

Modeling Shifts of Attention During Spatial Language Comprehension

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Introduction // Spatial Language



The dot is above the rectangle.

Introduction // Spatial Language



The dot is above? the rectangle.

Introduction // Key goals of this talk

- How to model acceptability ratings for spatial language?

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 - AVS model (Regier & Carlson, 2001)
 - rAVS model (Kluth, Burigo, & Knoeferle, 2016)

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- How to model acceptability ratings for spatial language?
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 - rAVS model (Kluth, Burigo, & Knoeferle, 2016)
- What is the role of the direction of the shift of visual attention?

Introduction // Key goals of this talk

- How to model acceptability ratings for spatial language?
 - AVS model (Regier & Carlson, 2001)
 - rAVS model (Kluth, Burigo, & Knoeferle, 2016)
- What is the role of the direction of the shift of visual attention?
- How to distinguish the AVS and the rAVS model?
 - computational and empirical study of predictions of the two models

AVS Model // Regier and Carlson (2001)

cognitive model:
Attentional **V**ector **S**um (AVS) model
(Regier & Carlson, 2001)

AVS Model // Regier and Carlson (2001)

inputspatial preposition: *above*

located object: LO



reference object: RO

→ AVS model

AVS Model // Regier and Carlson (2001)

inputspatial preposition: *above*

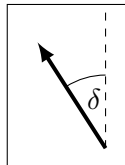
located object: LO



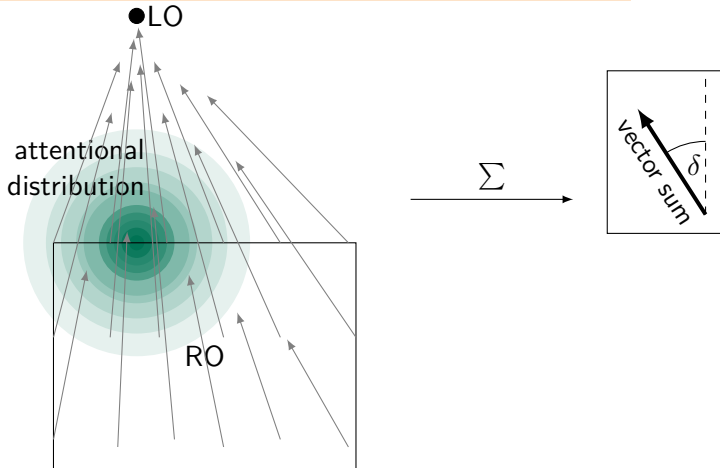
reference object: RO

→ AVS model → acceptability rating

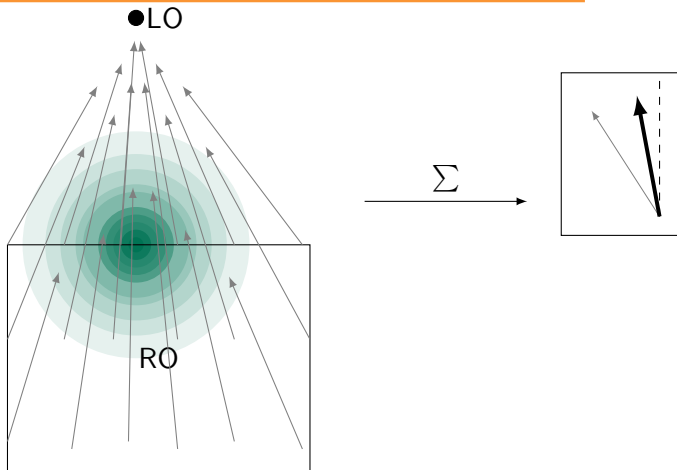
AVS Model // Regier and Carlson (2001)



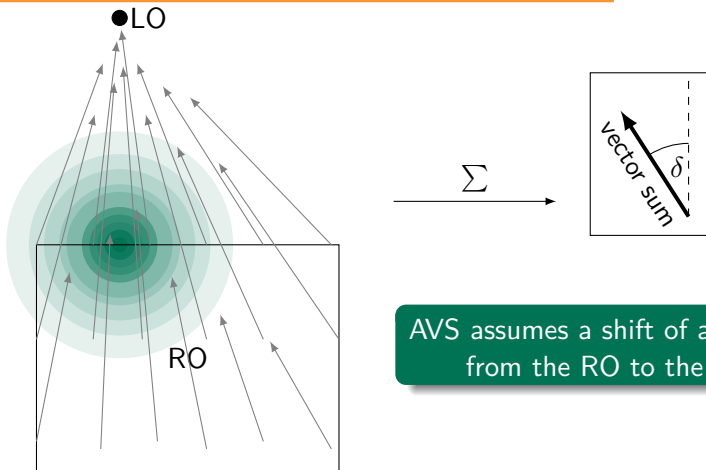
AVS Model // Regier and Carlson (2001)



AVS Model // Regier and Carlson (2001)



AVS Model // Regier and Carlson (2001)



AVS assumes a shift of attention
from the RO to the LO

Visual World Paradigm // Burigo and Knoeferle (2015)



“Die Box ist *über* der Wurst”
‘The box is above the sausage’

(image source: Burigo & Knoeferle, 2015, p. 6)

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Visual World Paradigm // Burigo and Knoeferle (2015)



Visual World Paradigm
provides evidence for a shift
of visual attention from the
LO to the RO

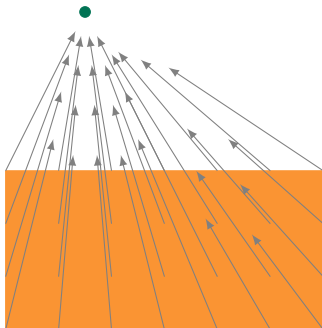
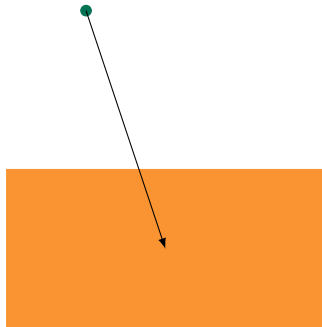
(see also Roth & Franconeri, 2012)

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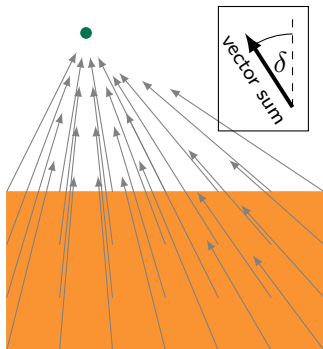
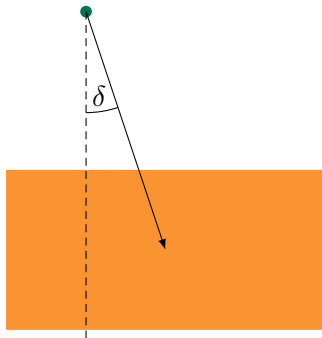
rAVS Model // Comparison to AVS Model

AVS model

reversed AVS (rAVS) model
(Kluth, Burigo, & Knoeferle, 2016)

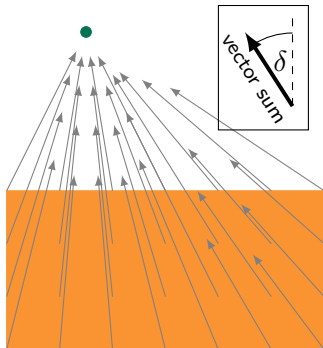
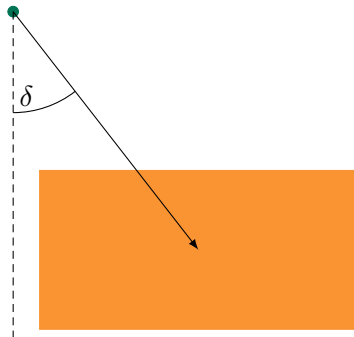
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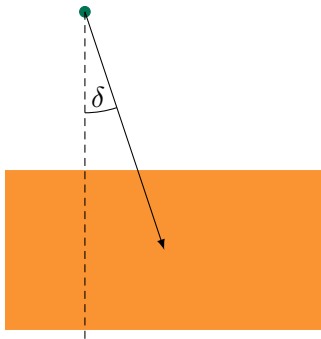
Model Comparison

- models perform equally well on the existing data from Regier and Carlson (2001, see Kluth, Burigo, & Knoeferle, 2016)
- does any of the two models reflect human acceptability ratings better than the other?

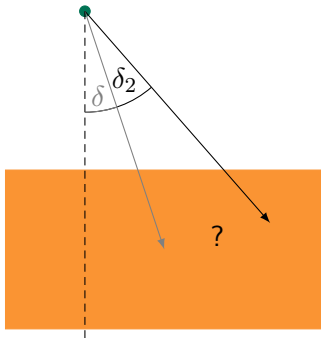
Model Comparison

- models perform equally well on the existing data from Regier and Carlson (2001, see Kluth, Burigo, & Knoeferle, 2016)
 - does any of the two models reflect human acceptability ratings better than the other?
- analyze predictions of models
- “intuitive” reasoning with the mechanisms of the models
 - based on the mechanisms of the rAVS model:
 1. effect of relative distance
 2. effect of asymmetrical ROs

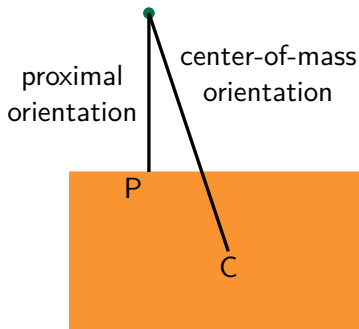
Mechanisms of the rAVS Model



Mechanisms of the rAVS Model

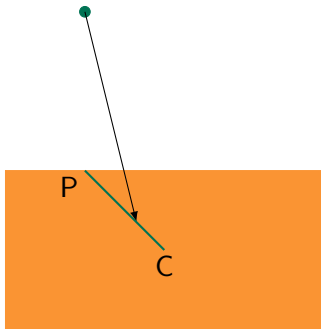


Mechanisms of the rAVS Model

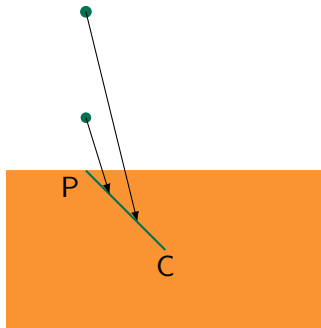


Regier (1996); Regier and Carlson (2001)

Mechanisms of the rAVS Model

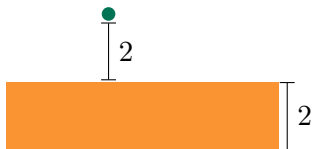


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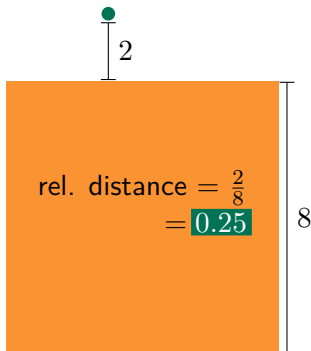


relative distance

Predictions // Relative Distance



$$\begin{aligned}\text{rel. distance} &= \frac{2}{2} \\ &= \mathbf{1}\end{aligned}$$



$$\begin{aligned}\text{rel. distance} &= \frac{2}{8} \\ &= \mathbf{0.25}\end{aligned}$$

$$\text{relative distance} = \frac{|LO, P|_x}{RO_{width}} + \frac{|LO, P|_y}{RO_{height}}$$

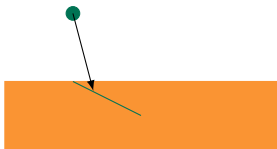
Predictions // Relative Distance



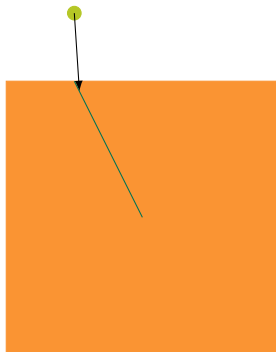
rating is

- equal ● \rightsquigarrow 0
- higher ● \rightsquigarrow +
- lower ● \rightsquigarrow -

Predictions // Relative Distance – rAVS



rAVS: relative distance: 1.0
→ lower acceptability
rating



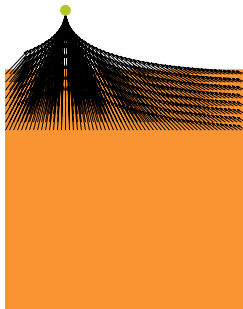
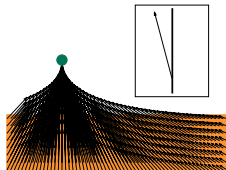
relative distance: 0.25
→ higher acceptability
rating

rating is

- equal ● \rightsquigarrow 0
- higher ● \rightsquigarrow +
- lower ● \rightsquigarrow -

rAVS pattern: -

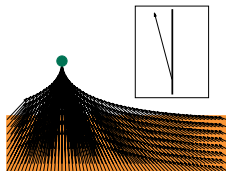
Predictions // Relative Distance – AVS



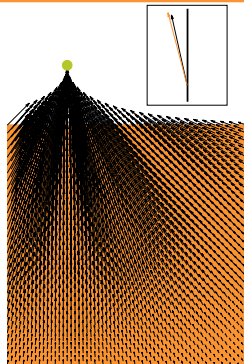
rating is

- equal ● \rightsquigarrow 0
- higher ● \rightsquigarrow +
- lower ● \rightsquigarrow -

Predictions // Relative Distance – AVS



AVS: higher deviation
 → lower acceptability
 rating



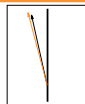
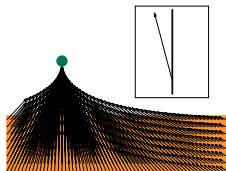
AVS: lower deviation
 → higher acceptability
 rating

rating is

- equal ● ~ 0
- higher ● ~ +
- lower ● ~ -

AVS pattern: -

Predictions // Relative Distance – AVS



rating is

- equal ● \rightsquigarrow 0
- higher ● \rightsquigarrow +
- lower ● \rightsquigarrow -

AVS pattern: ?

but: different
parameters \rightsquigarrow
different
patterns

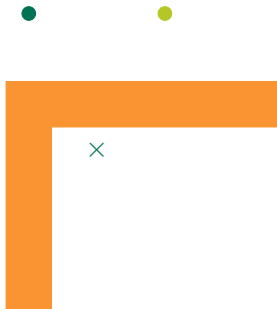
Predictions // Agenda

1. effect of relative distance
2. effect of asymmetrical ROs

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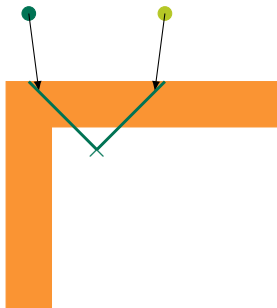
Predictions // Asymmetrical ROs



rating is

- equal ● \rightsquigarrow 0
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- lower ● \rightsquigarrow -

Predictions // Asymmetrical ROs – rAVS



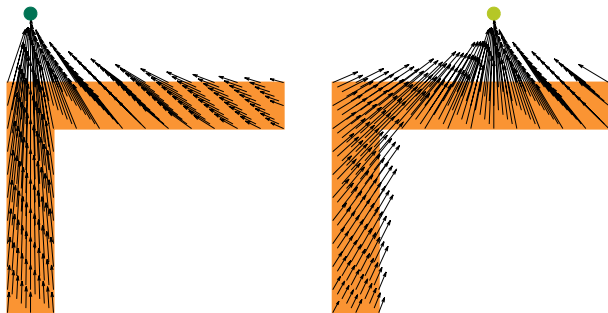
rating is

- equal ● \rightsquigarrow 0
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- lower ● \rightsquigarrow -

rAVS pattern: 0

rAVS: asymmetry of RO is represented in the center-of-mass \rightarrow
equal acceptability ratings

Predictions // Asymmetrical ROs – AVS



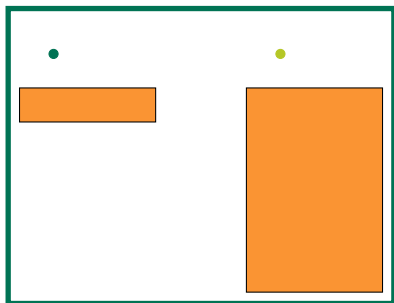
rating is

- equal ● \rightsquigarrow 0
- higher ● \rightsquigarrow +
- lower ● \rightsquigarrow -

AVS pattern: +

AVS: left LO has more mass directly below it (compared to right LO) → left LO is supported by more vectors with low deviation → left LO is rated higher than right LO

Predictions // Summary



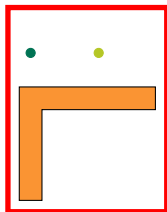
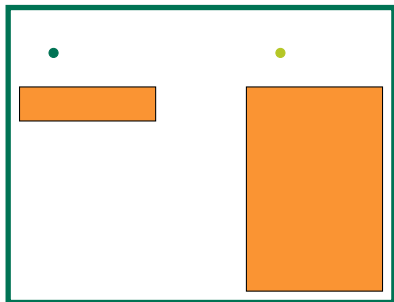
rating is

- equal ● \rightsquigarrow 0
- higher ● \rightsquigarrow +
- lower ● \rightsquigarrow -

rAVS: -

AVS: ?

Predictions // Summary



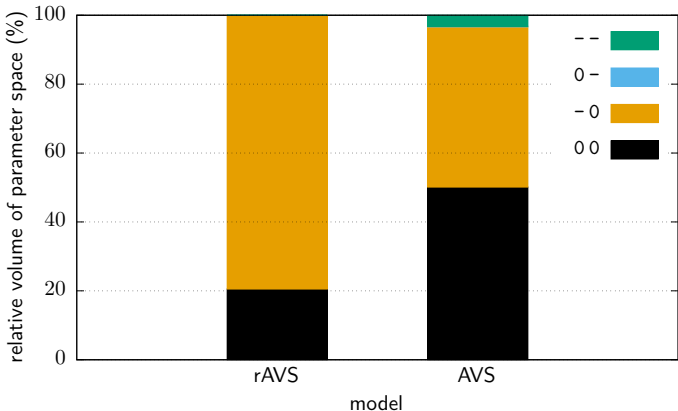
rating is

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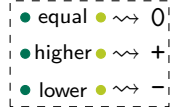
rAVS: -0

AVS: ?+

Parameter Space Partitioning (PSP) // Pitt et al. (2006)



rating is



“intuitive”
patterns:
rAVS: -0
AVS: ?+

Predictions // Discussion of PSP Results

rAVS:

- PSP confirms “intuitive” predictions
 - clear formulation

AVS:

- PSP does *not* confirm “intuitive” predictions
 - harder to understand the mechanisms of the model

Predictions // Discussion of PSP Results

rAVS:

- PSP confirms “intuitive” predictions
 - clear formulation
- generates less predictions:
2 / 9
 - easier to falsify

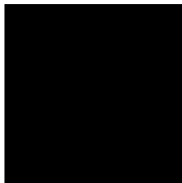
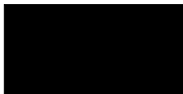
AVS:

- PSP does *not* confirm “intuitive” predictions
 - harder to understand the mechanisms of the model
- generates more predictions:
4 / 9
 - harder to falsify

Empirical Study

- test predictions of models empirically
- two conditions:
 - relative distance
 - asymmetrical ROs
- two prepositions:
 - 'über' (above / over)
 - 'unter' (below / under)

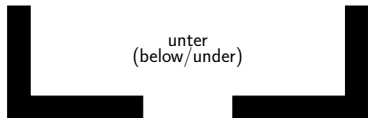
Empirical Study // Materials – Relative Distance ROs



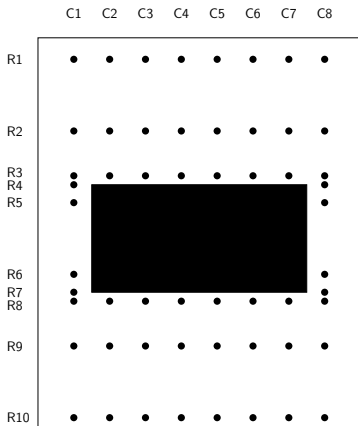
Empirical Study // Materials – Asymmetrical ROs



Empirical Study // Materials – Asymmetrical ROs



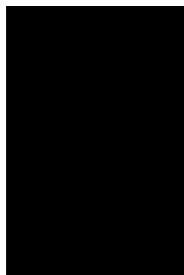
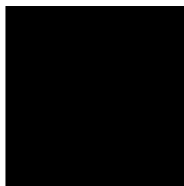
Empirical Study // Materials – LOs & Linguistic Input



Der Punkt ist über / unter dem Objekt.
The dot is above / below the object.
over / under

- 28 LOs \times 2 prepositions \times 8 ROs
= 448 trials
- 34 native German speakers
participated (mean age: 23.79)
- rating scale: 1 – 9

Analysis // Relative Distance



baseline RO

three difference scores:

①

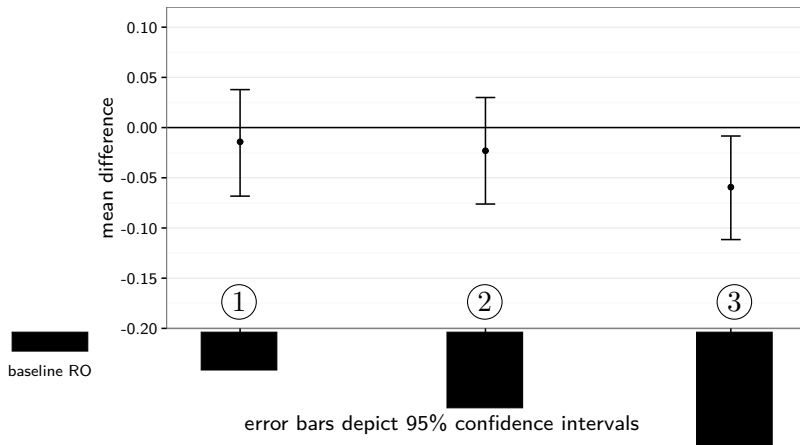
②

③

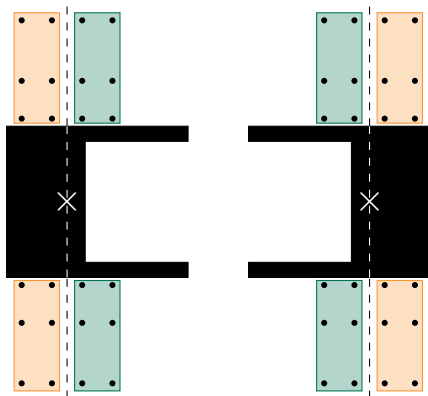
'über' and 'unter' ratings

Results // Relative Distance

relative distance effect, 'über' & 'unter' ratings

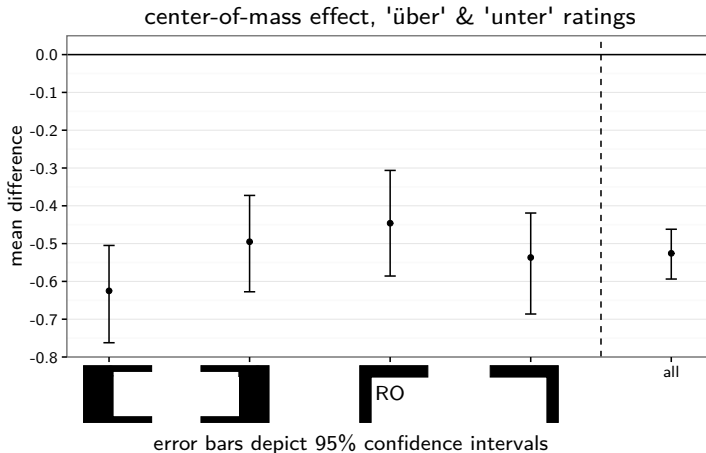


Analysis // Asymmetrical ROs – Center-of-Mass

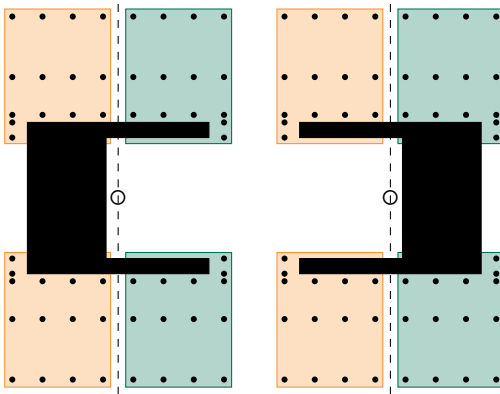


- 'über' and 'unter' ratings
- ratings for LOs above mass minus ratings for LOs above cavity

Results // Asymmetrical ROs – Center-of-Mass

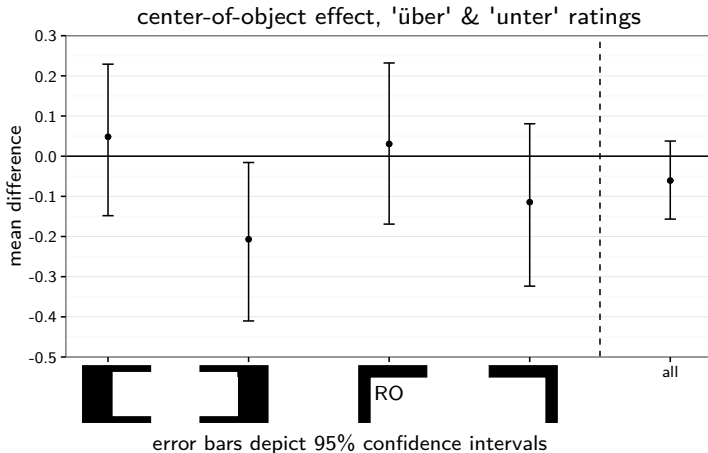


Analysis // Asymmetrical ROs – Center-of-Object



- 'über' and 'unter' ratings
- ratings for left LOs minus ratings for right LOs

Results // Asymmetrical ROs – Center-of-Object



Discussion // Effects of RO Shape

- relative distance affects acceptability ratings
 - confirms predictions by the rAVS model

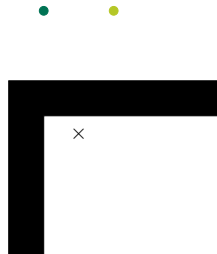
empirical pattern: -



Discussion // Effects of RO Shape

- relative distance affects acceptability ratings
 - confirms predictions by the rAVS model
- center-of-mass orientation had not the effect suggested by Regier (1996); Regier and Carlson (2001)
 - disconfirms both models

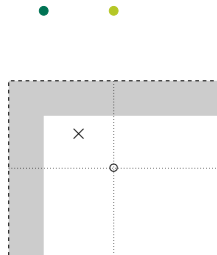
empirical pattern: --



Discussion // Effects of RO Shape

- relative distance affects acceptability ratings
 - confirms predictions by the rAVS model
- center-of-mass orientation had not the effect suggested by Regier (1996); Regier and Carlson (2001)
 - disconfirms both models
- people seem to rely on the center-of-object instead
 - work in progress to include the center-of-object into both models
(Kluth, Burigo, Schultheis, & Knoeferle, 2016b, in preparation)

empirical pattern: --



Conclusion // Shift of Attention

- What can we learn about the direction of the shift of attention?

Conclusion // Shift of Attention

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 - empirical study designed to test for predicted *ratings*
 - prediction from the rAVS model confirmed (relative distance)
 - indirect support for a shift from the LO to the RO

Conclusion // Shift of Attention

- What can we learn about the direction of the shift of attention?
 - empirical study designed to test for predicted *ratings*
 - prediction from the rAVS model confirmed (relative distance)
 - indirect support for a shift from the LO to the RO
- future work: (Kluth, Burigo, Schultheis, & Knoeferle, 2016a; Kluth et al., in preparation)
 - assess the models on the data
 - conduct a visual world paradigm study

Thank you for your attention!

References

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