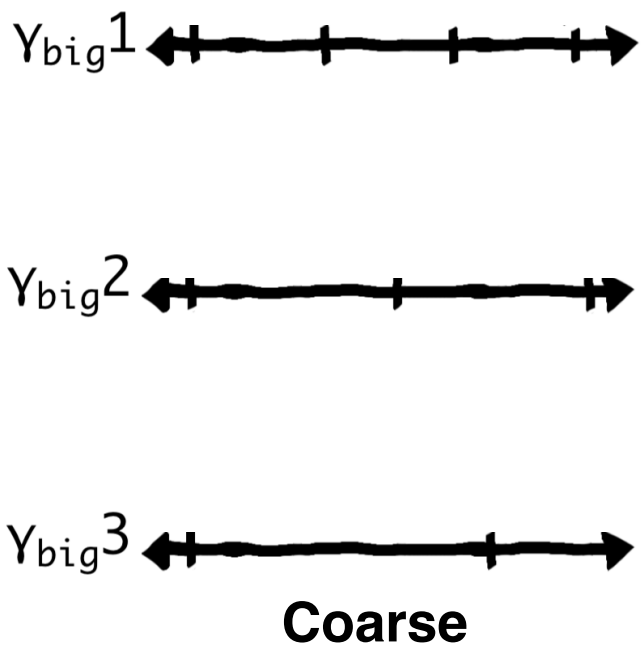

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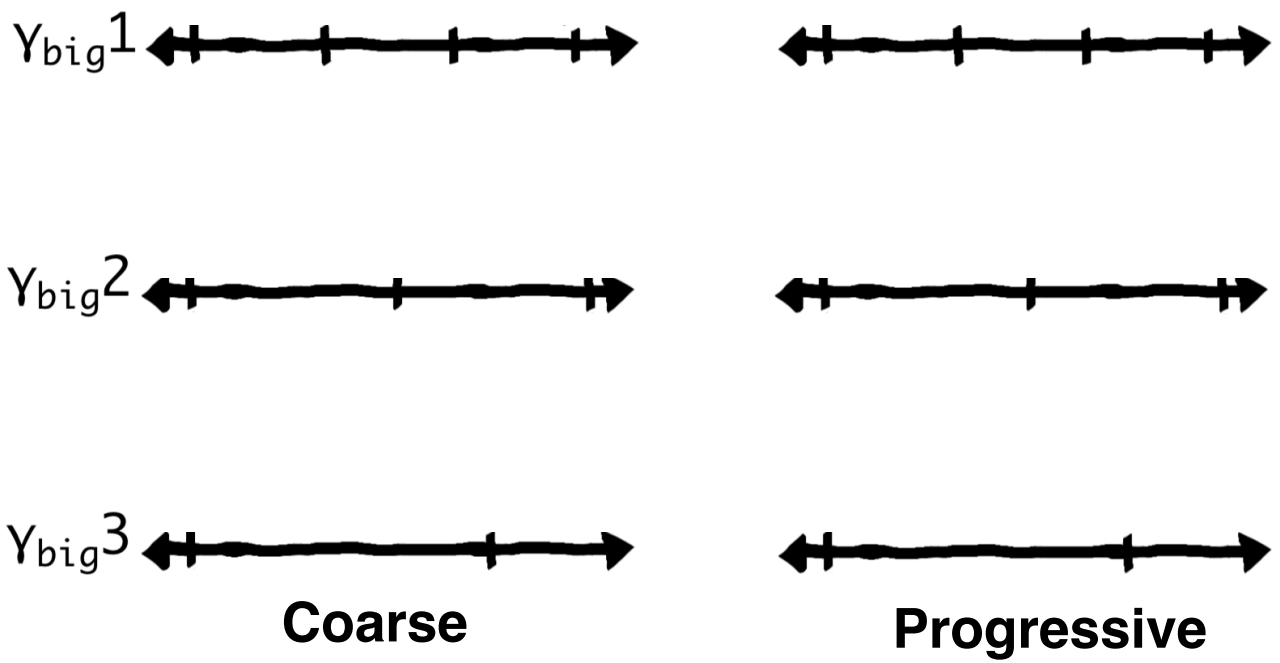

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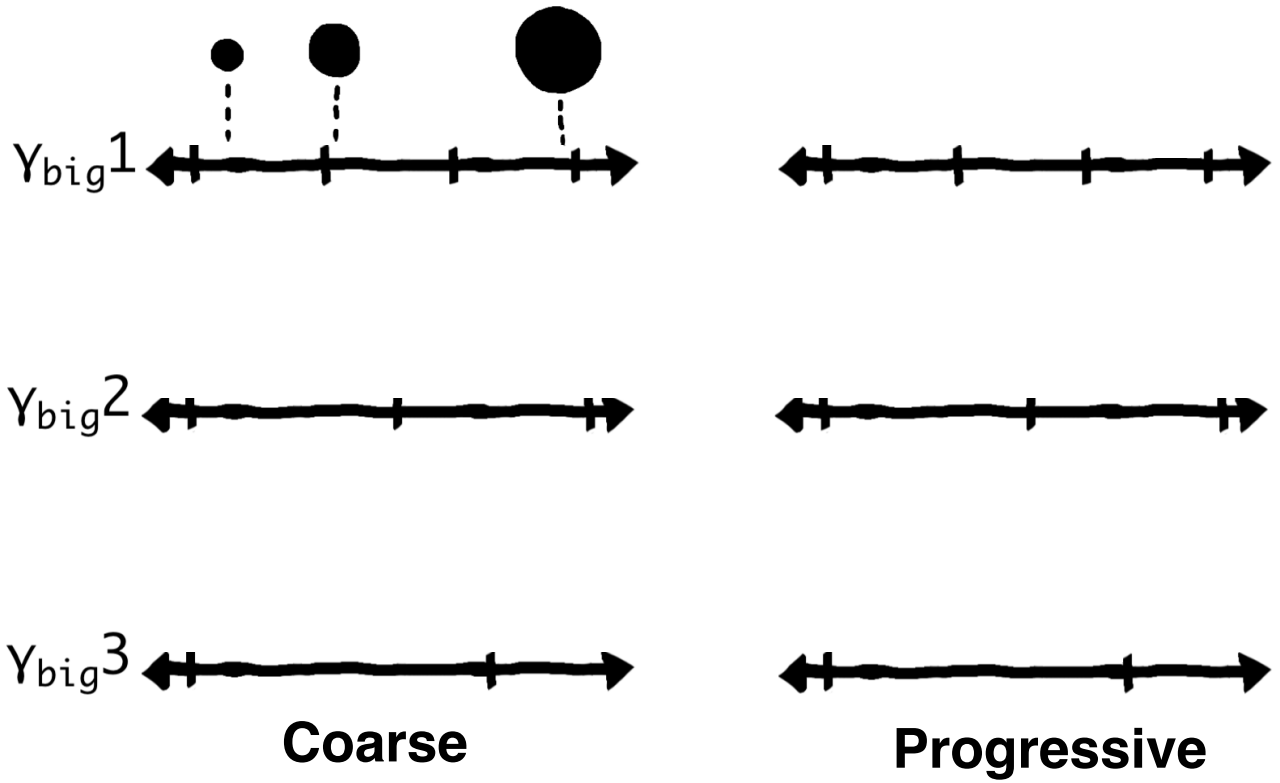

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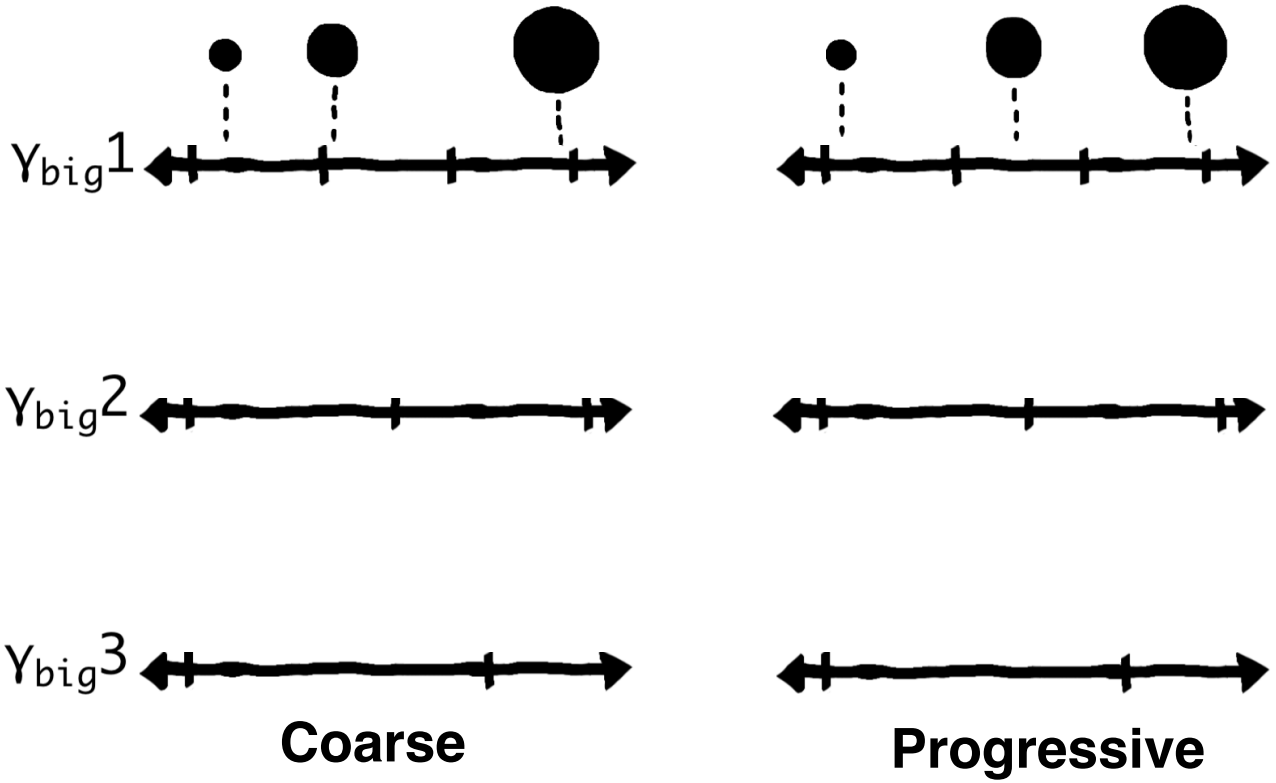

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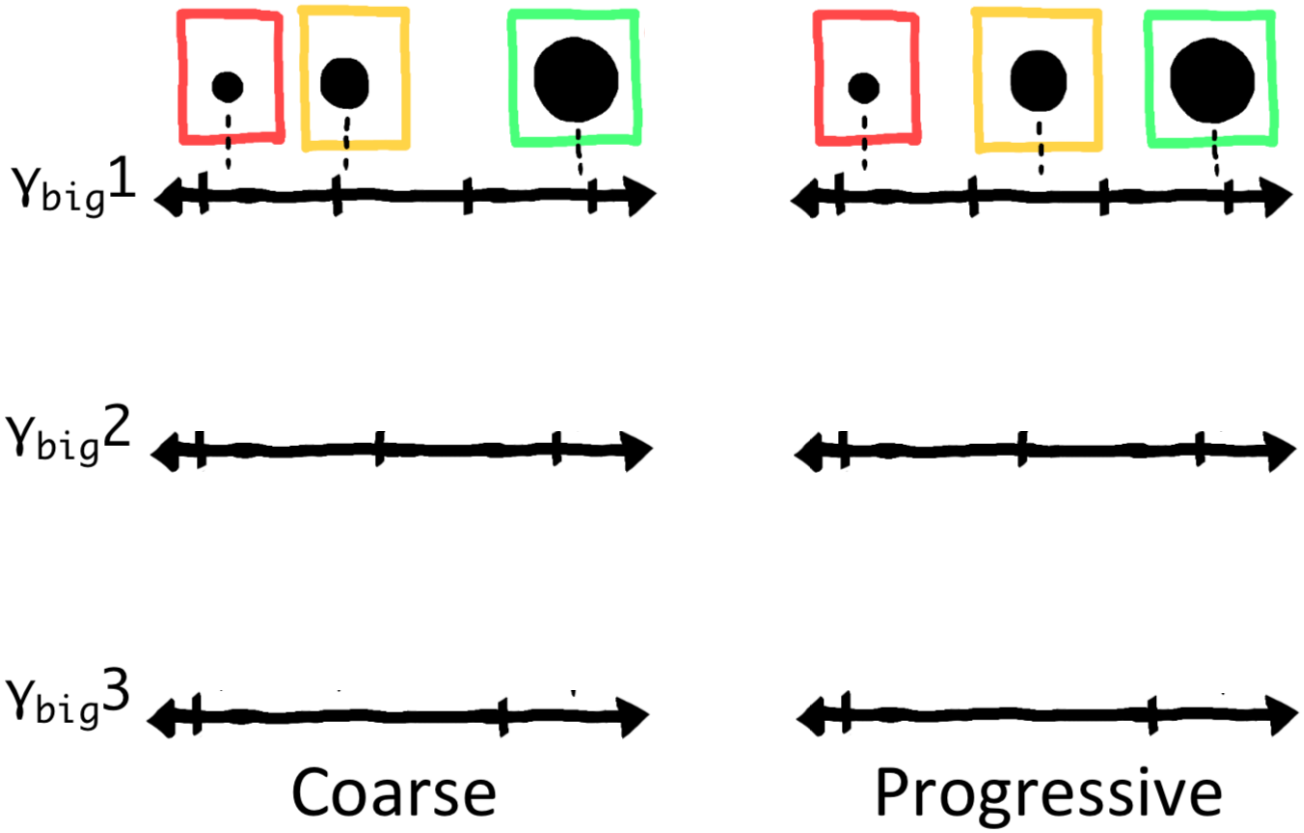

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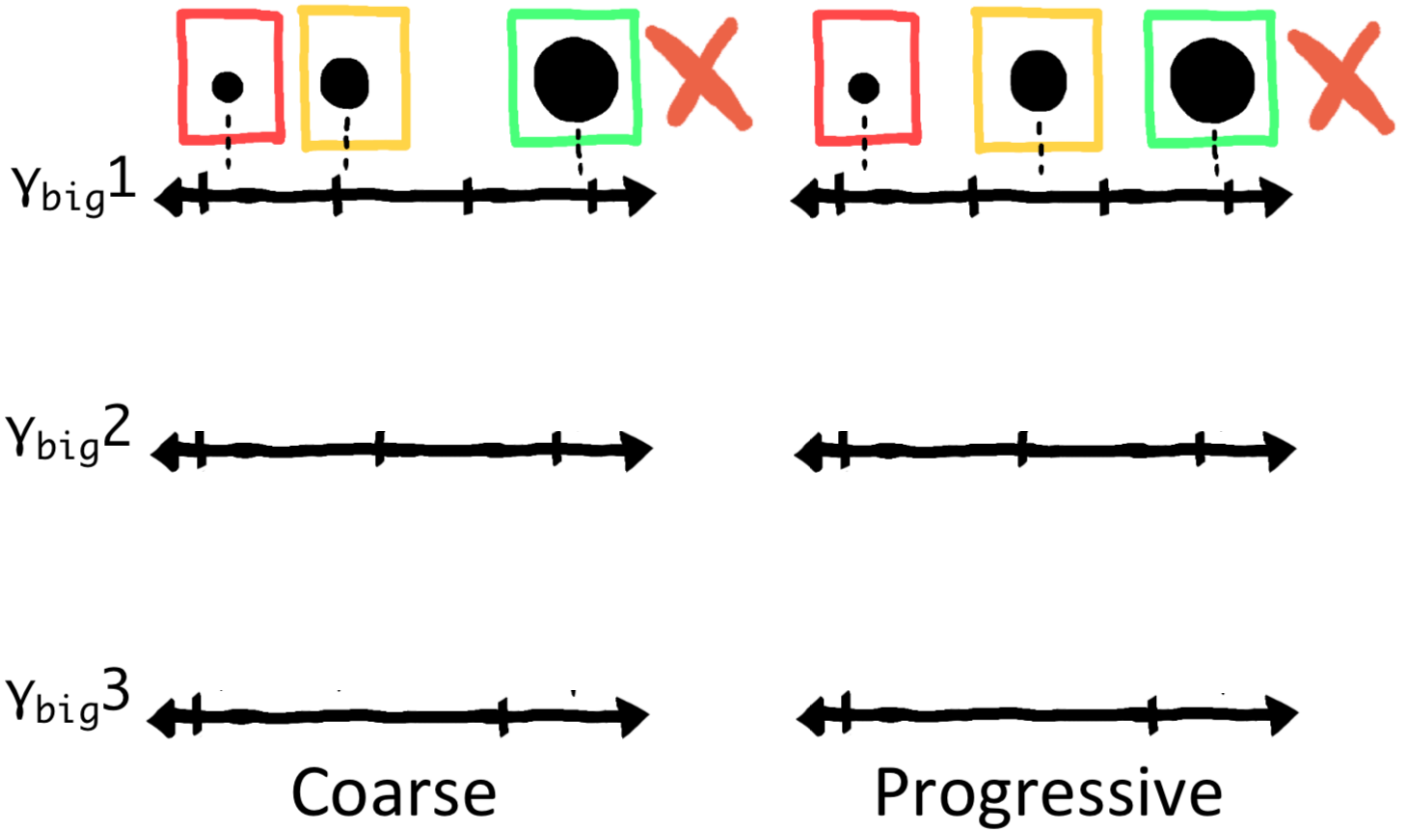

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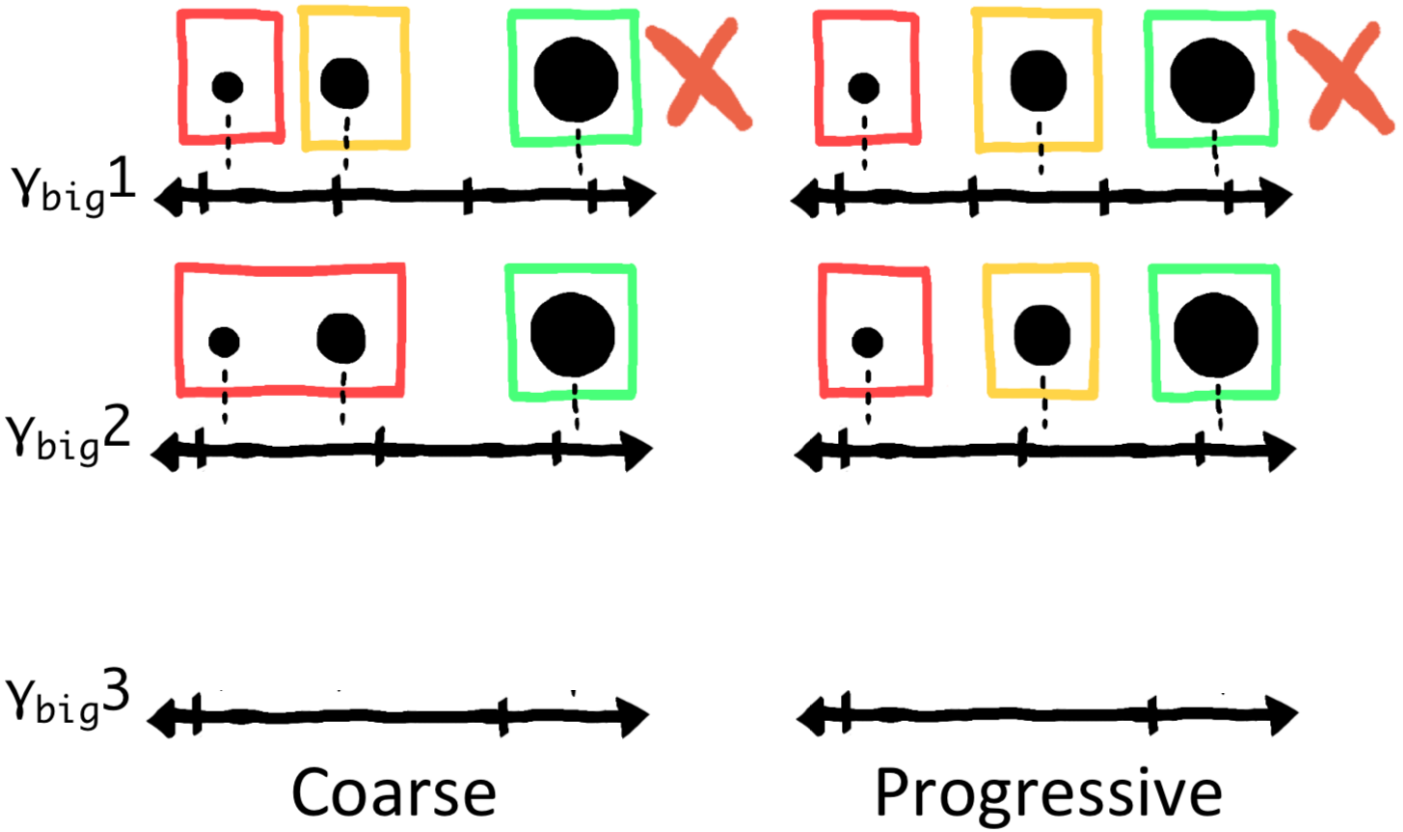

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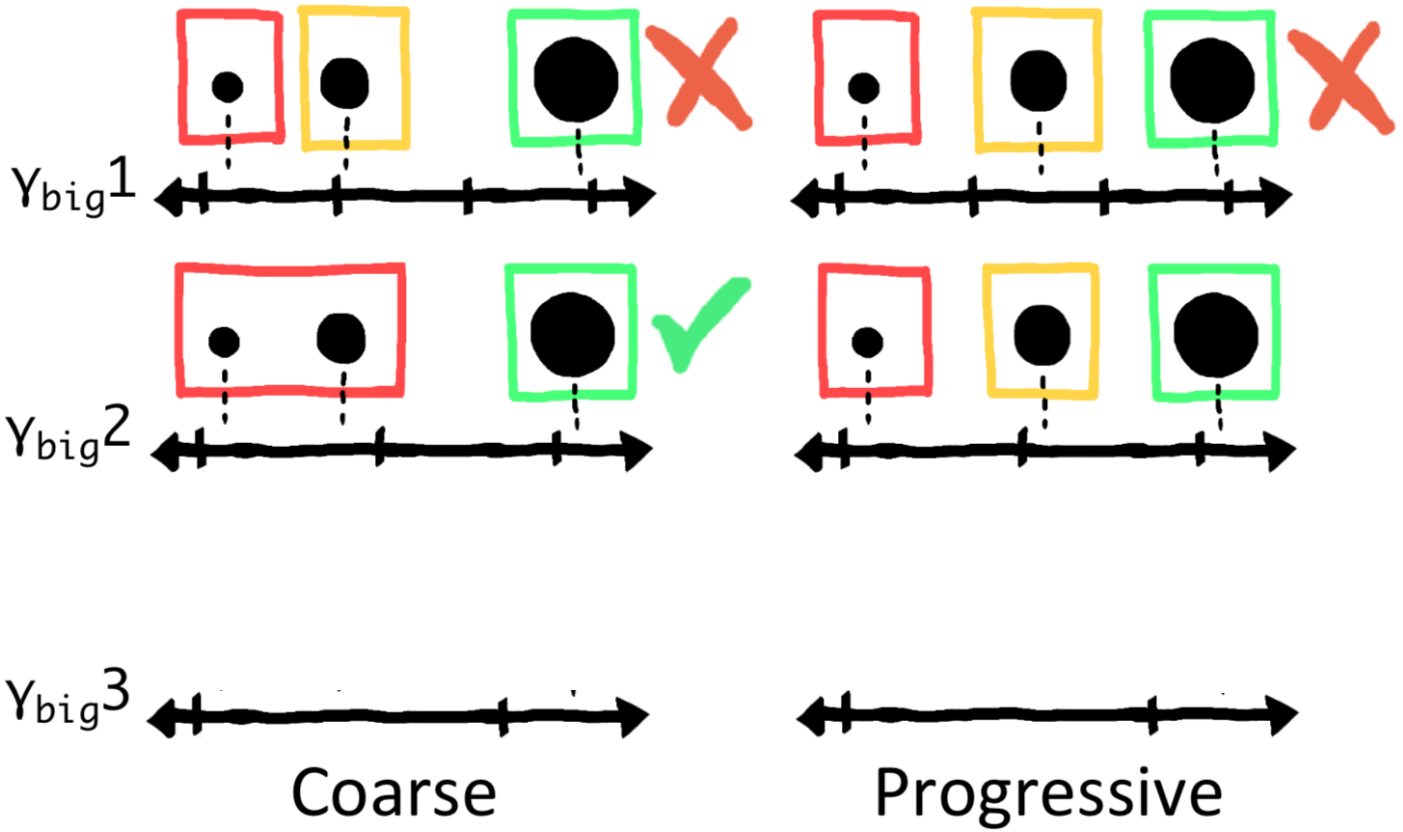

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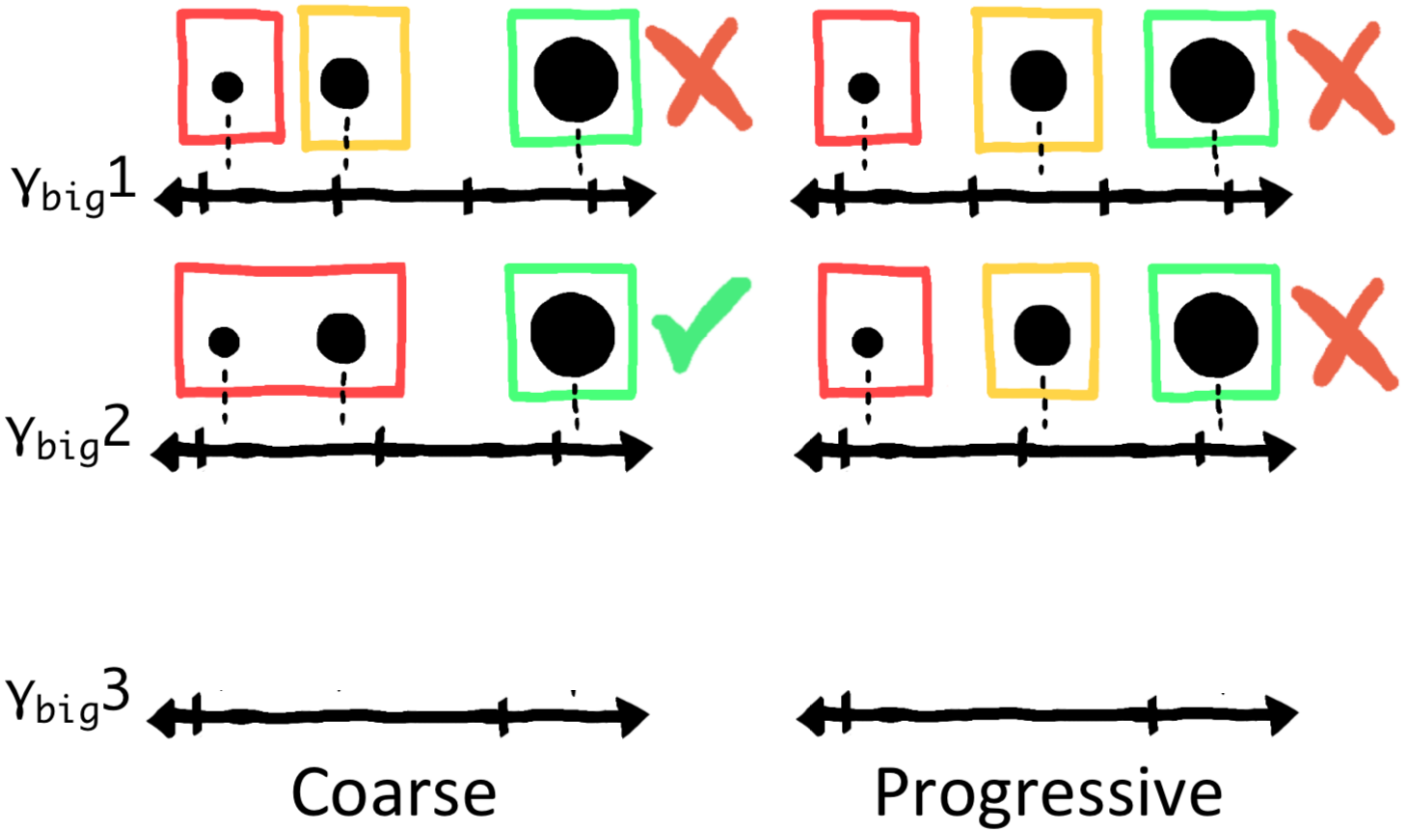

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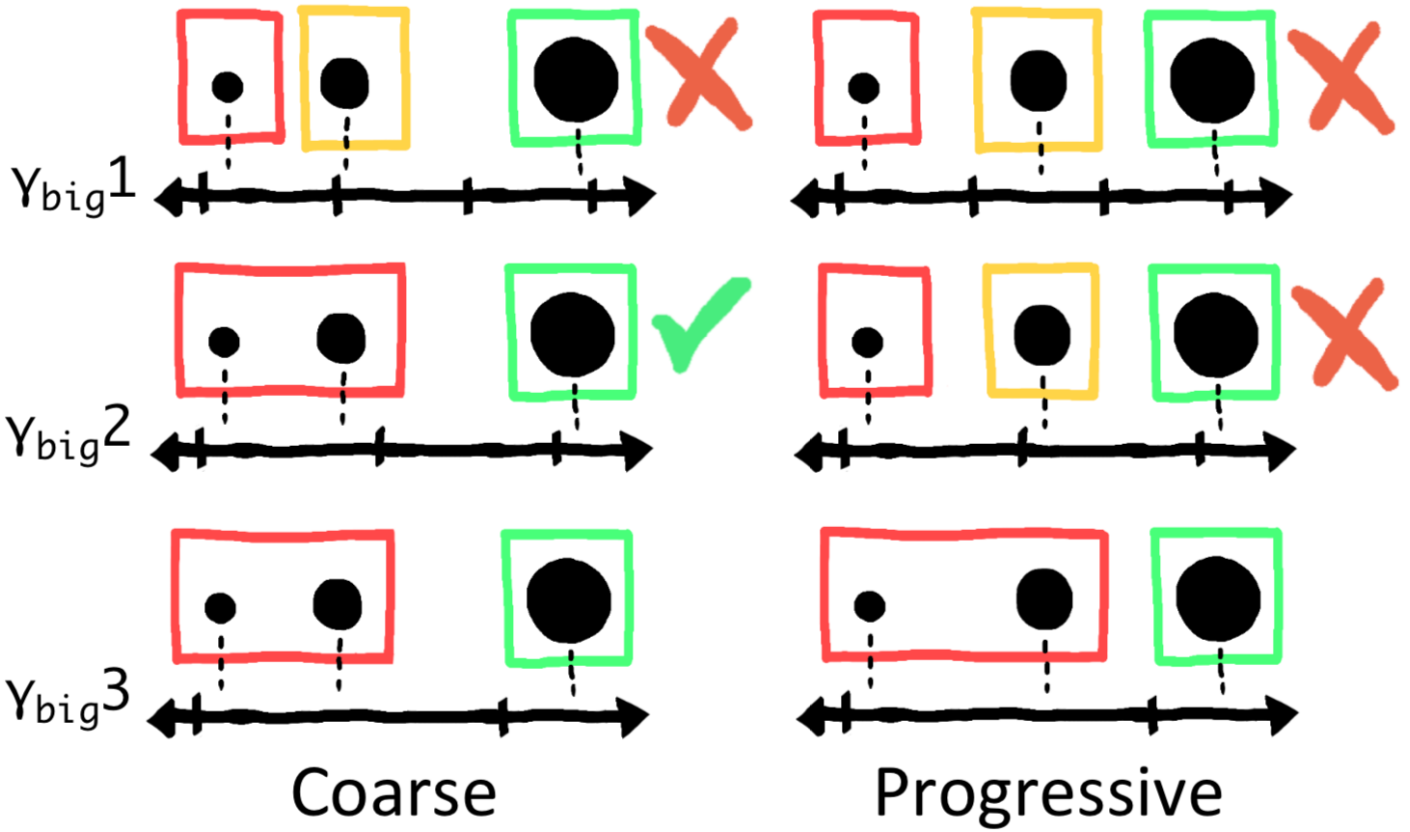

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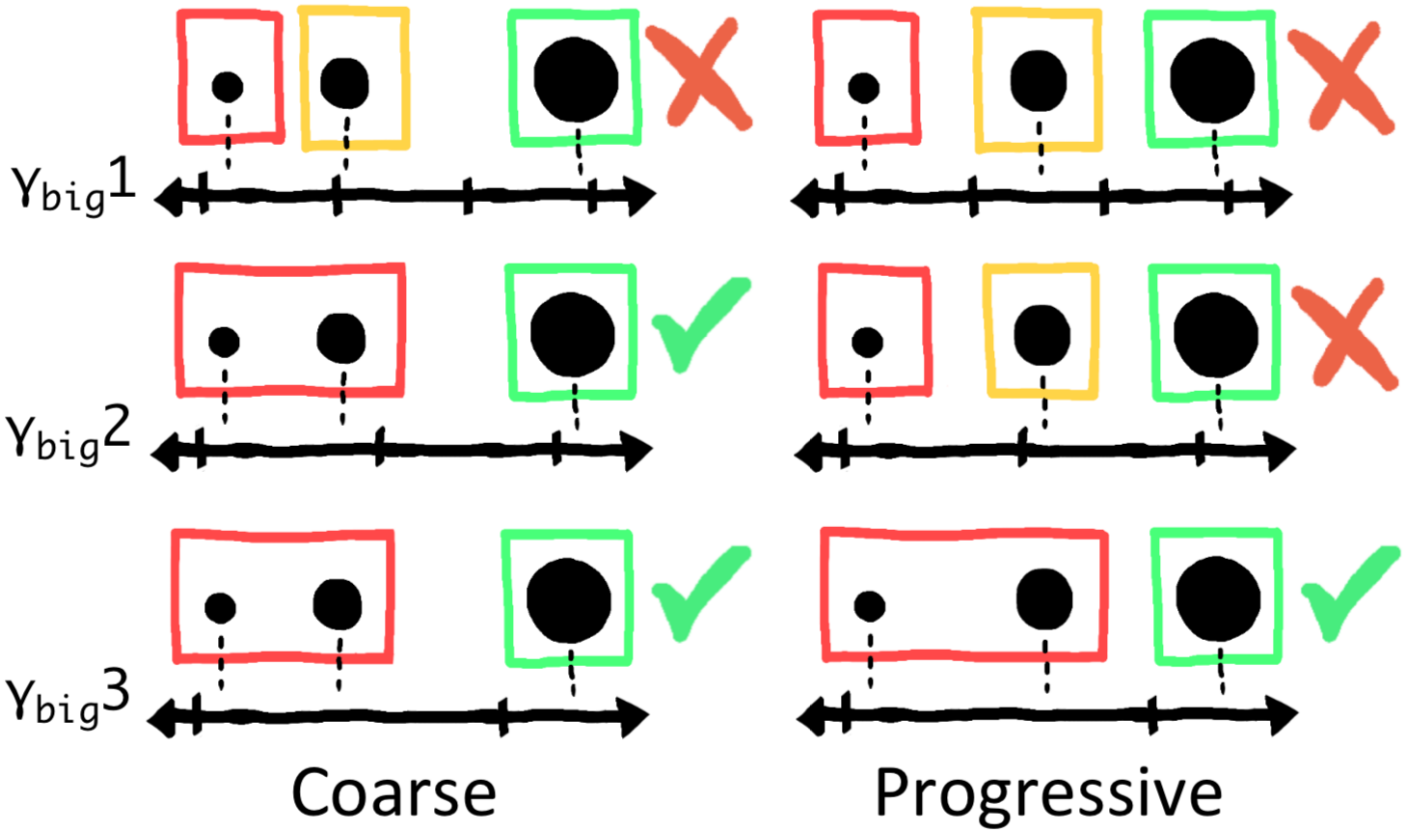

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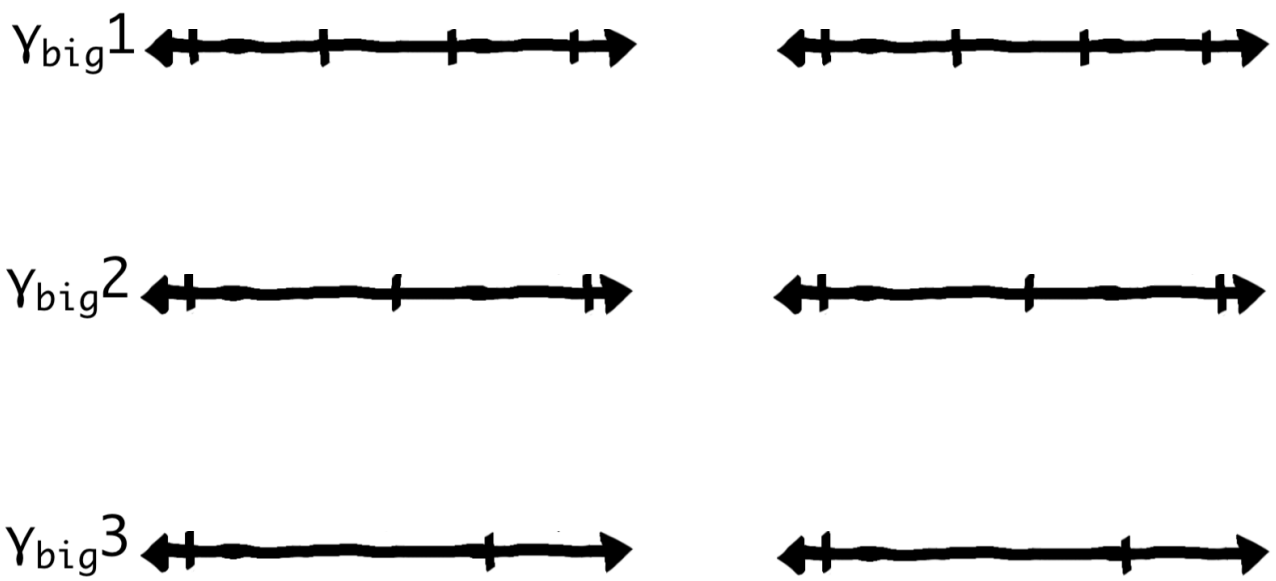

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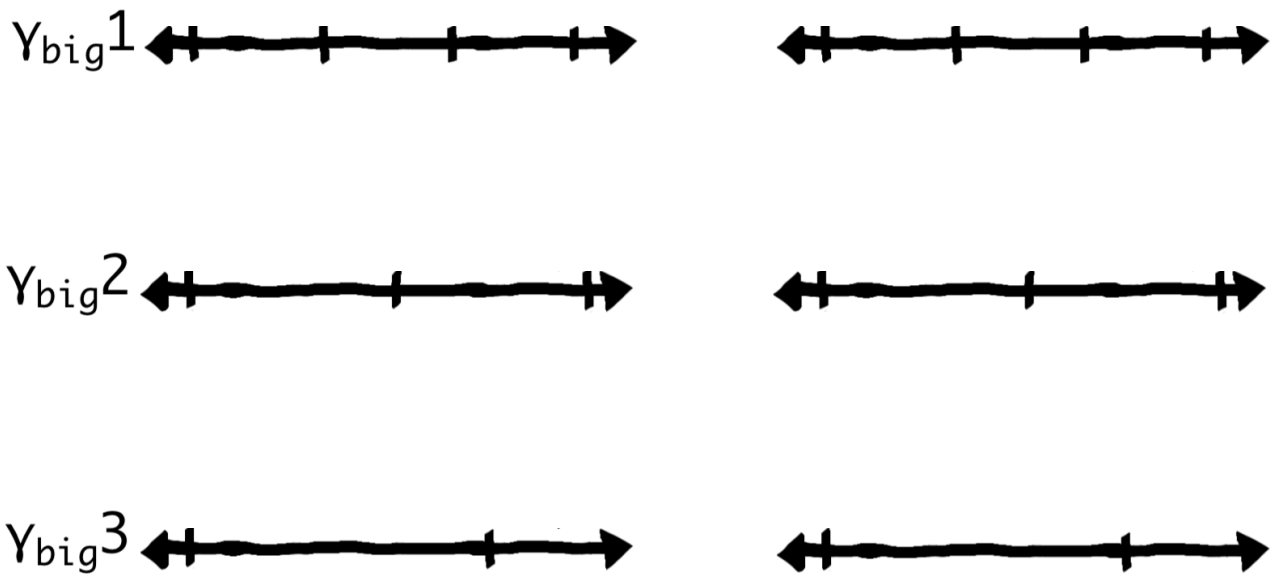
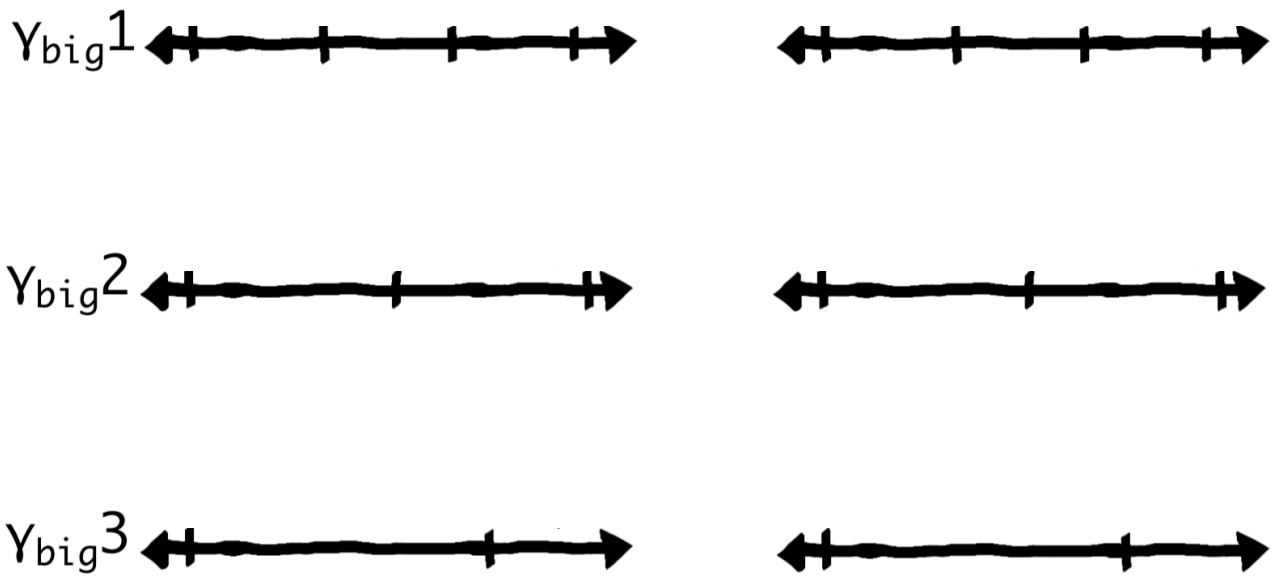


Progressive Card. 3

Linking Function



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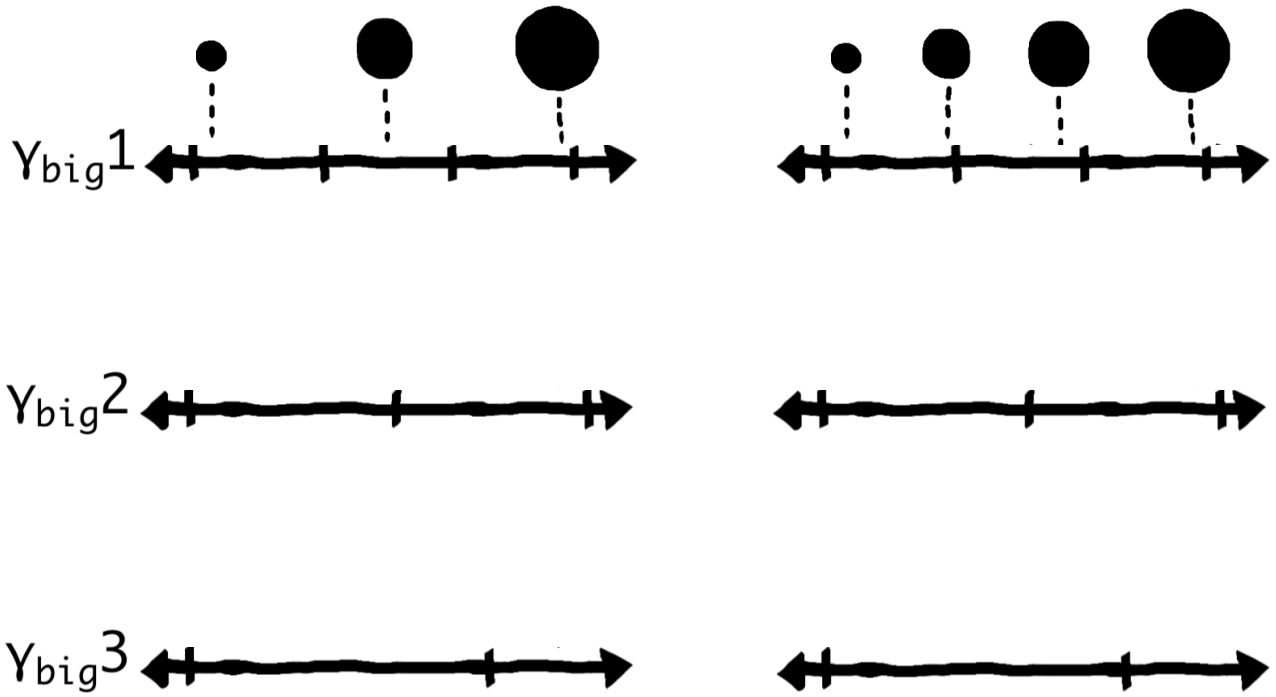
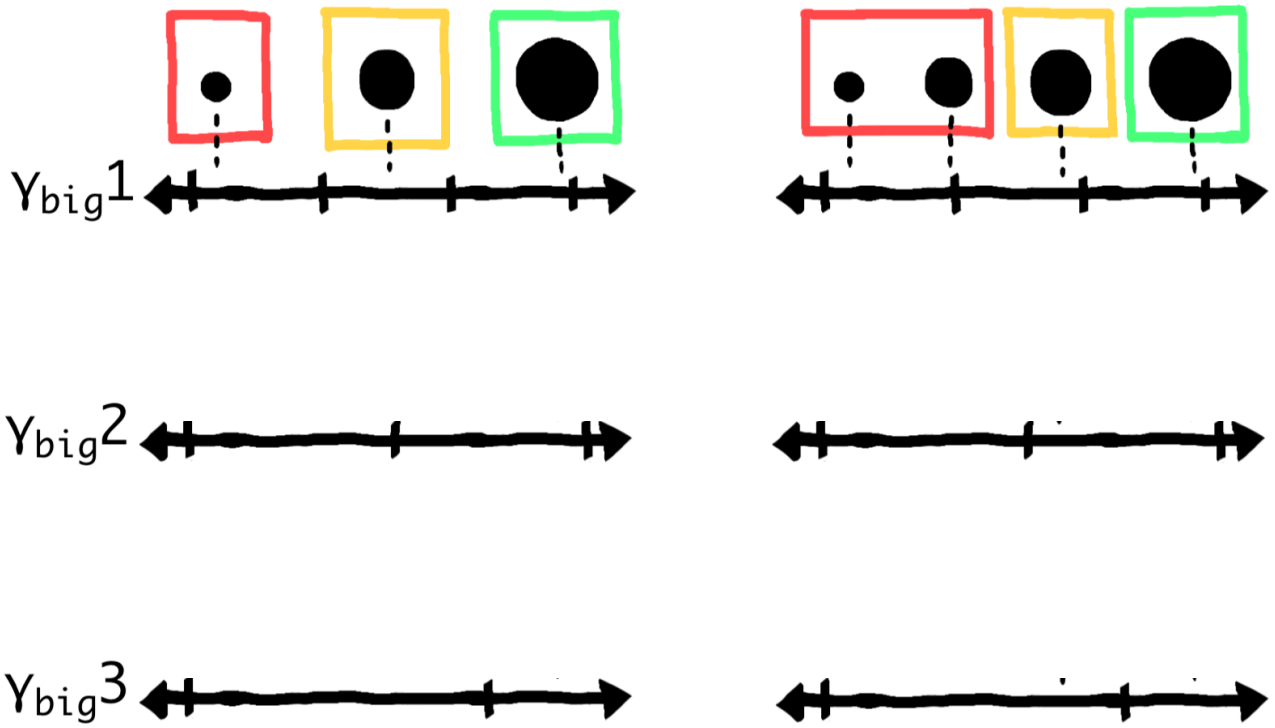


Progressive Card. 3

Progressive Card. 4

Linking Function



Progressive Card. 3

Progressive Card. 4

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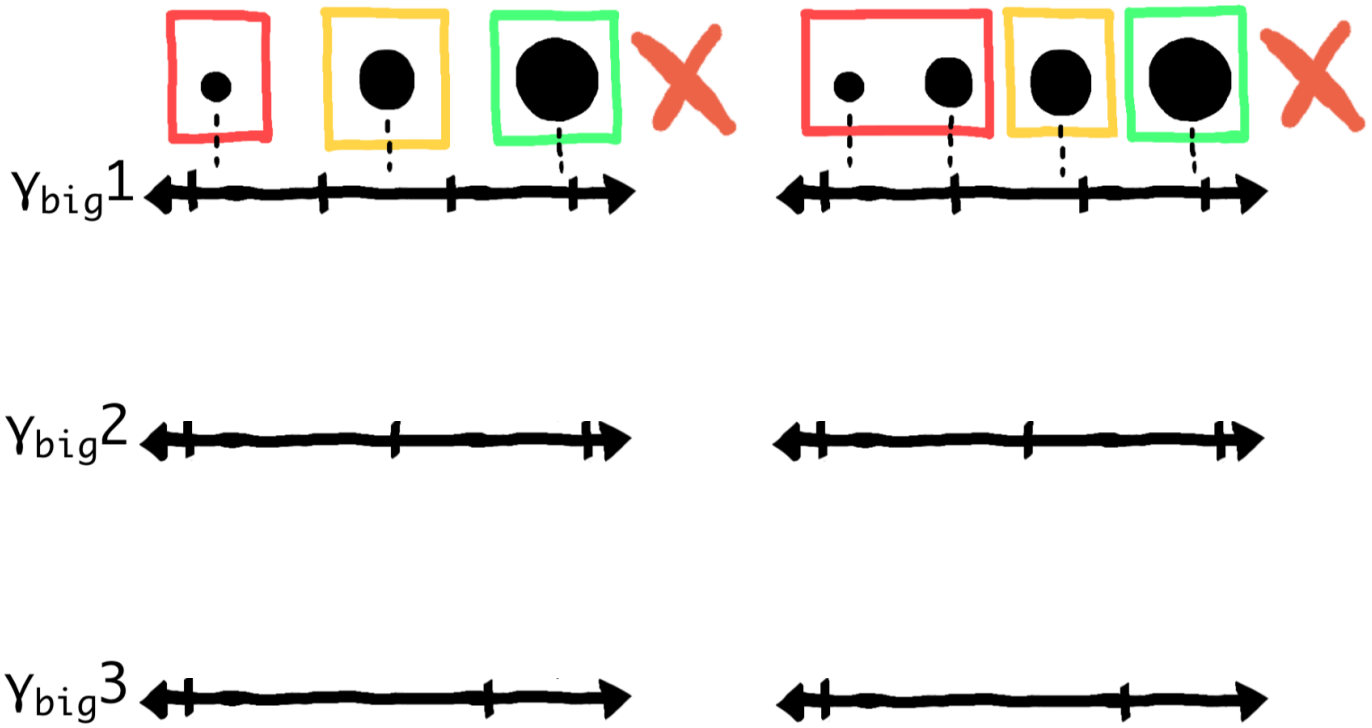

Progressive Card. 3

Progressive Card. 4

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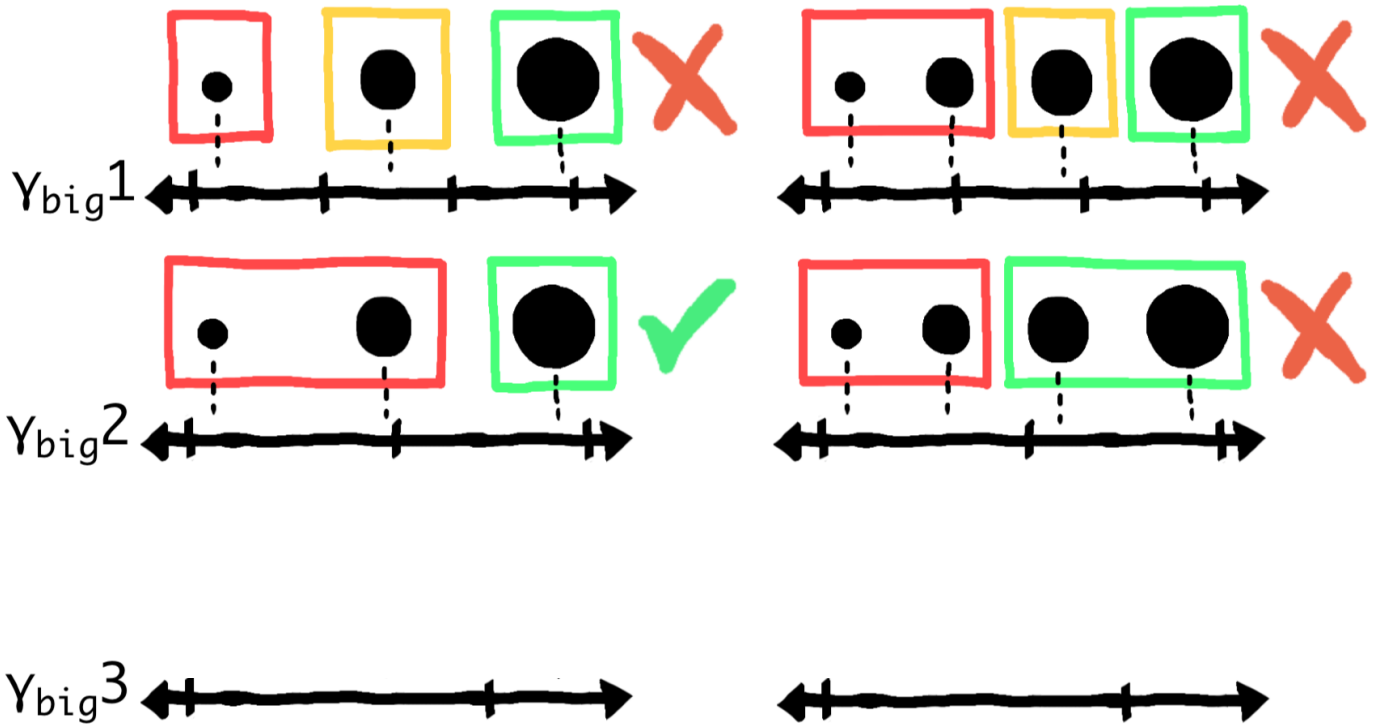

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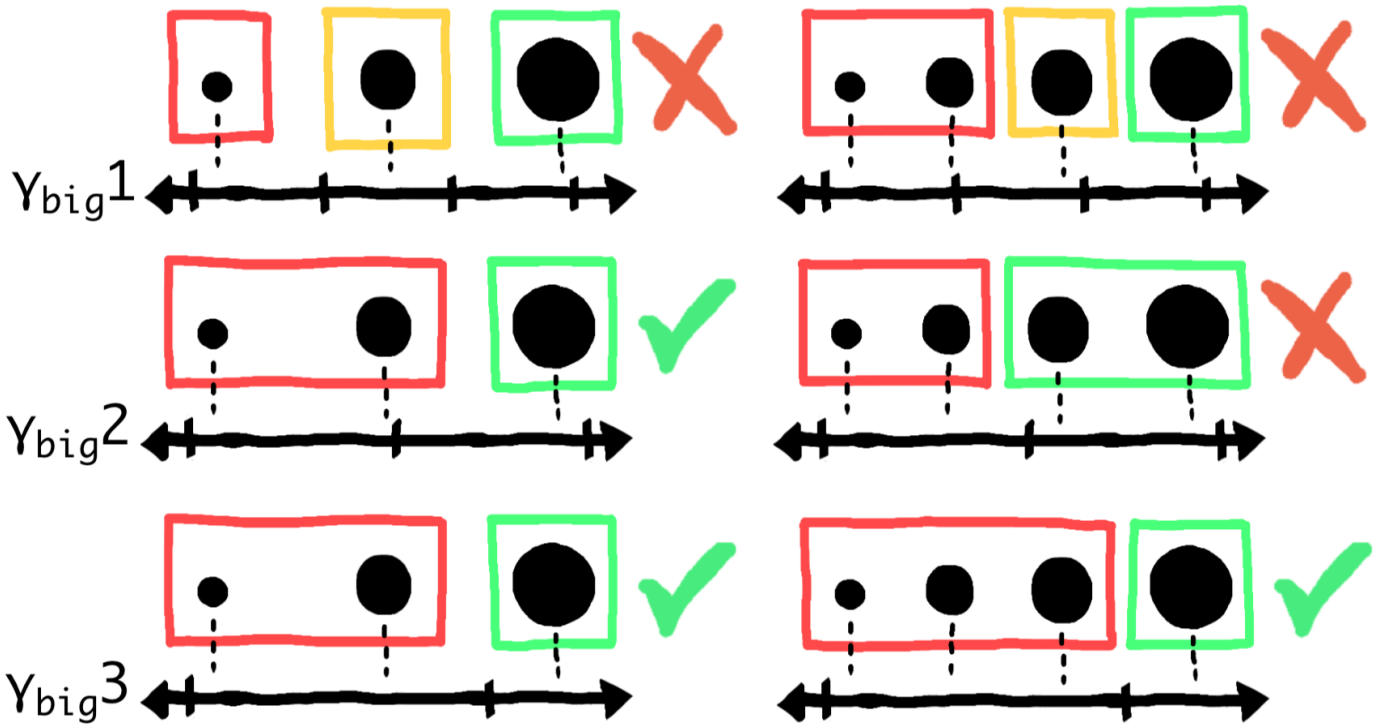


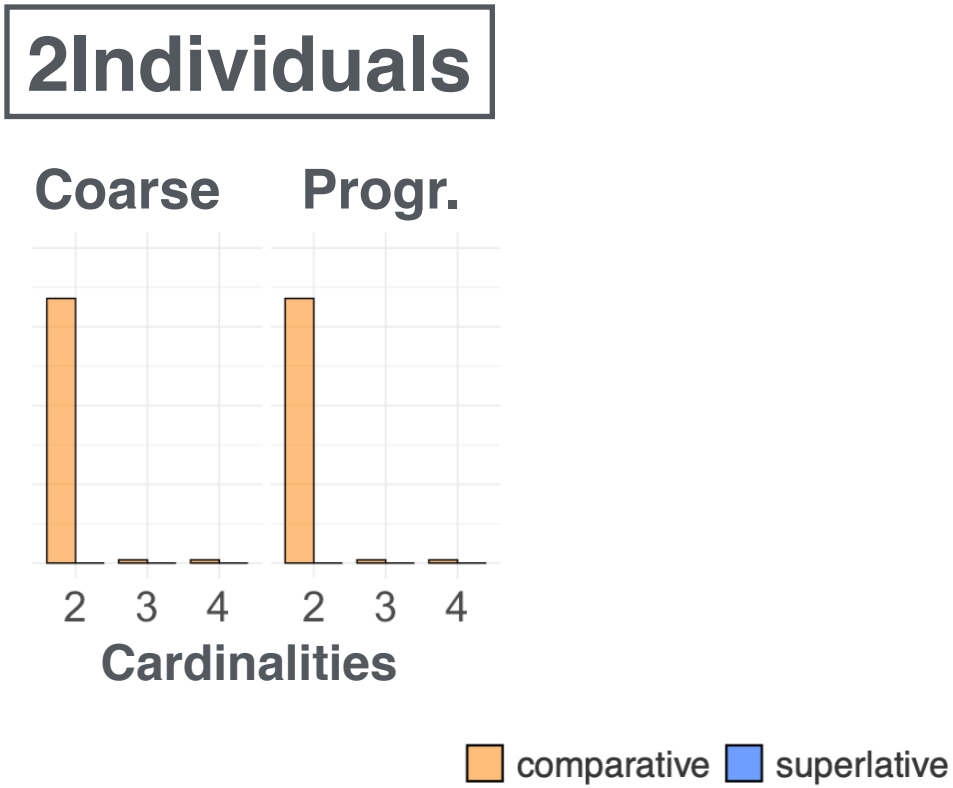
Progressive Card. 3

Progressive Card. 4

Qualitative Predictions

Predictions: Comparative

Predictions: Comparative

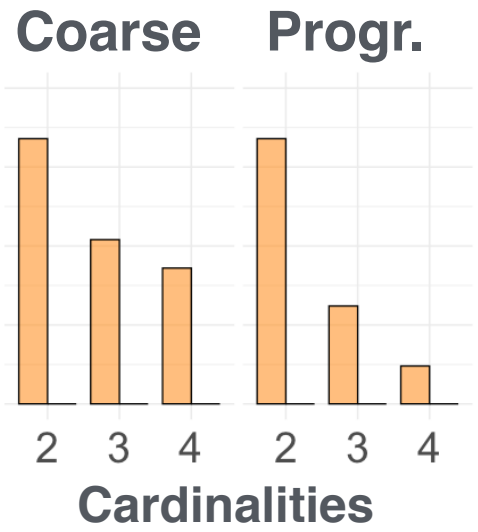


Predictions: Comparative

Predictions: Superlative

2Individuals

2Degrees

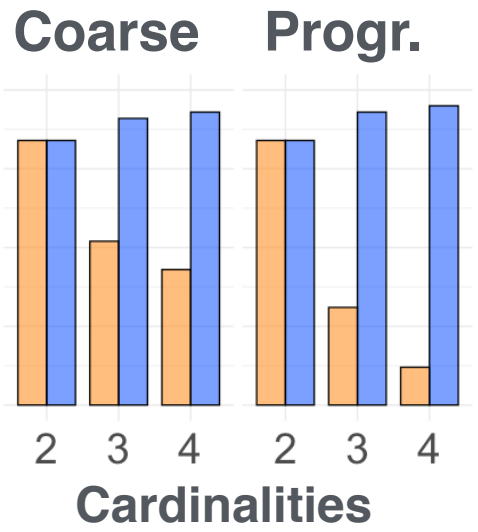


comparative superlative

Predictions: Superlative

2Individuals

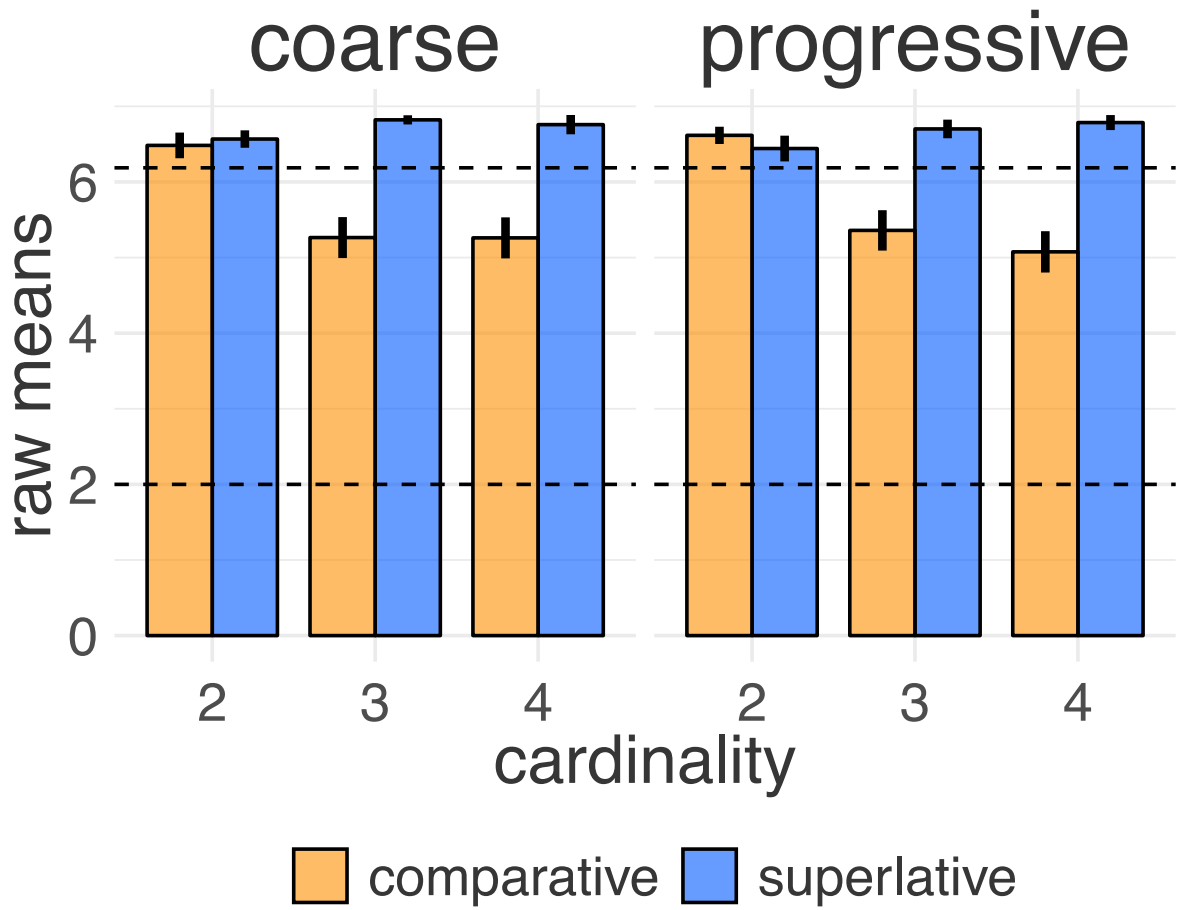
2Degrees



comparative superlative

Results

Results

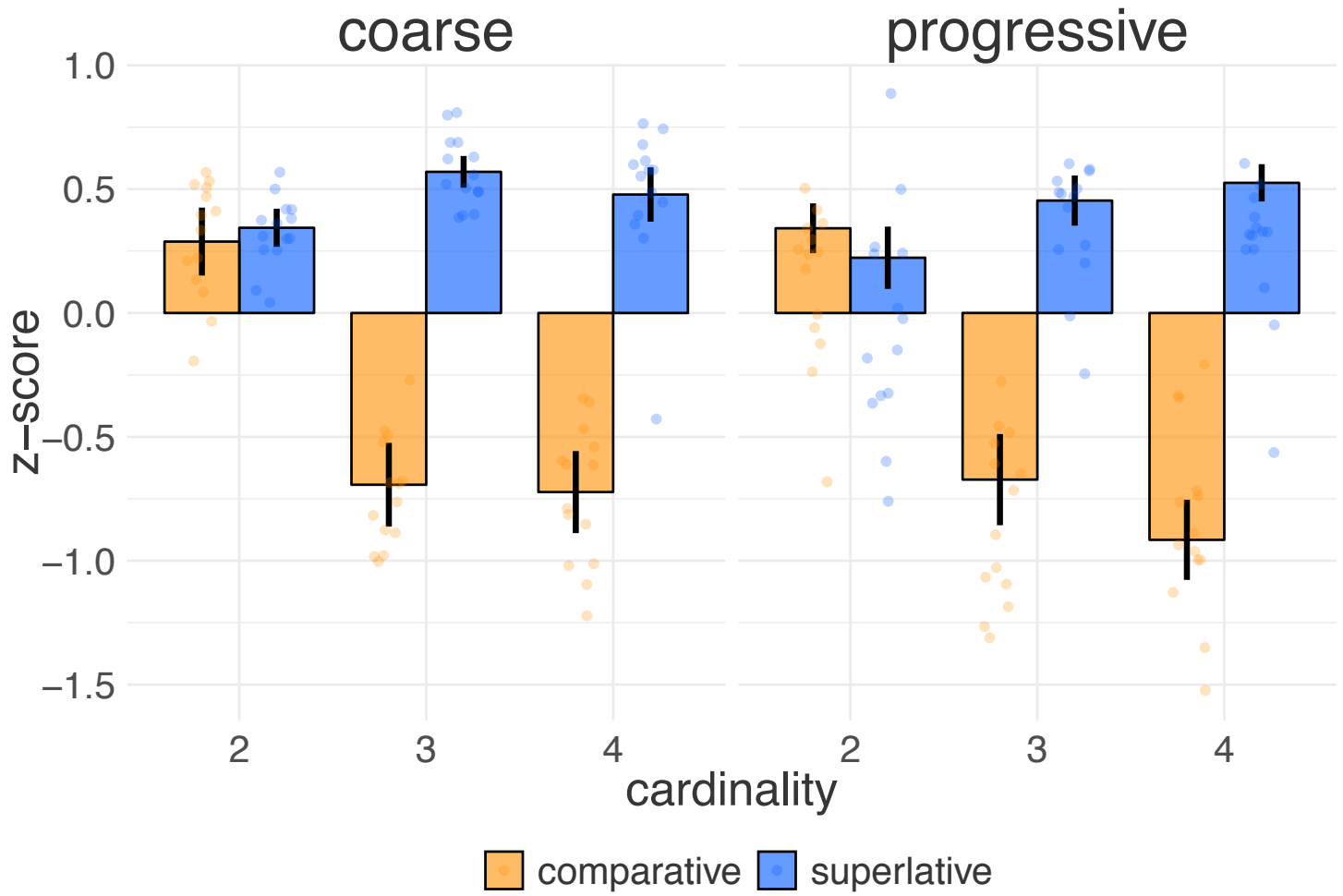


Grammatical Fillers
No Reference Failure

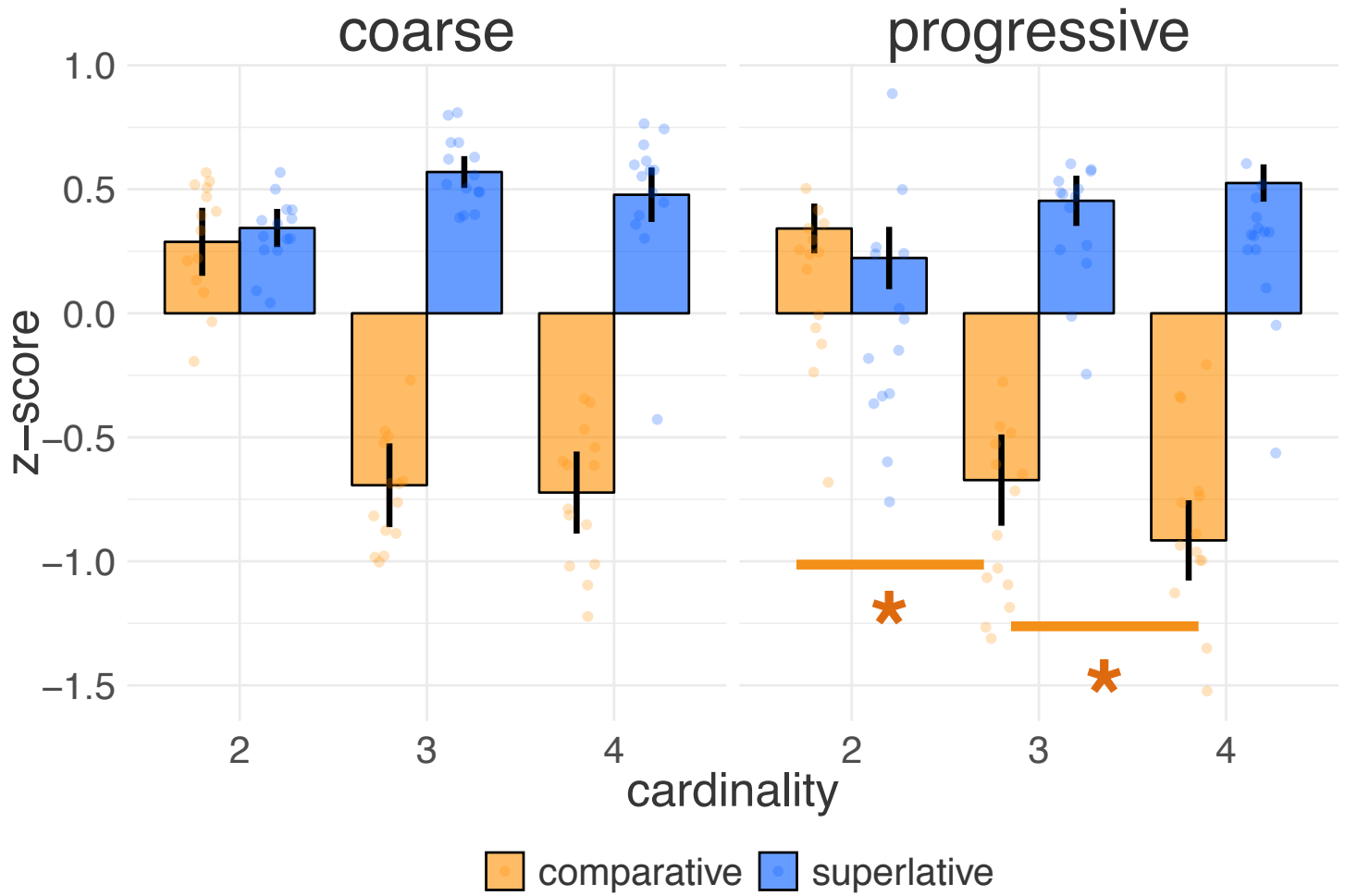
Global
Reference Failure
Fillers

n=140

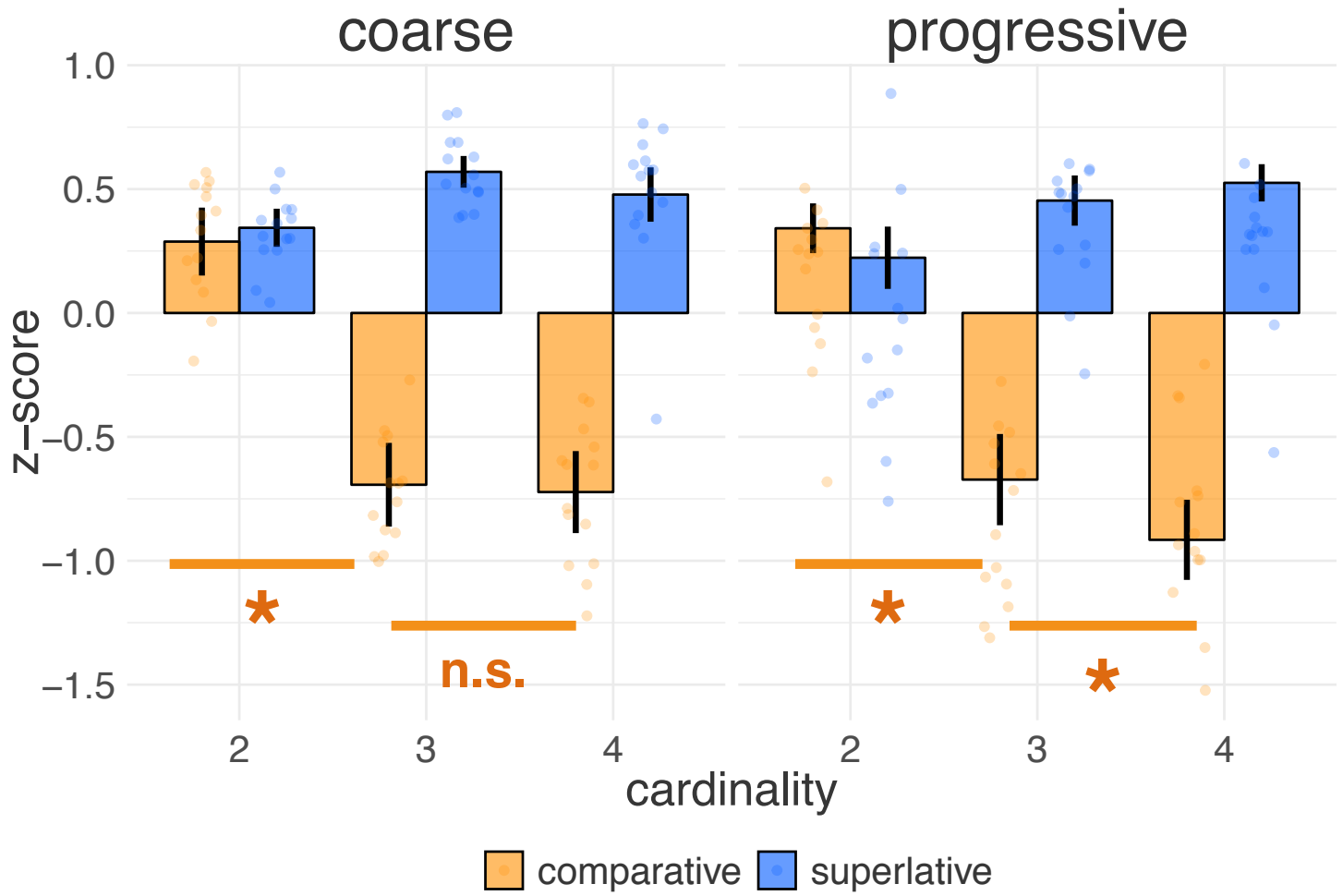
z-scored acceptability judgements



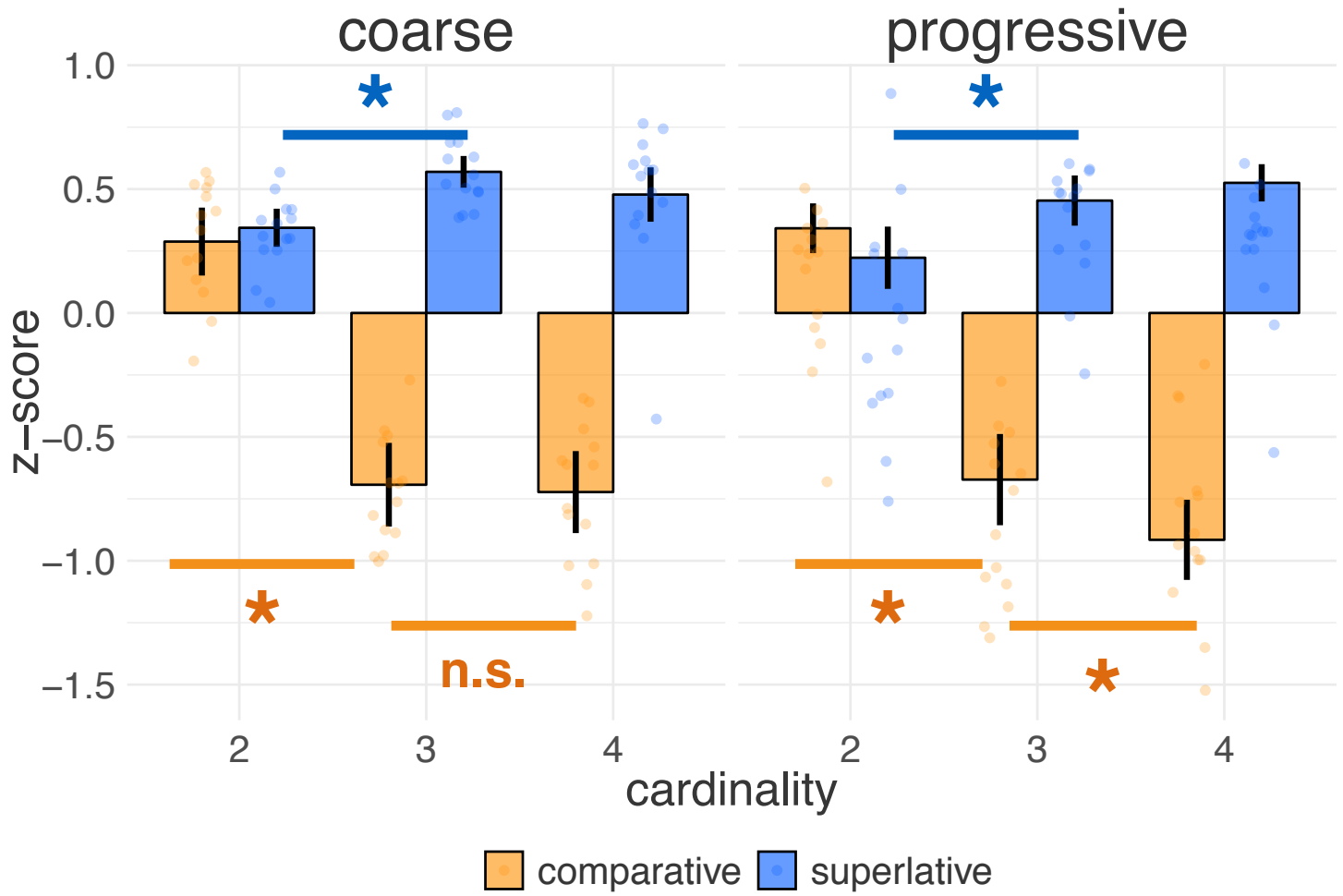
z-scored acceptability judgements



z-scored acceptability judgements



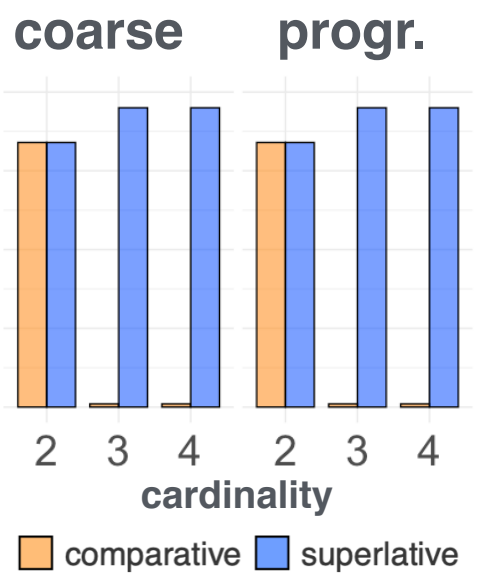
z-scored acceptability judgements



Discussion: 2Individuals

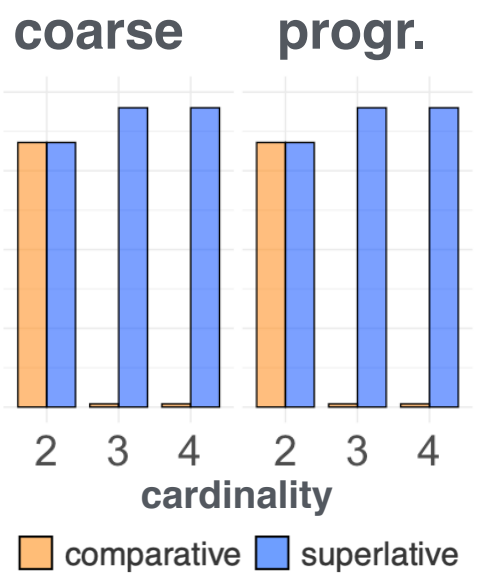
Discussion: 2Individuals

2Individuals Predictions

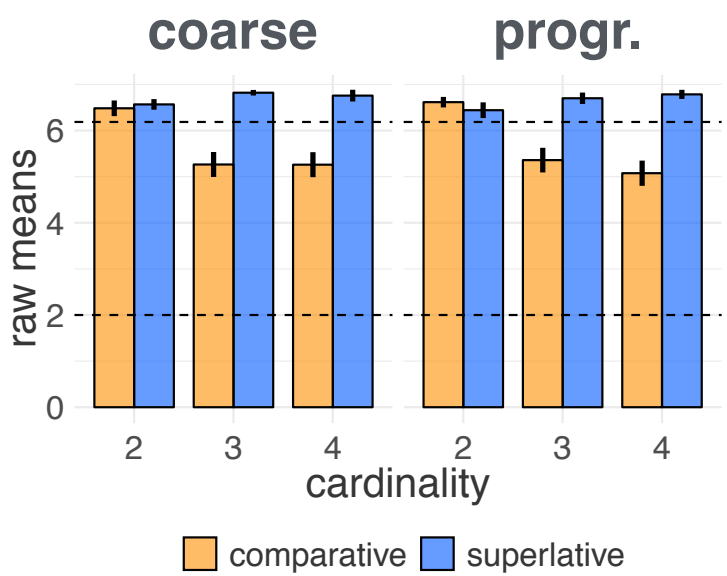


Discussion: 2Individuals

2Individuals Predictions



Experimental Results



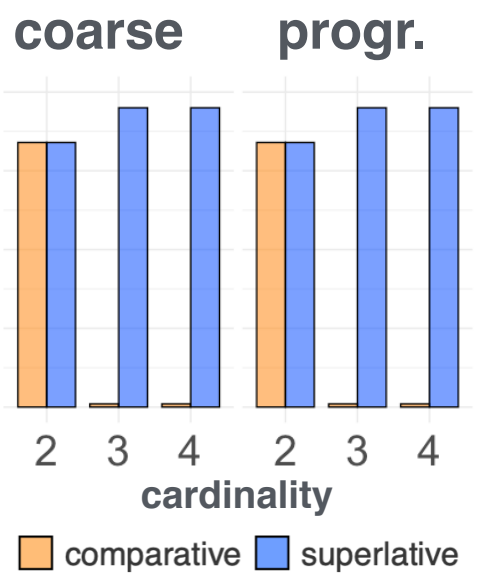
Grammatical Fillers
No Reference Failure

Global
Reference Failure
Fillers

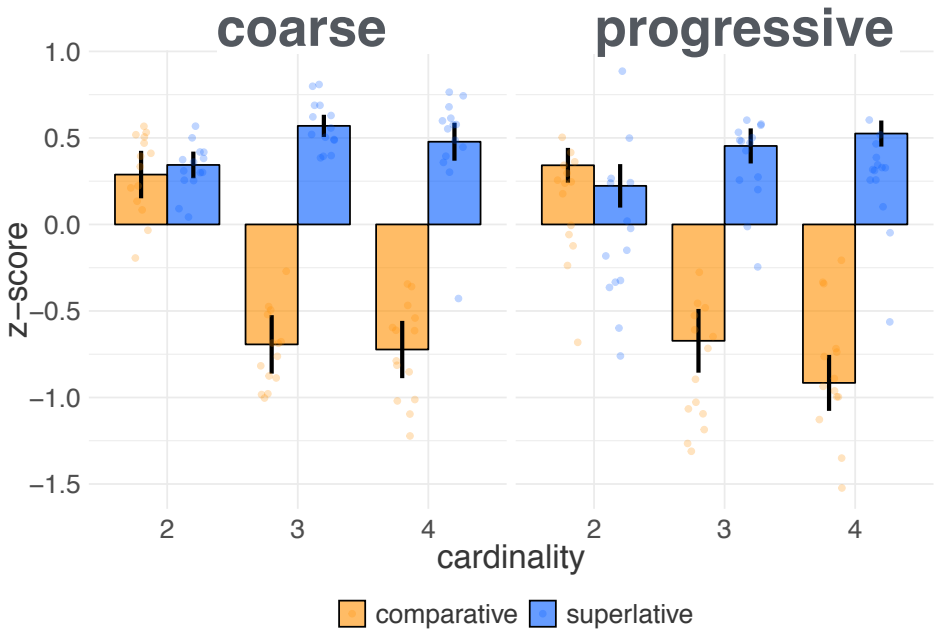
No global reference failure for the comparative at higher cardinalities

Discussion: 2Individuals

2Individuals Predictions

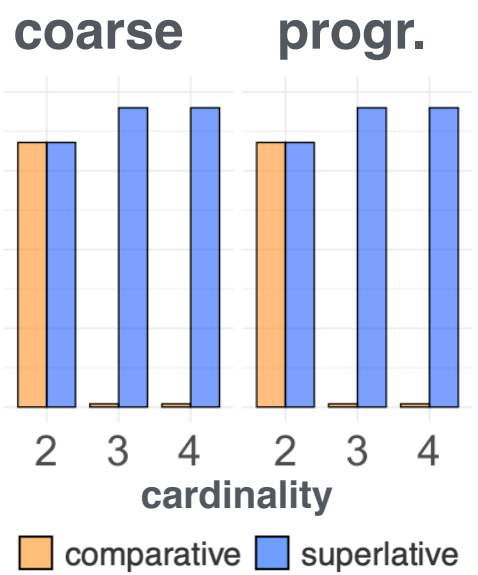


Experimental Results

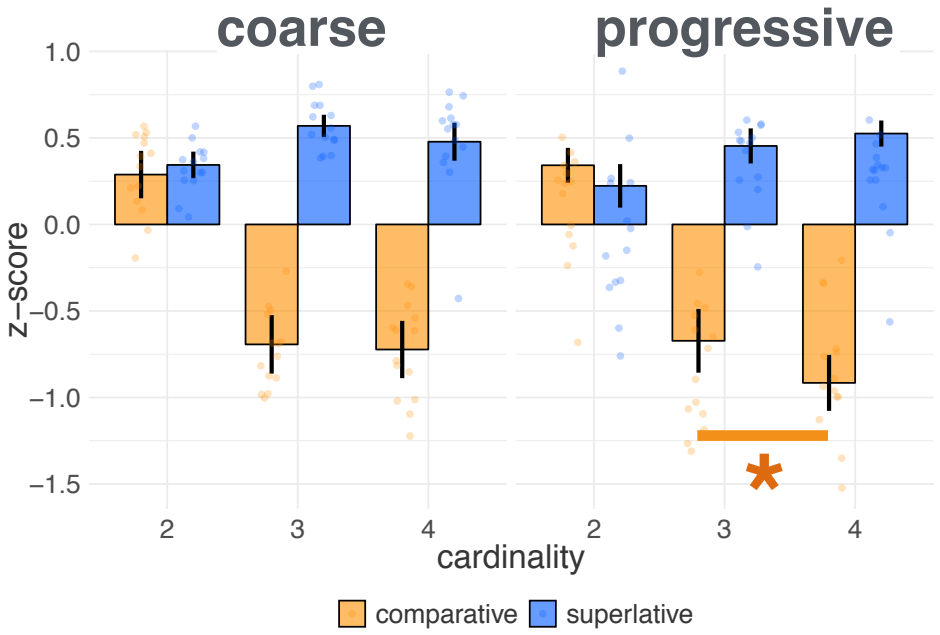


Discussion: 2Individuals

2Individuals Predictions



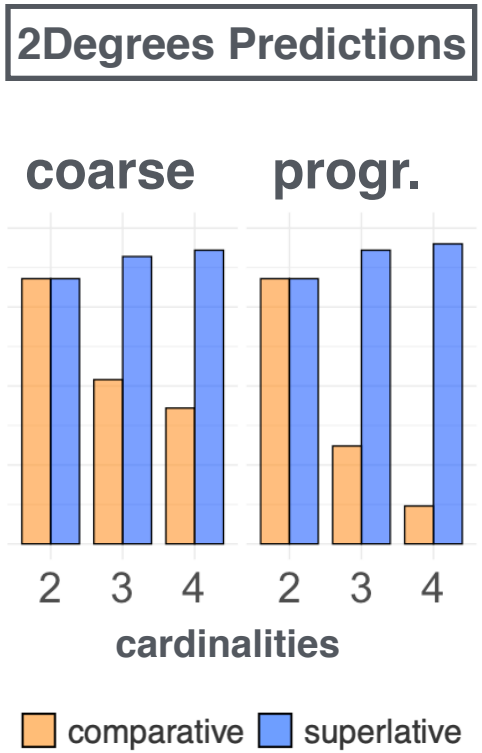
Experimental Results



2I Theory does not predict gradient acceptability effects for comparative

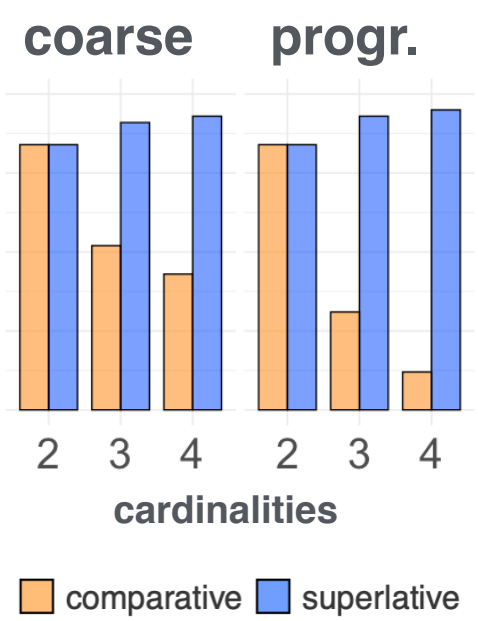
Discussion: 2Degrees

Discussion: 2Degrees

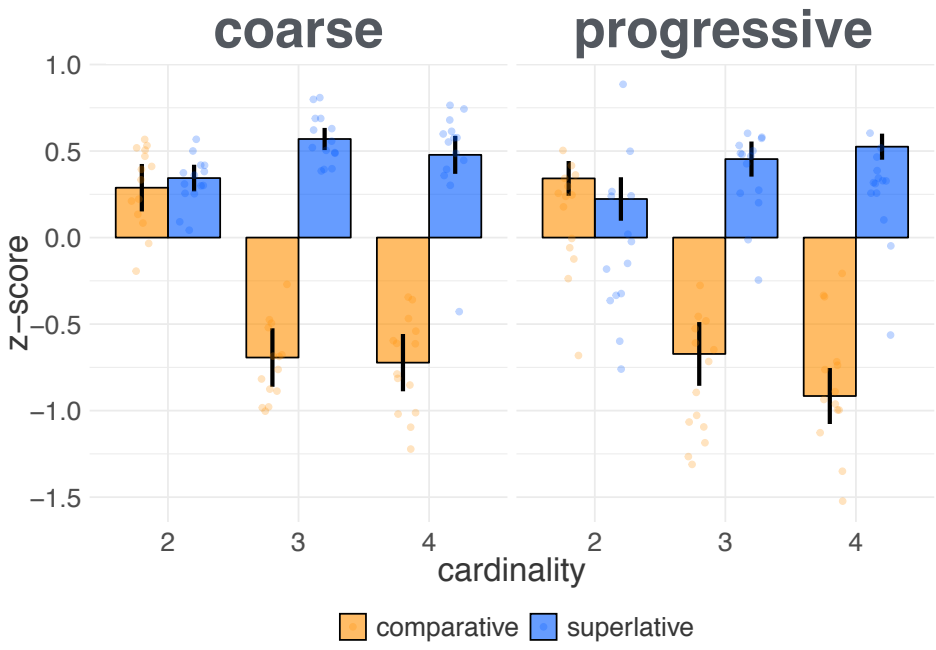


Discussion: 2Degrees

2Degrees Predictions

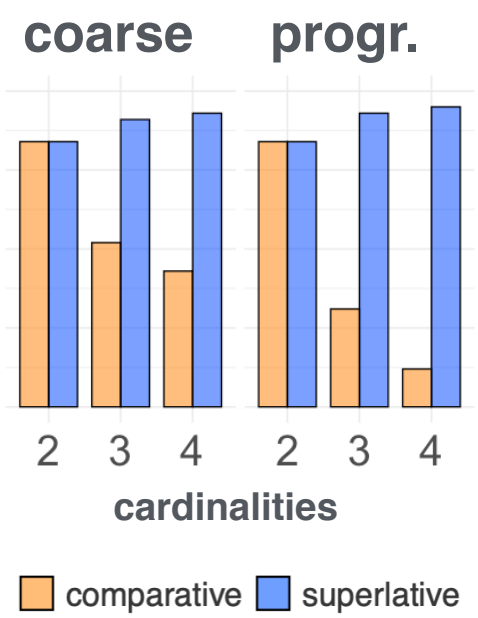


Experimental Results



Discussion: 2Degrees

2Degrees Predictions



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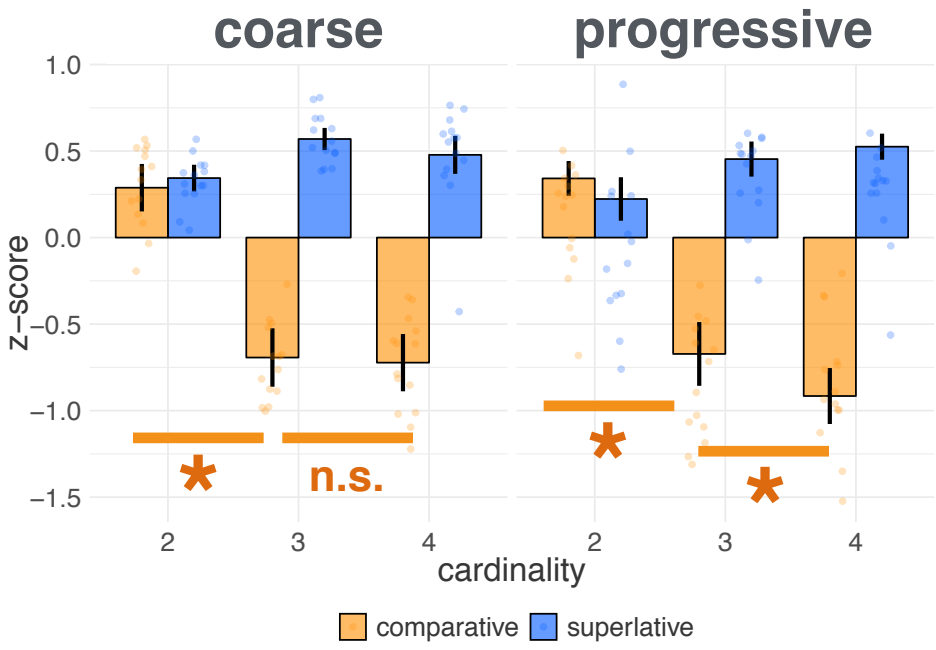
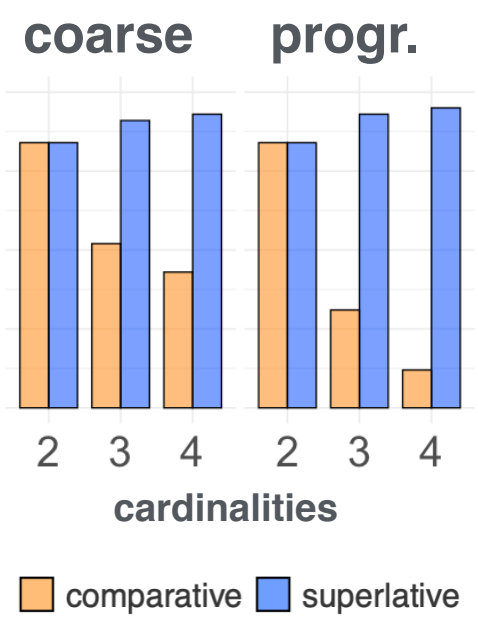


Discussion: 2Degrees

2Degrees Predictions



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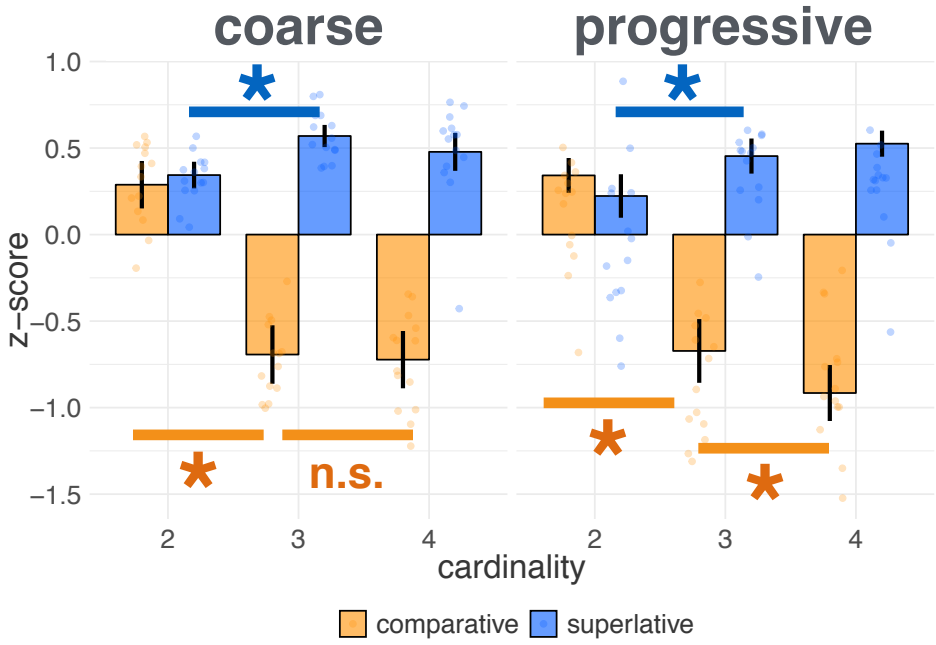
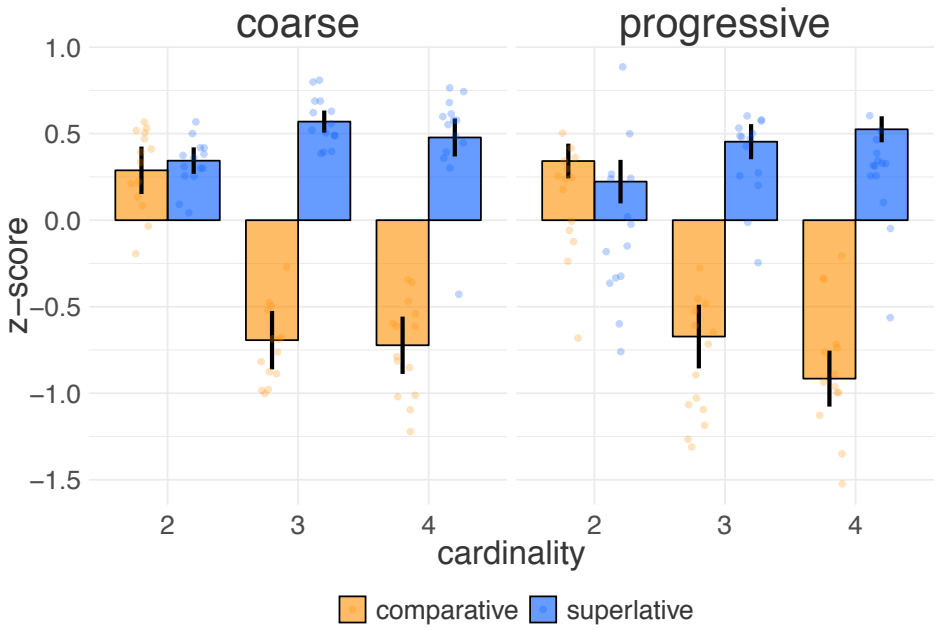


Interim Discussion

Gradient acceptability of comparative only predicted by 2Degrees Theory

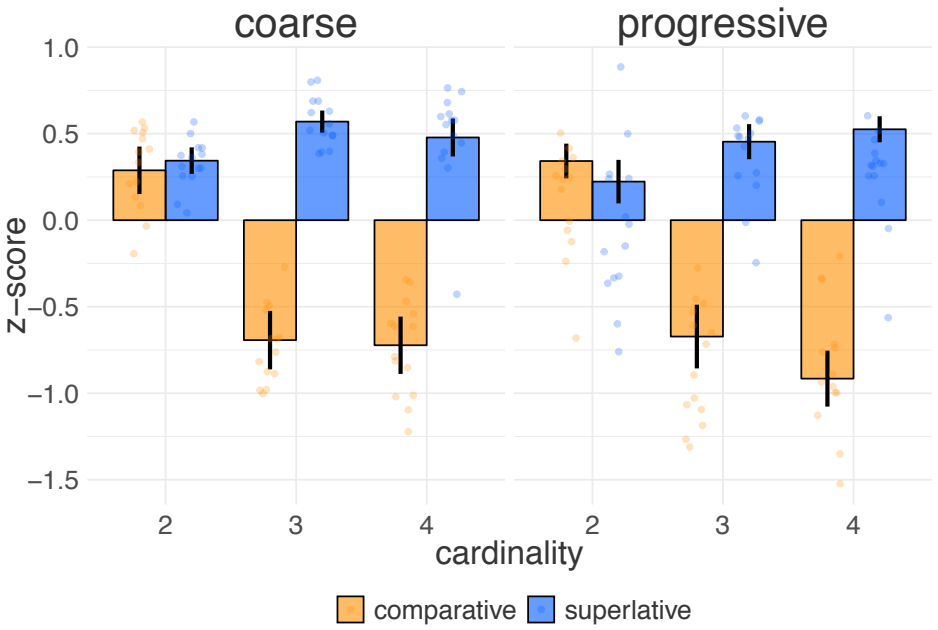


2Individuals Theory

2Degrees Theory

Interim Discussion

Gradient acceptability of comparative only predicted by 2Degrees Theory



~~2Individuals Theory~~

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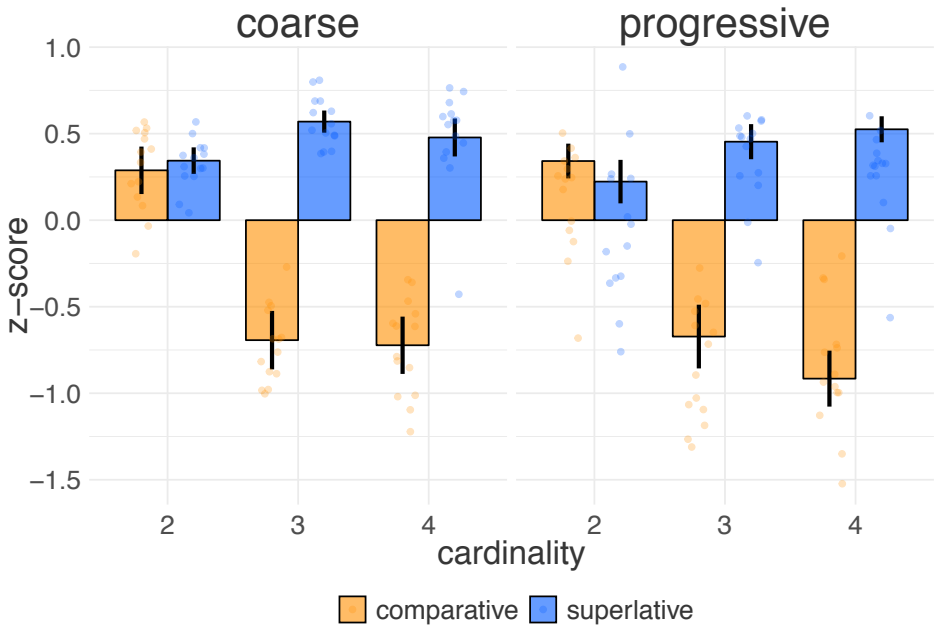
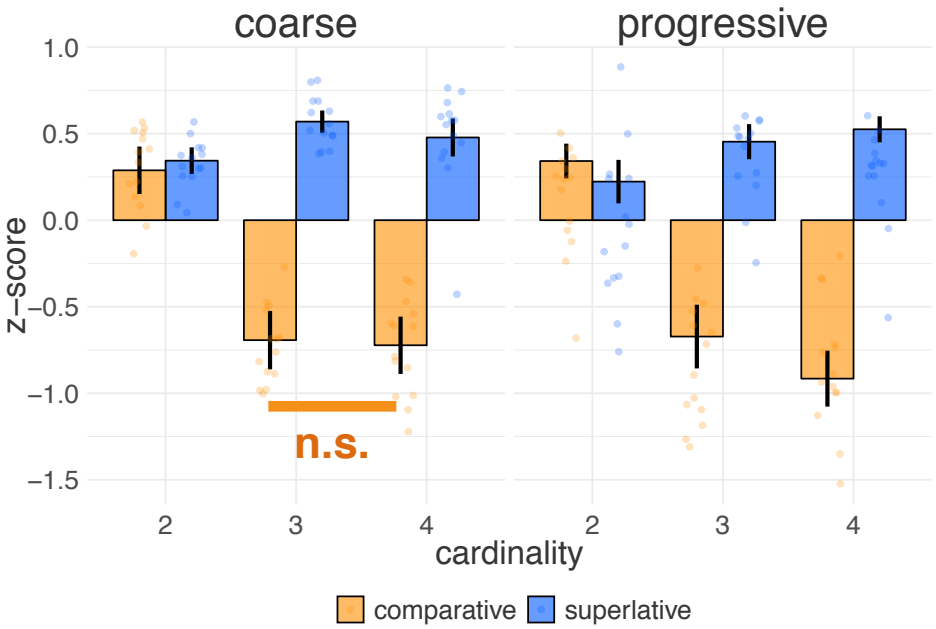


~~2Individuals Theory~~

2Degrees Theory ✓

Interim Discussion

- Why no significant effect in coarse condition for comparative?



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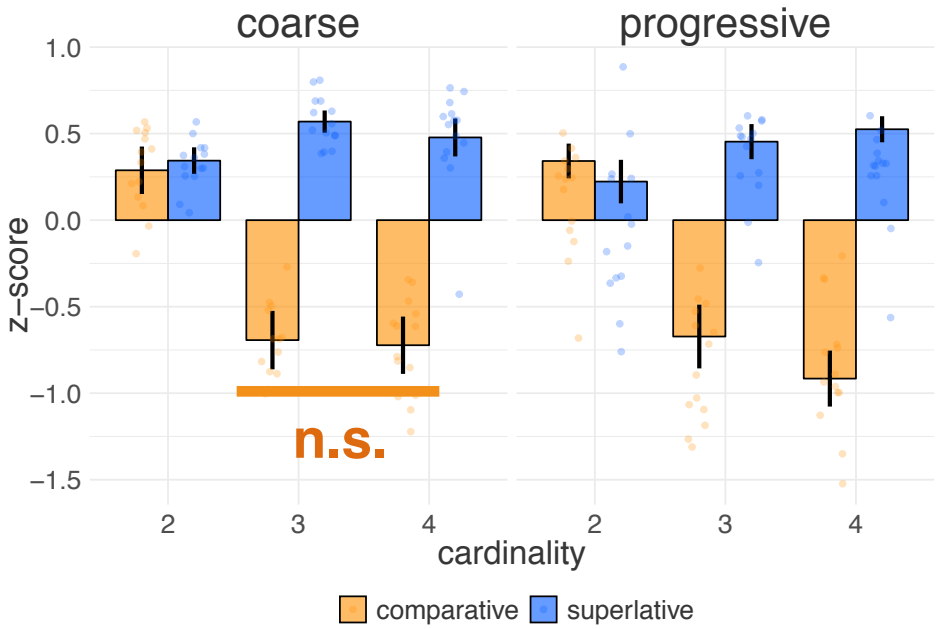
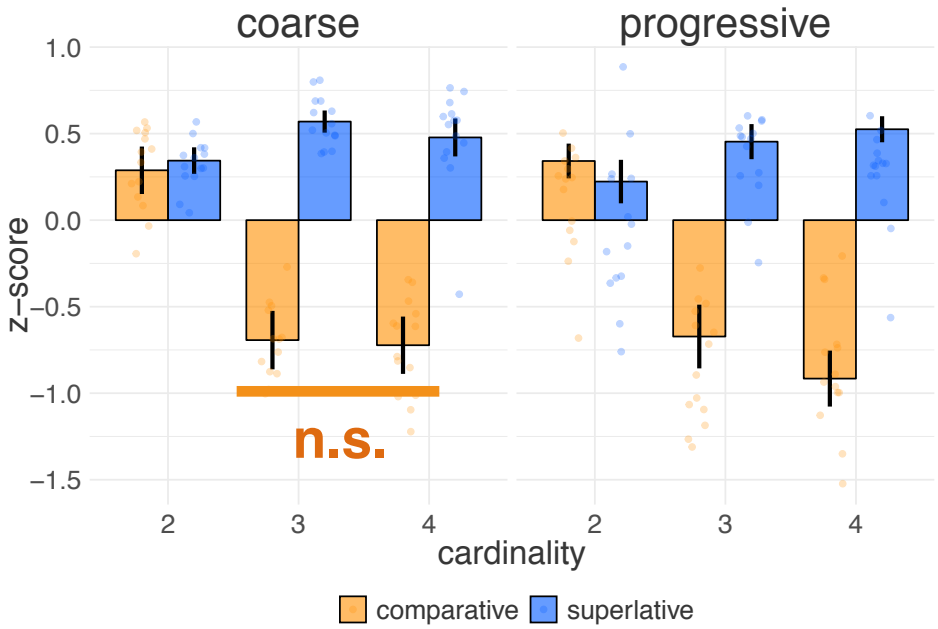


Proposal:

Penalty against pragmatic weakening

Interim Discussion

- Why no significant effect in coarse condition for comparative?



Proposal:

Penalty against pragmatic weakening

$|\gamma_{A,C}| = |C|$

Interim Discussion

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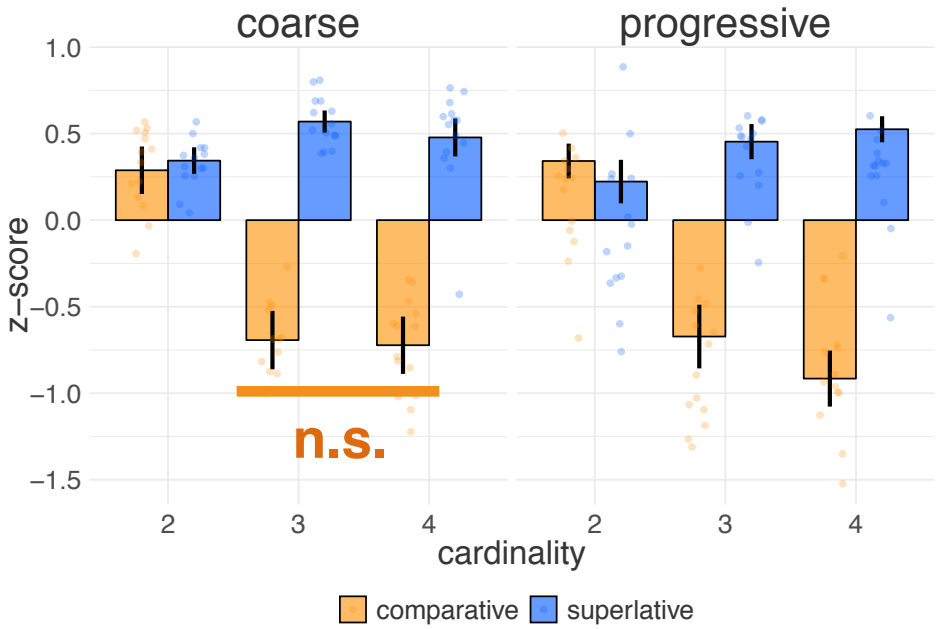

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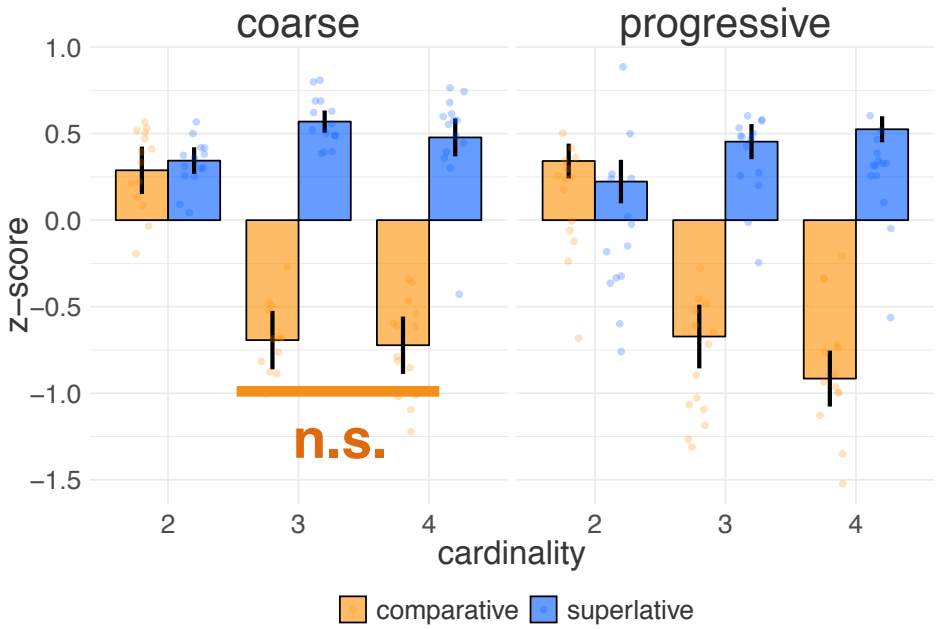


Proposal:

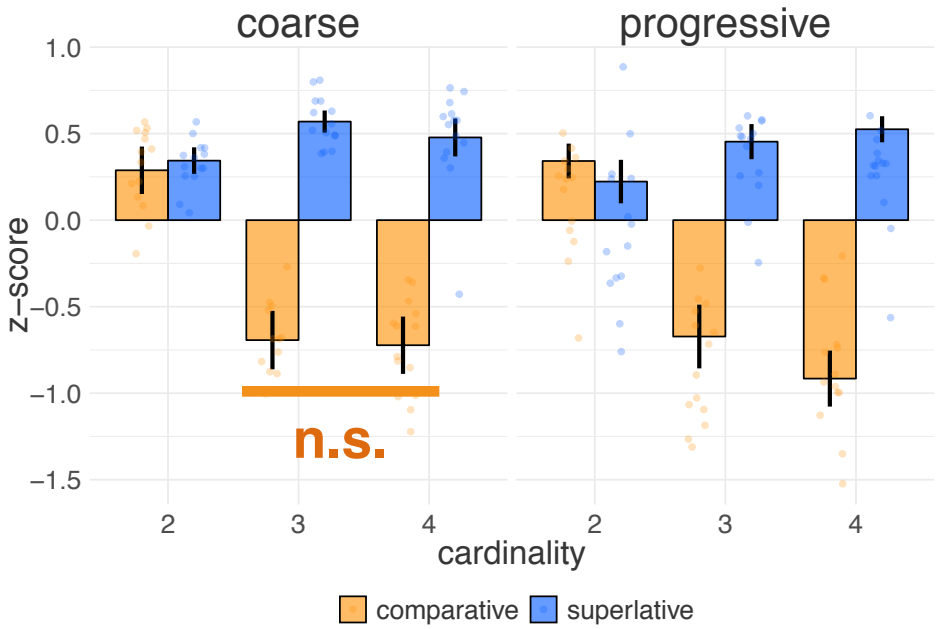
Penalty against pragmatic weakening

$|\gamma_{A,C}| = |C|$

$|\gamma_{A,C}| < |C|$

Interim Discussion

- Why no significant effect in coarse condition for comparative?



Proposal:

Penalty against pragmatic weakening

$|\gamma_{A,C}| = |C|$

$|\gamma_{A,C}| < |C|$

(Cf. Schwarzschild 1996; Champollion 2016)

Computational Modeling

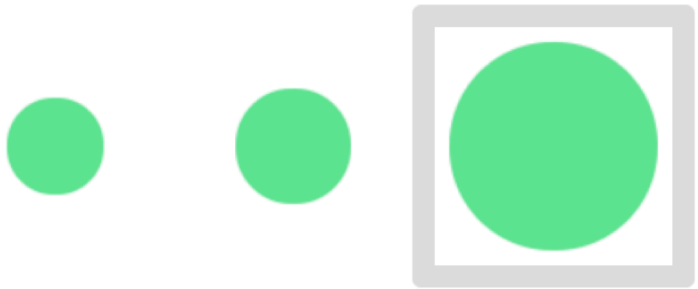
Rational Speech Act Models

- Probabilistic models of language interpretation
- Language understanding as social reasoning
- Speaker & Listener recursively reason about each other
- Formalization of Gricean pragmatics that uses Bayesian reasoning

Frank & Goodman (2012);
Goodman & Frank (2016)

Our Experiment in RSA

This is the biggest circle.

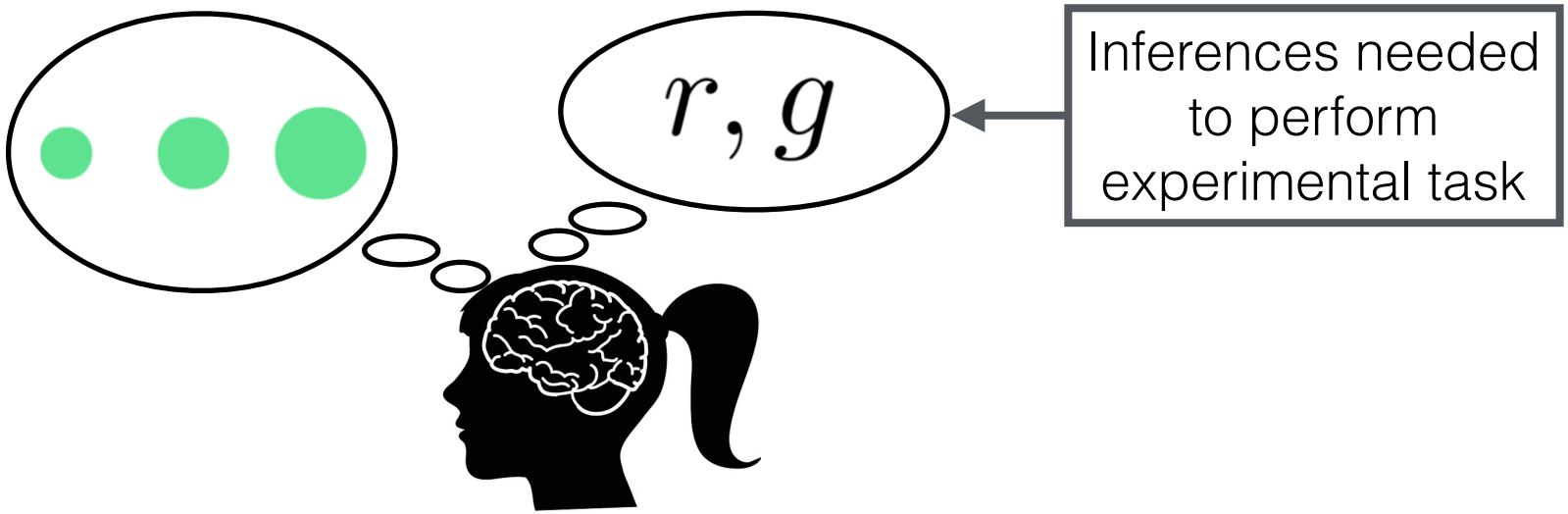


How acceptable is the above description of the scene?

	1	2	3	4	5	**6**	7	
(Bad)	○	○	○	○	○	●	○	(Good)

Back *Next*

Modeling our Experiment in RSA



Pragmatic Listener (L1)

The bigger circle.

$$L_1(r, g \mid d = \text{The bigger circle})$$

Pragmatic Listener (L1)

$$L_1(r, g \mid d = \text{The bigger circle})$$

Bayesian Update

Pragmatic Listener (L1)

$$L_1(r, g \mid d = \text{The bigger circle}) \propto$$

$$S_1(d = \text{The bigger circle} \mid r, g) \cdot P(r) \cdot P(g \mid d)$$

Likelihood **Priors**

Speaker (S1)

- Speaker modeled as quasi-rational agent that prefers high-utility utterances

$$S_1(d \mid r, g)$$

Speaker (S1)

- Utility defined as a trade-off between two communicative pressures:

$$S_1(d \mid r, g) \propto \exp(\alpha \times \ln(L_0(r \mid d, g)) - \text{cost}(d))$$

Maximize informativity of the utterance to the listener (efficiency)

Speaker (S1)

- Utility defined as a trade-off between two communicative pressures:

$$S_1(d \mid r, g) \propto \exp(\alpha \times \ln(L_0(r \mid d, g)) - \text{cost}(d))$$

Minimize production cost for the speaker (efficacy)

Speaker (S1)

- Utility defined as a trade-off between two communicative pressures:

$$S_1(d \mid r, g) \propto \exp(\alpha \times \ln(L \ (r \mid d, g)) - \mathsf{cost}(d))$$

Speaker and Listener models are mutually recursive

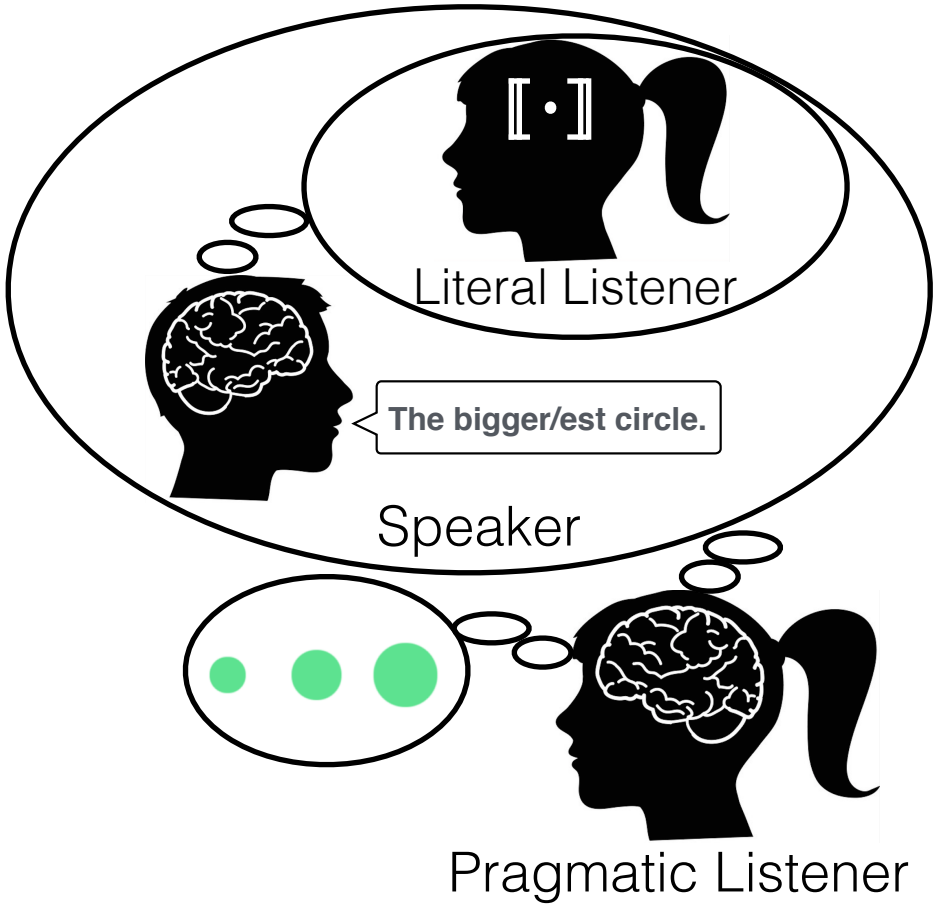
Literal Listener (L0)

- Grounds model in truth-conditional semantics

$$L_0(r \mid d, g) \propto [\![d]\!]^g(r) \cdot P(r)$$

$$P(r) = \begin{cases} \epsilon & \text{if } r = \text{fail} \\ \text{uniform} & \text{otherwise} \end{cases}$$

RSA Model


⟦·⟧
Literal Listener
The bigger/est circle.
Speaker
Pragmatic Listener

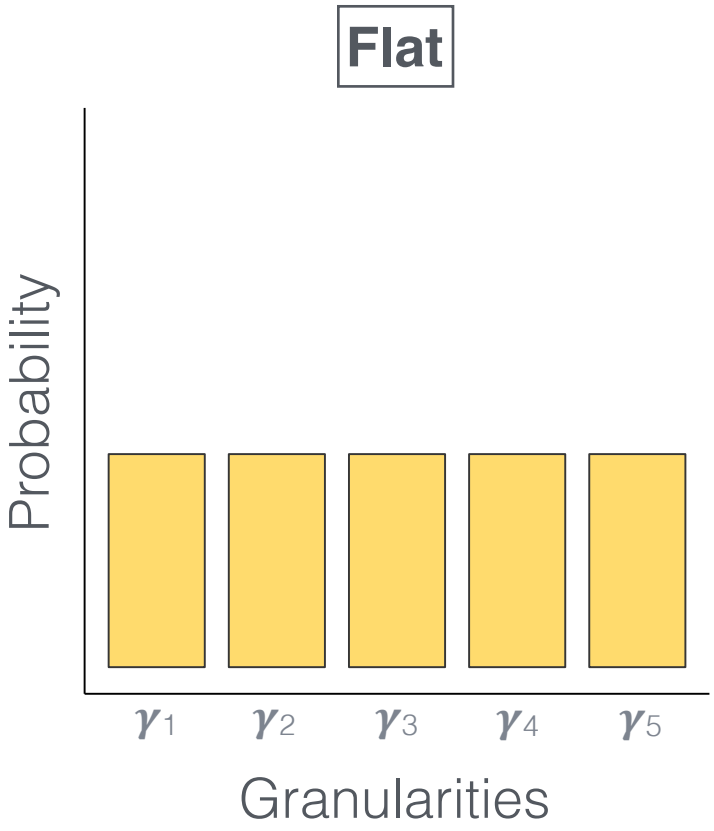
Pragmatic Weakening

Granularity Priors

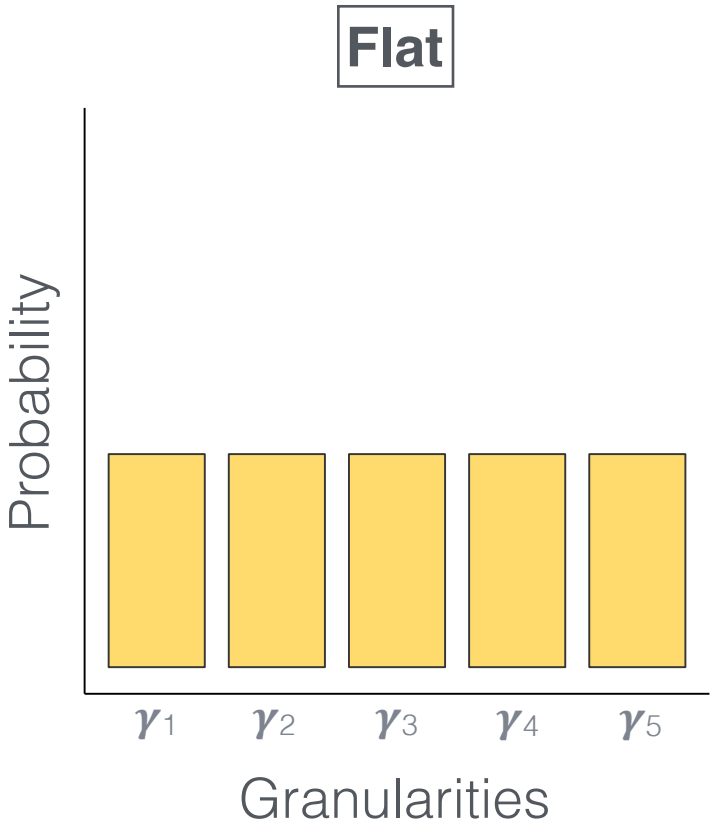
Flat

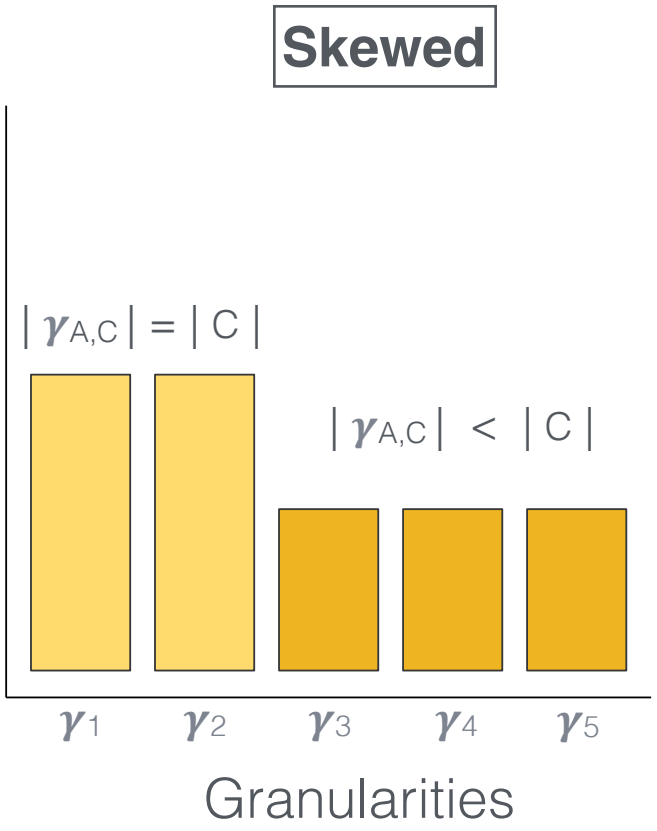
Skewed

Granularity Priors



Granularity Priors





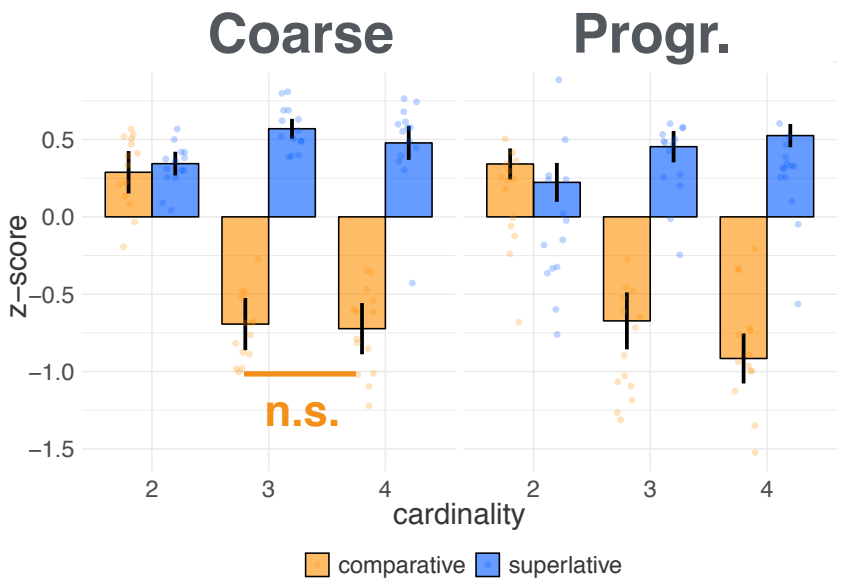
Simulations

Flat Granularity Prior

Flat Granularity Prior

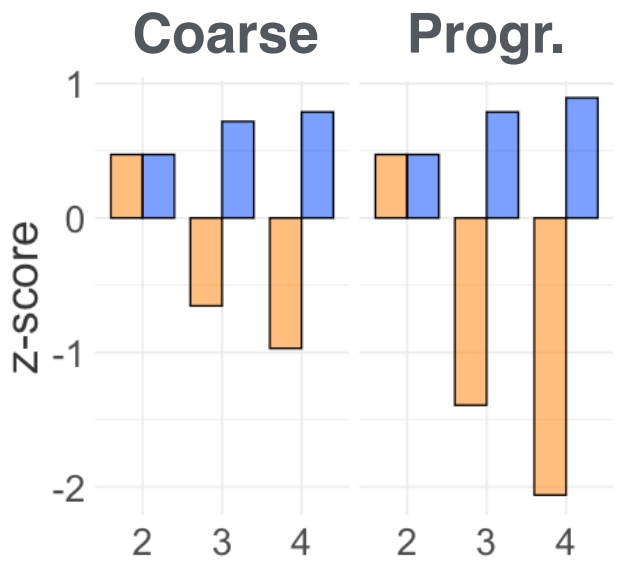
Model

Experiment

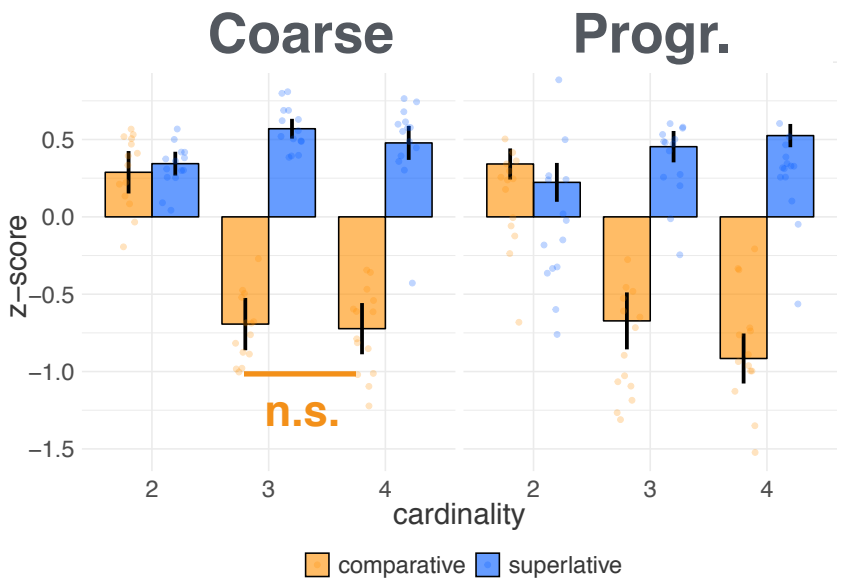


Flat Granularity Prior

Model



Experiment



Flat Granularity Prior

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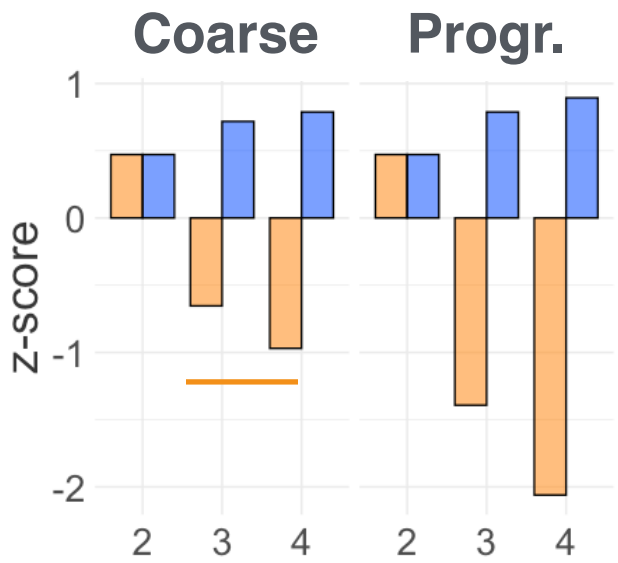
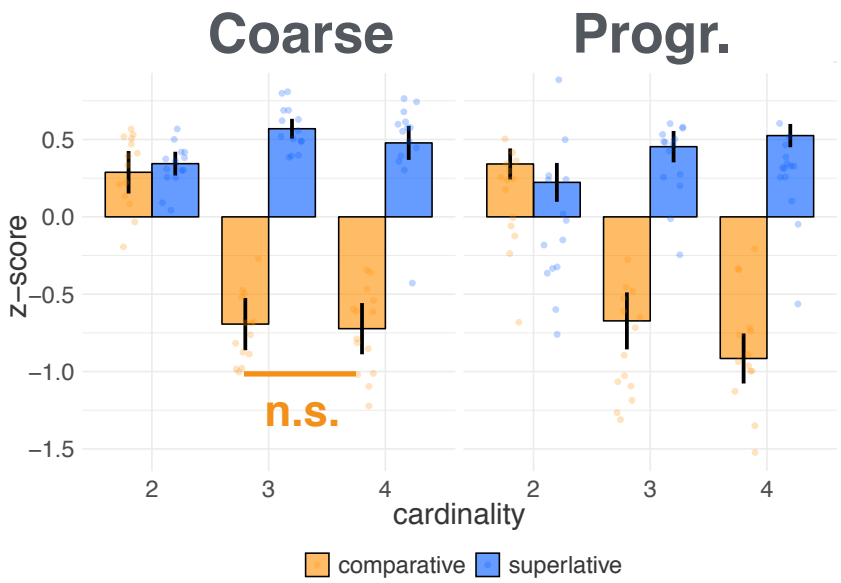


Experiment



Flat Granularity Prior

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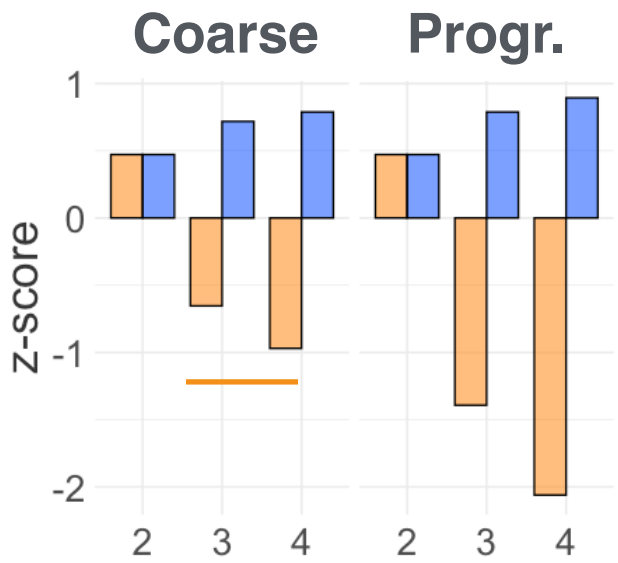

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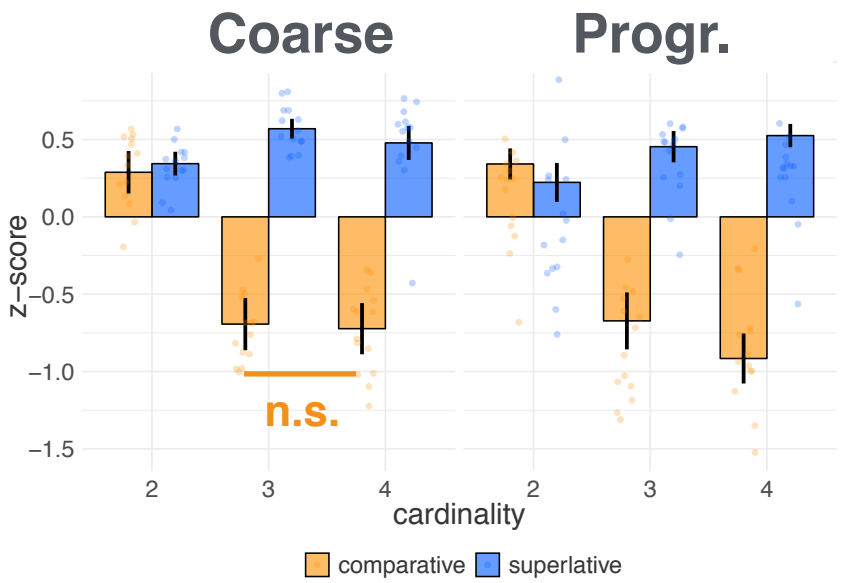
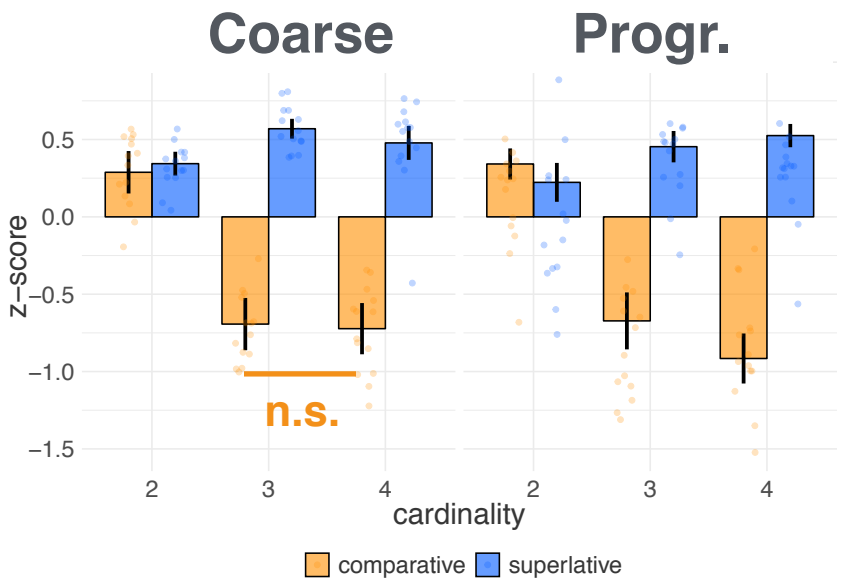


✚ No significant effect in coarse condition comparative ✗

Skewed Granularity Prior

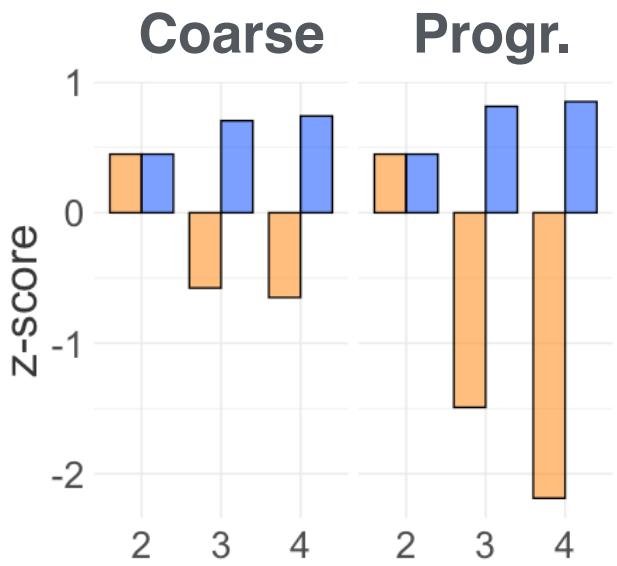
Model

Experiment

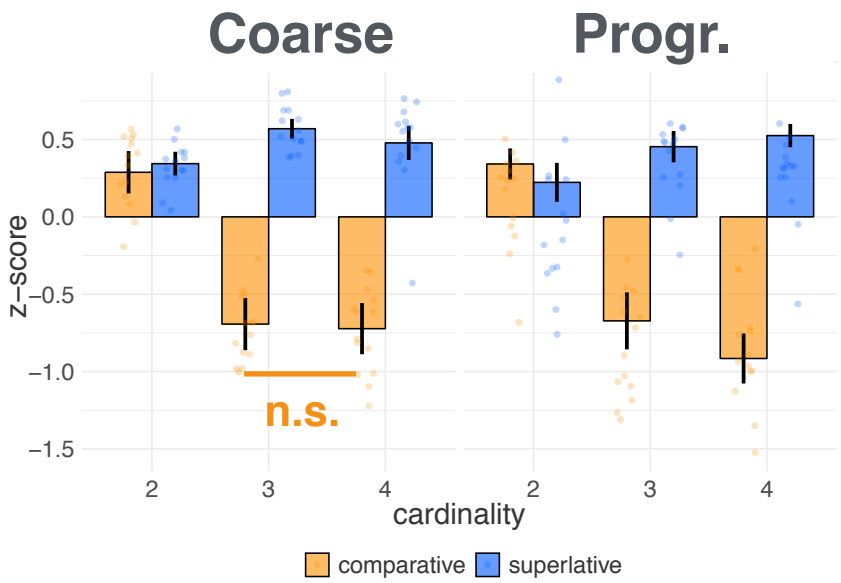


Skewed Granularity Prior

Model

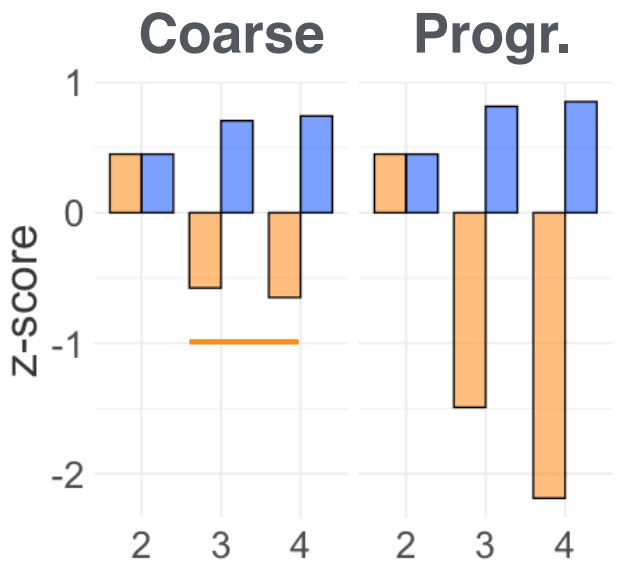


Experiment



Skewed Granularity Prior

Model



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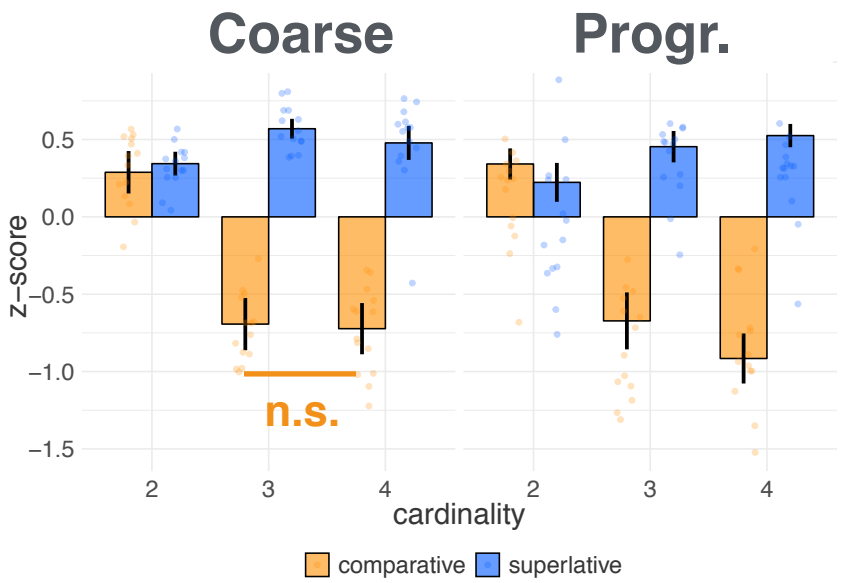

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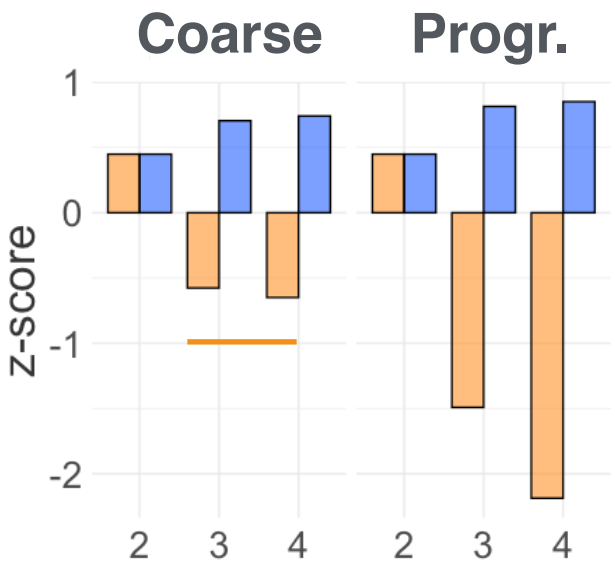

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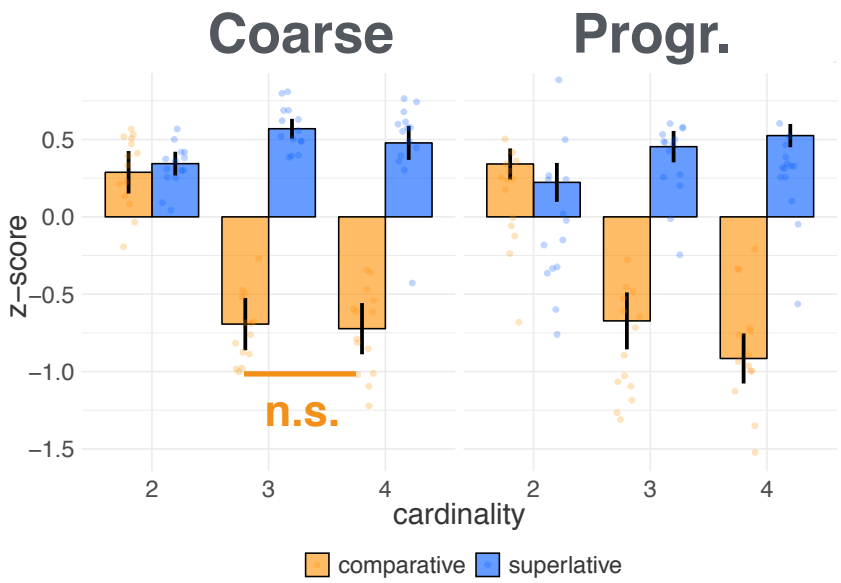


✚ No significant effect in coarse condition comparative ✓

Conclusion

1. Our experimental results are incompatible with 2I Theory

2. Our results can be explained by the **2D Theory**

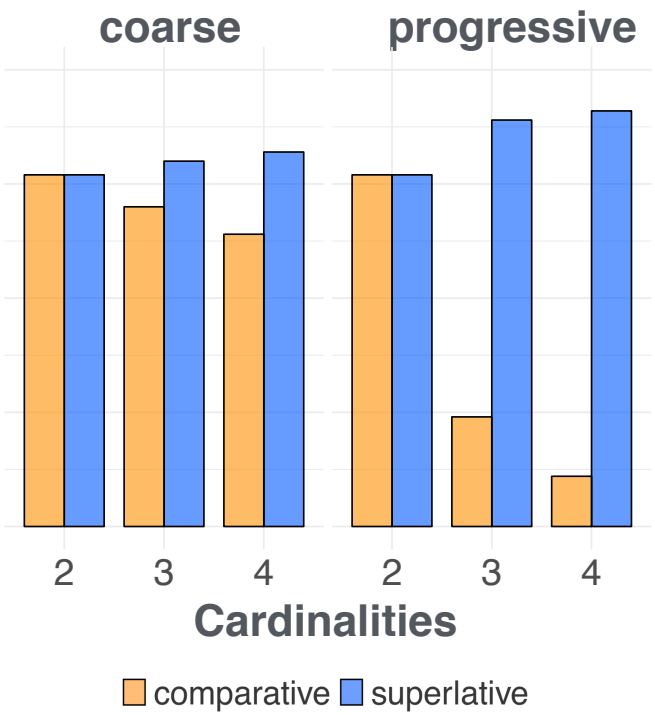
3. 2D Theory alone fails to account for lack of effect in Coarse condition

→ Post hoc computational modeling:
dispreference for pragmatic weakening

Thank you

Flat Granularity Prior

Model



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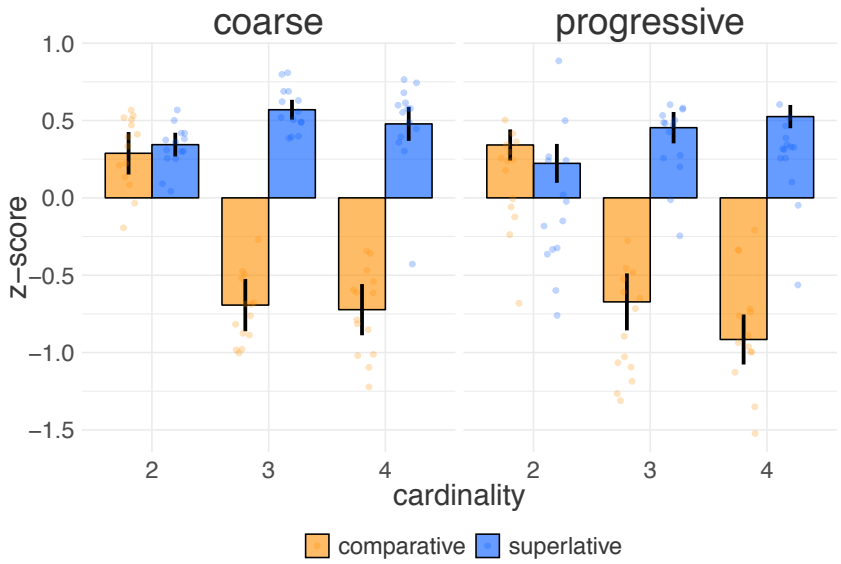
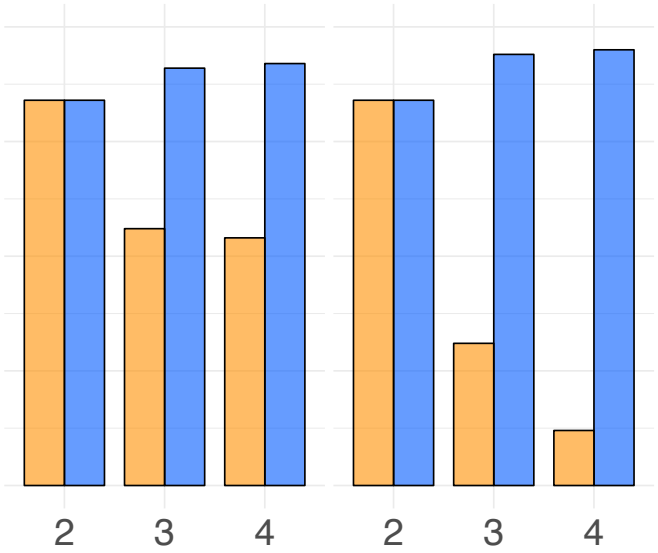
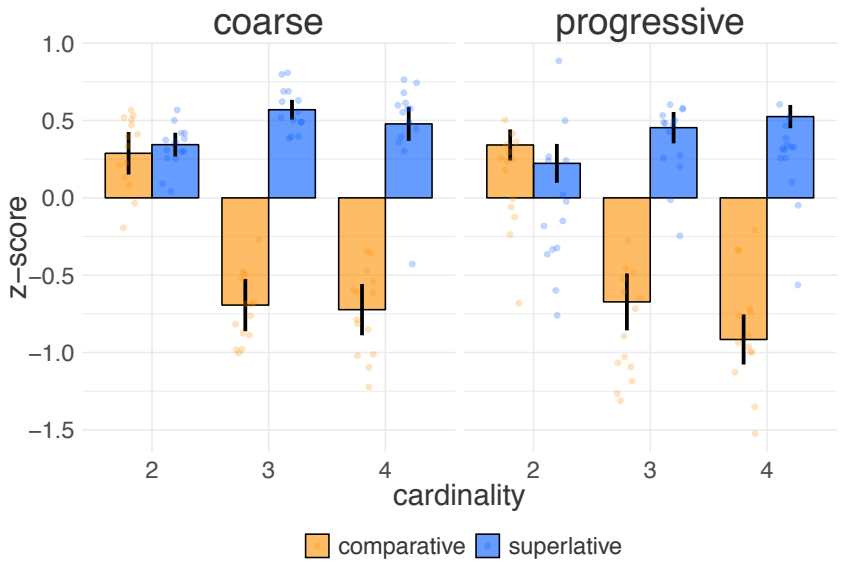


Skewed Granularity Prior

Model

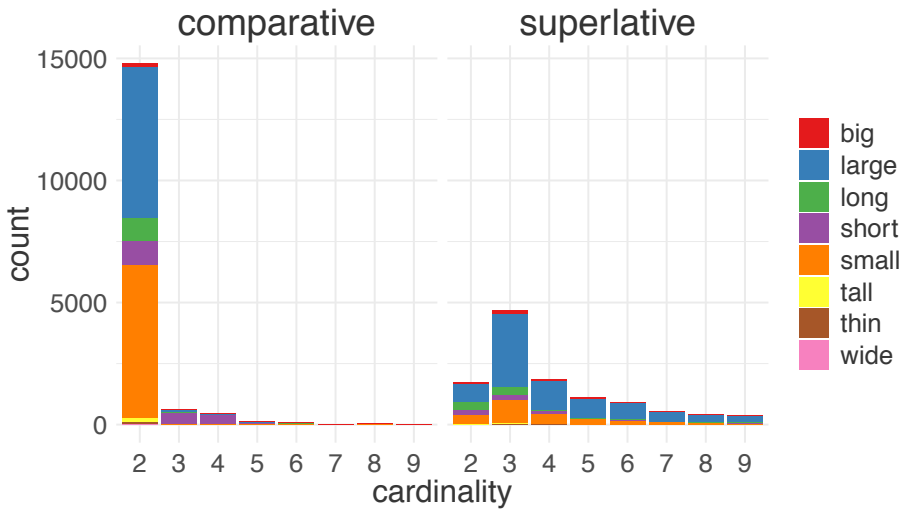


Experiment

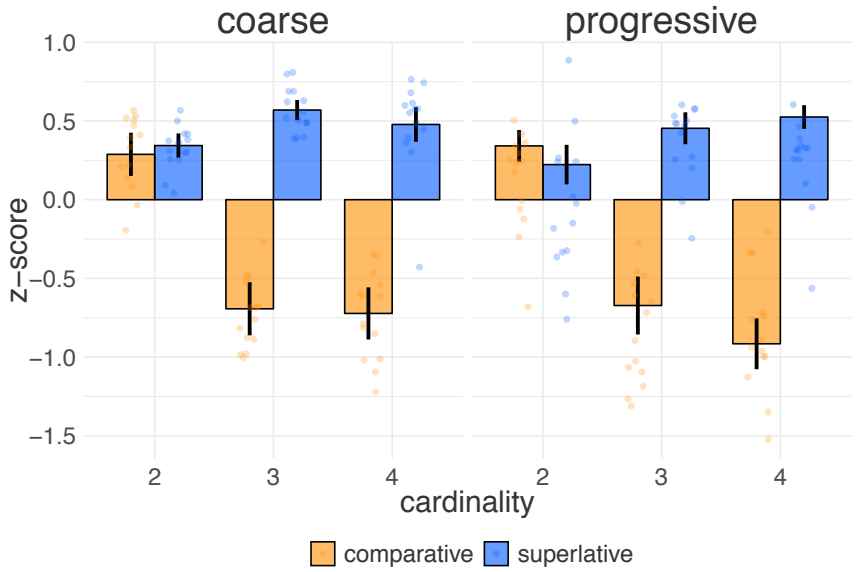


Production-Comprehension Mismatch?

Corpus Data

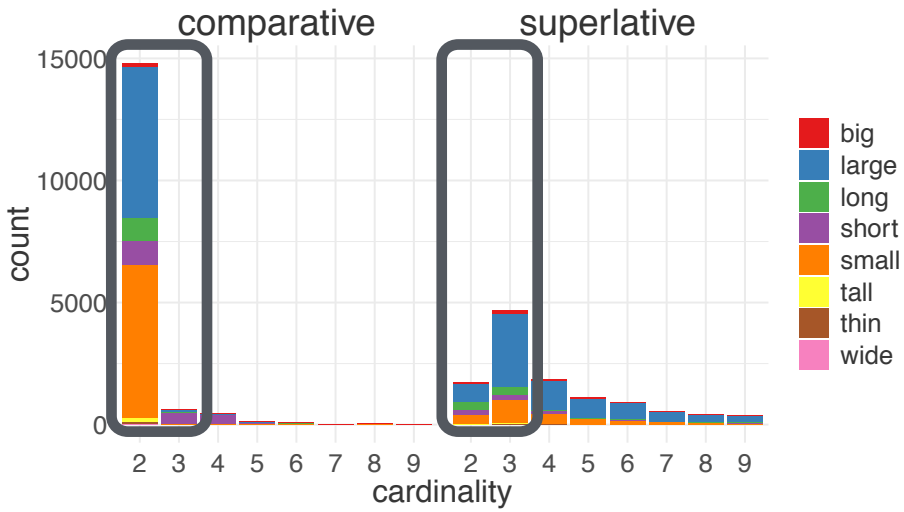


Experiment

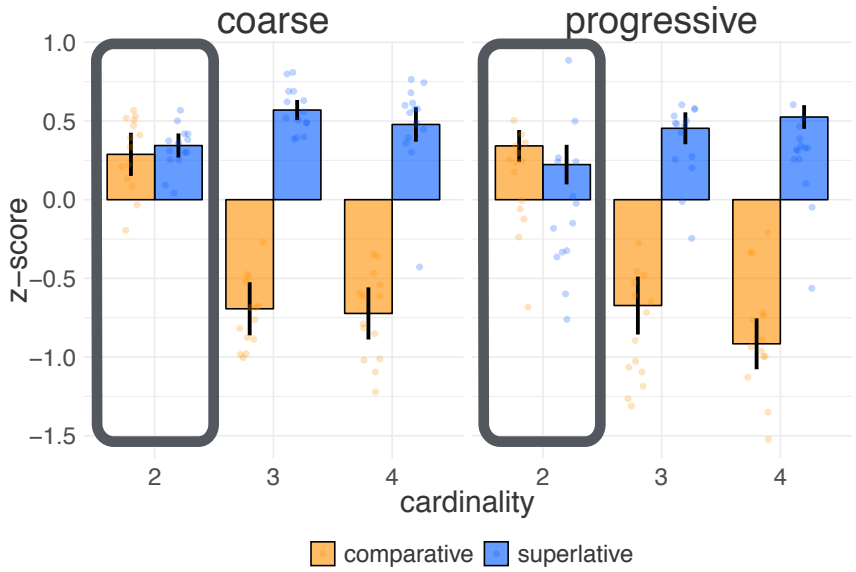


Production-Comprehension Mismatch?

Corpus Data



Experiment



Maximize presupposition (Heim 1991) effects in production, not expected in comprehension

Production Pilot Data

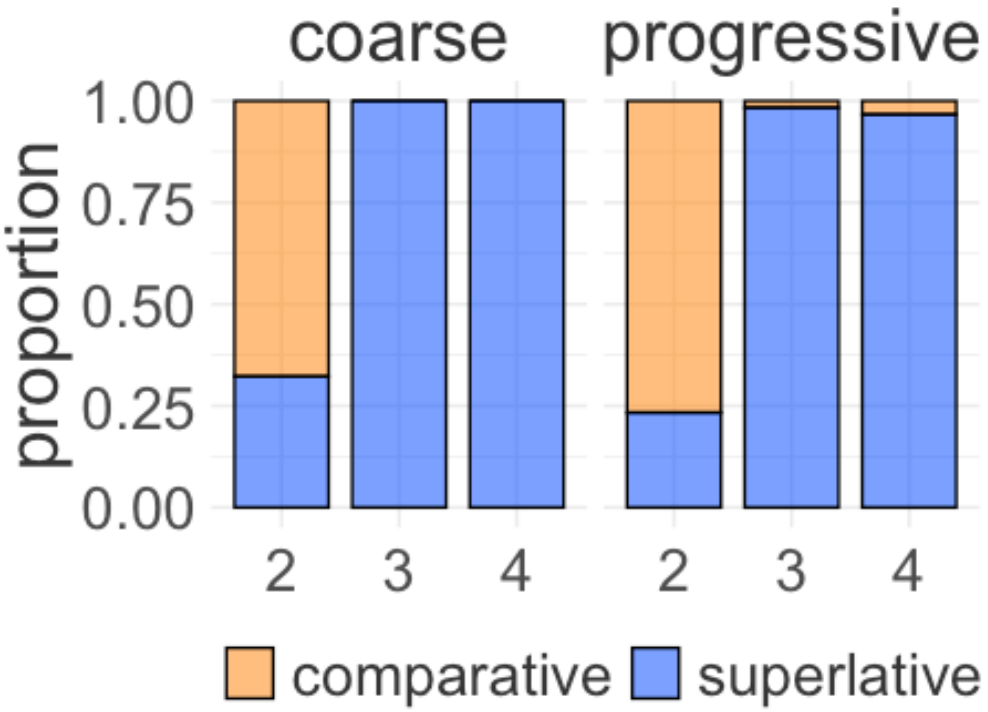
How would you describe this scene?

This is the tallest cylinder.

This is the taller cylinder.

Neither

Production Pilot Data



Preference for comparative at cardinality 2

Consistent with corpus data