EYETRACKING WORKSHOP

visual world

CAnDA
Göttingen September 2022

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experimental methods: on line

Visual World paradigm with eye movements recording

assumption

language-related cognitive processes
take time

the more complex they are
the more time they take

eye-mind revisited: eyes move to the picture that is maximally relevant for the interpretation adopted by the participant as it becomes available

pros

may inform in the on line comprehension processes

tells exactly at which point participants develop a given interpretation

informs on how relevant and salient the object on the scenario are and whether they facilitate/interfere with on line processing

cons

~~hard to implement~~
~~hard to analyze~~
~~costly instrument~~

Visual World experiment with eye-tracking

assumptions →

language-related cognitive processes take time ↓

the more complex they are
the more time they take

↓

the eye-mind assumption revisited

⇩

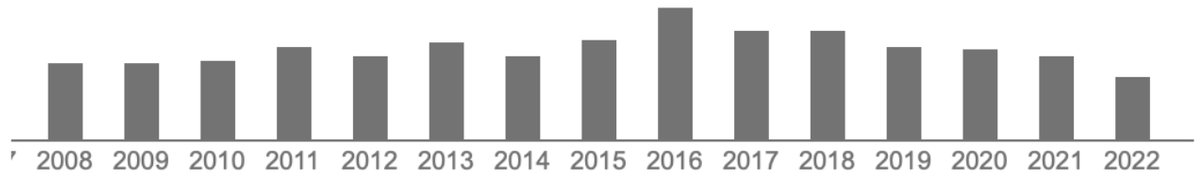
the eyes move to the picture that is maximally relevant for the interpretation that is adopted by the participant as it becomes available

Visual World experiment with eye-tracking

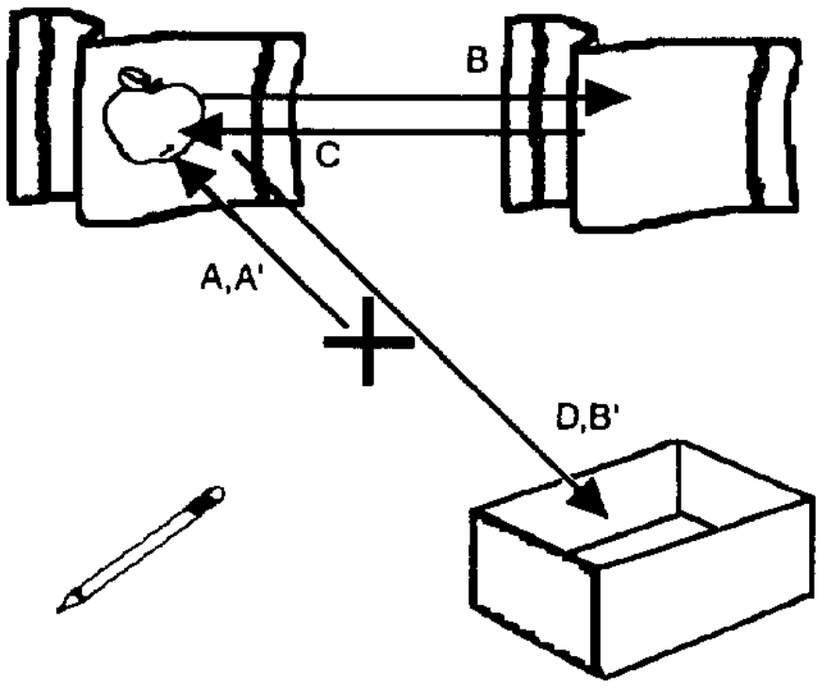
Integration of Visual and Linguistic Information in Spoken Language Comprehension

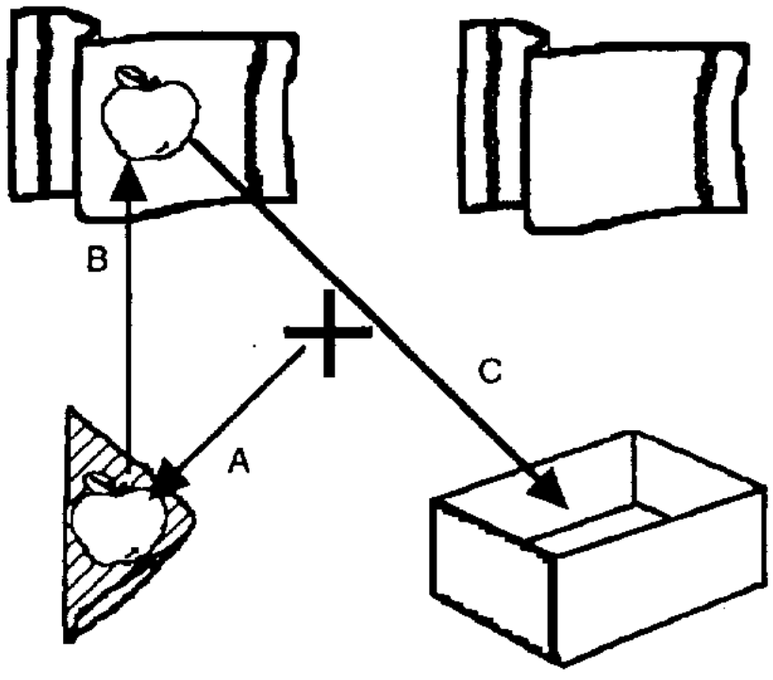
Michael K. Tanenhaus,* Michael J. Spivey-Knowlton,
Kathleen M. Eberhard, Julie C. Sedivy

1995

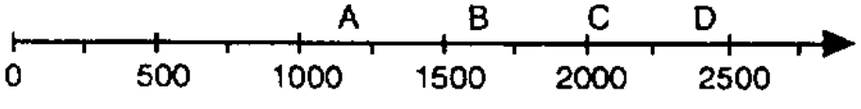


3313 citations over time





"Put the apple on the towel in the box."



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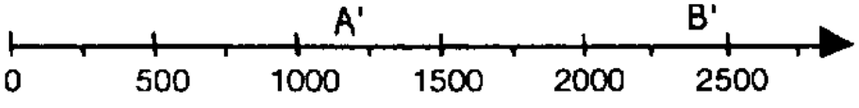
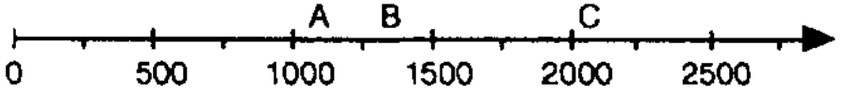


Time (ms)

"Put the apple on the towel in the box."



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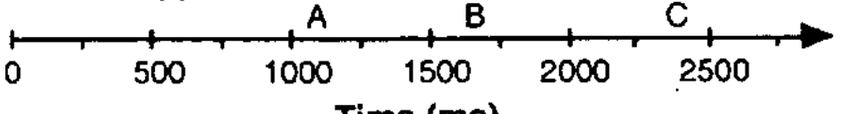
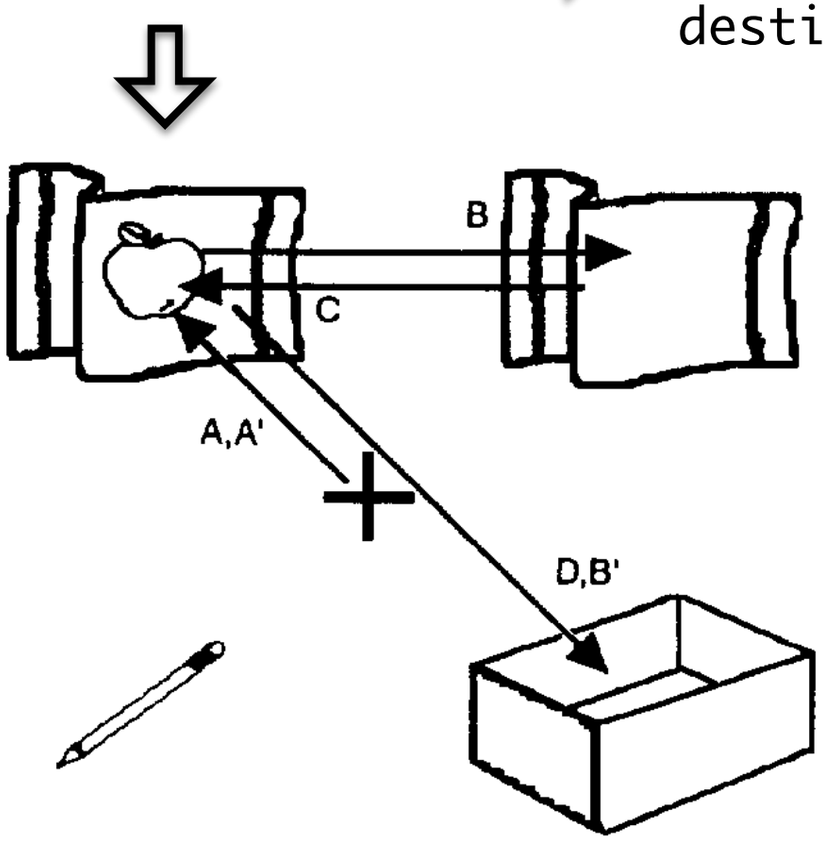
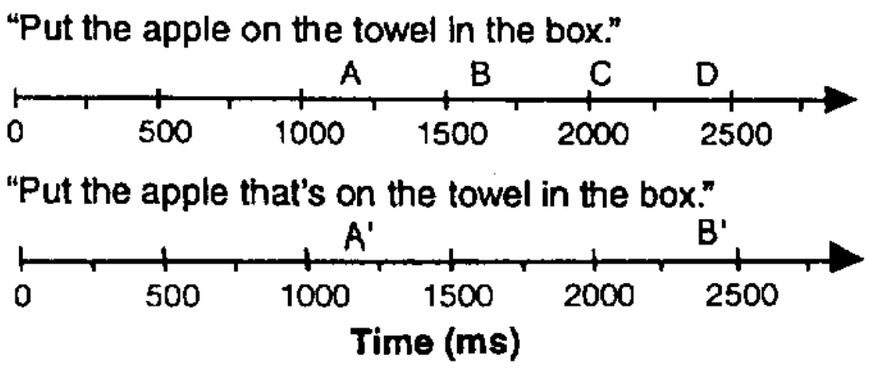


Time (ms)

Visual World experiment with eye-tracking

looks towards the incorrect location ⇨ ‘on the towel’ interpreted as destination





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vs.

no looks to the incorrect destination in the unambiguous condition

Visual World experiment with eye-tracking

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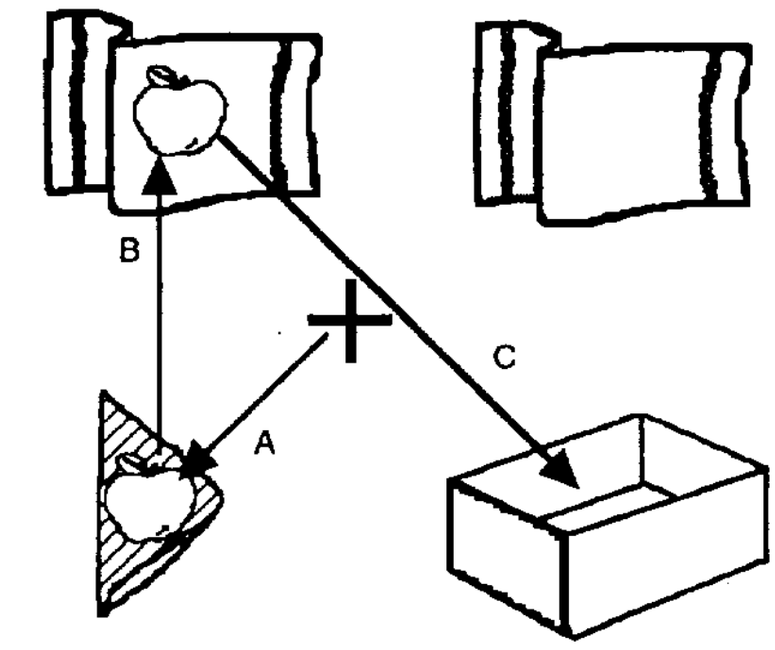
no differences between ambiguous and unambiguous condition in the looks to the correct destination (the box)

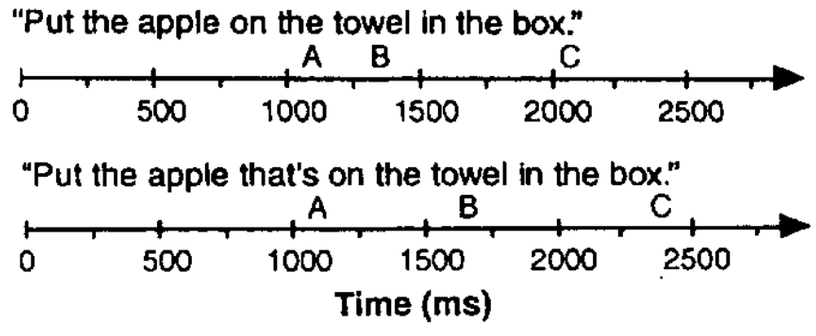
initial referential uncertainty:
looks at both apples

⇩

on the towel immediately interpreted as modifier (not destination)

⇨





Visual World experiment with eye-tracking

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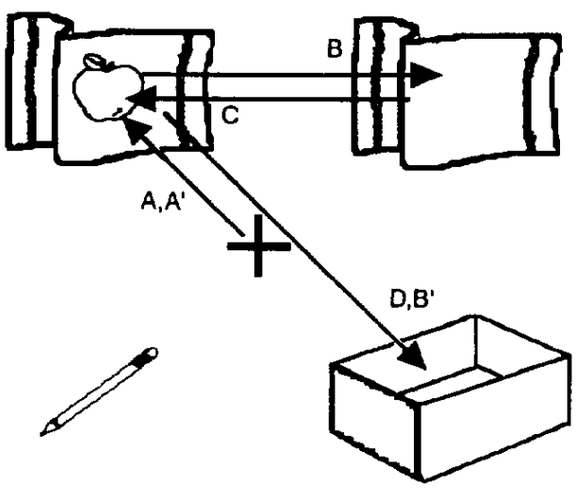
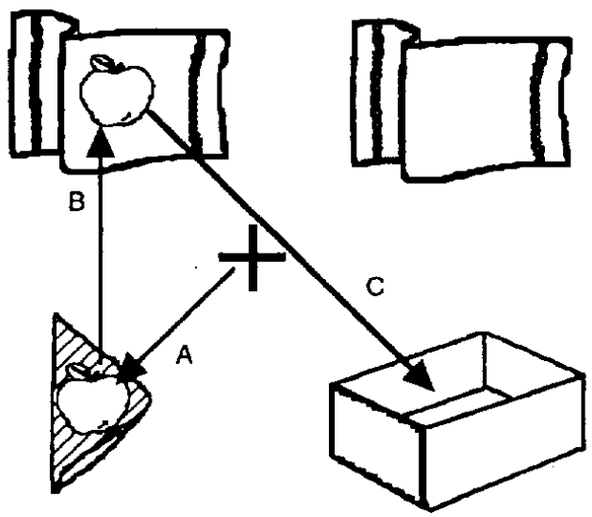
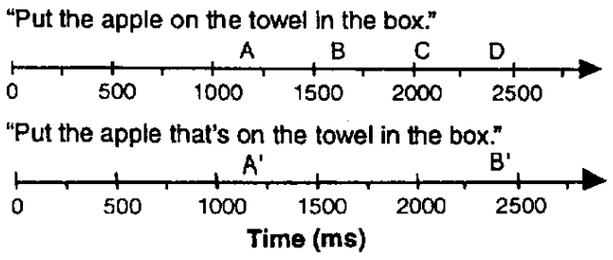
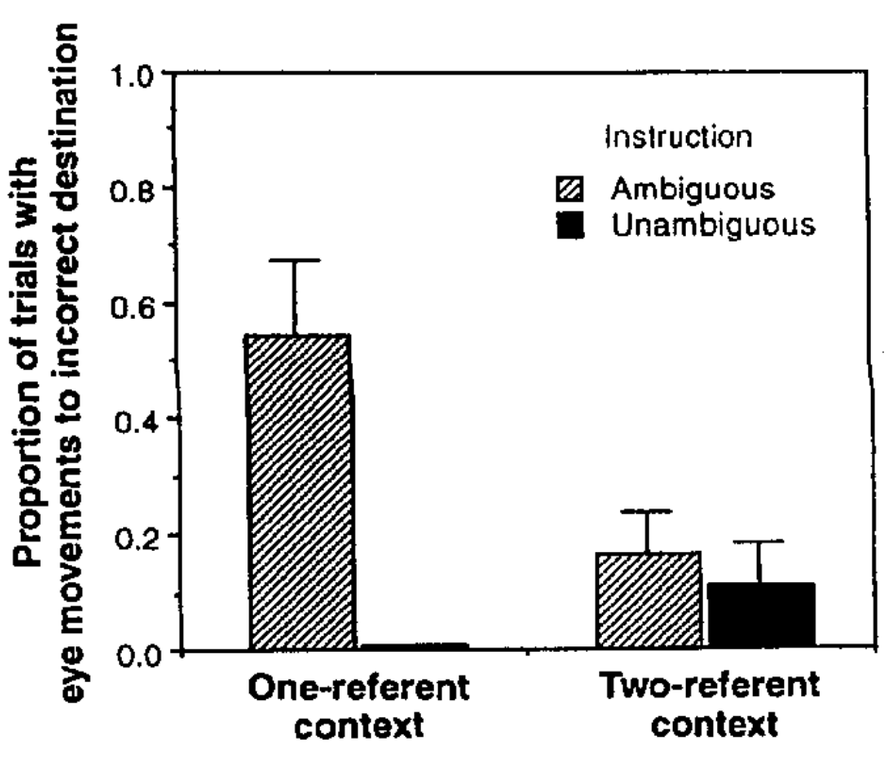








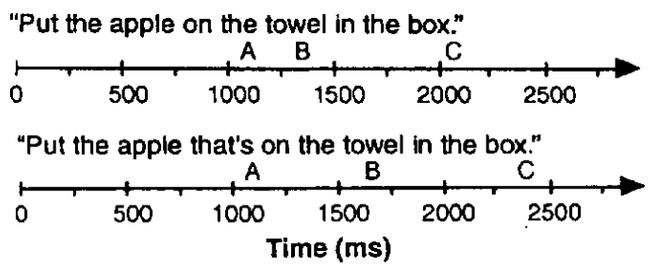


Fig. 3. Proportion of trials in which participants looked at the incorrect destination.

Visual World experiment with eye-tracking

pros

- tells us something about what representation is processed
- tells us exactly when it becomes available to the interpreter
- informs on the saliency of the objects present in the visual scenario and whether they facilitate/interfere with the on line processing of the linguistic input
- very valuable in semantic/pragmatic psycholinguistic research
- permits the manipulation of the prosody

scalar computation takes time

---

reaction times

Bott & Noveck (2004)

"some elephants are mammals"

pragmatic responders ("no") take more time

reading times

Breheny et al. (2006)

"The director had a meeting with *some* of the consultants.

The rest did not manage to attend."

penalty at 'the rest' with biased context

Panizza et al. (2009)

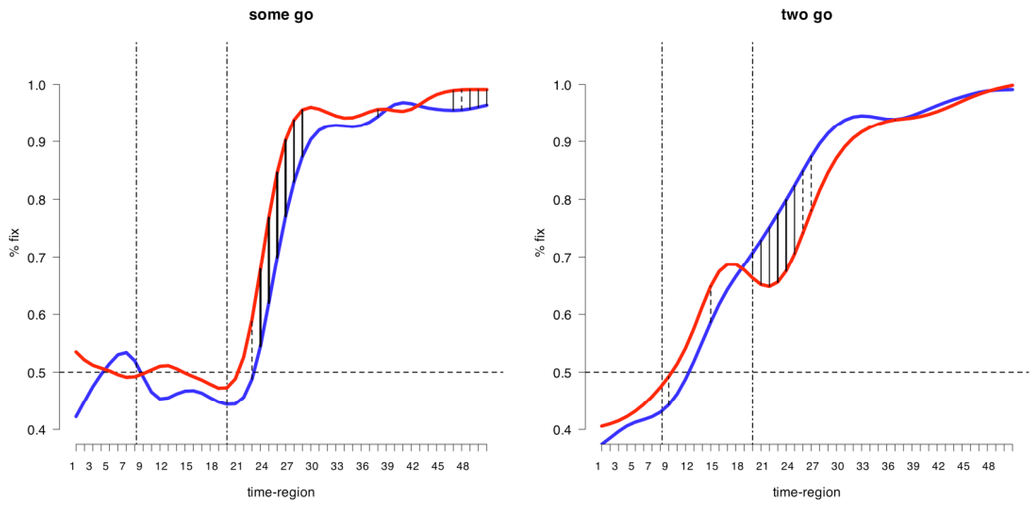
" (if) John parked two cars in the garage,

and he parked a third card in the courtyard."

slow down in UE, reanalysis in DE

reference resolution (visual world paradigm)

Snedeker et al. (2009),
Panizza et al. (2009)

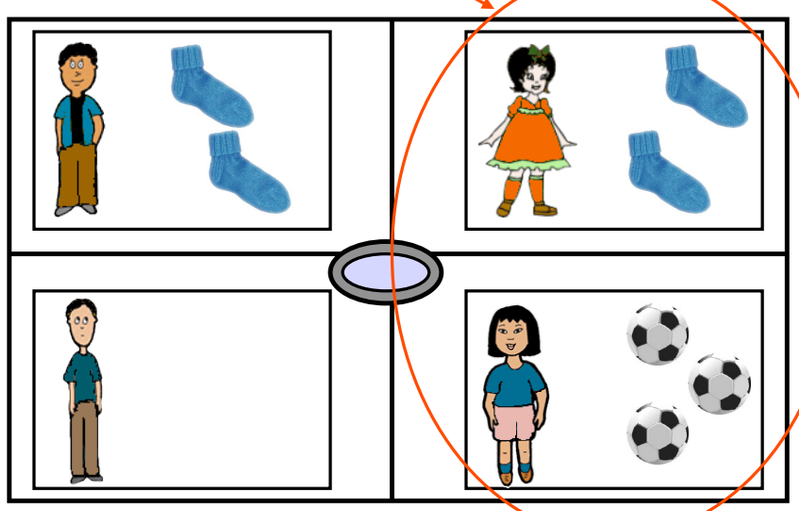


late access to "some but all" meaning

the Visual Word paradigm (with children)

Huang & Snedeker, 2009.
Huang, Spelke & Snedeker, 2013

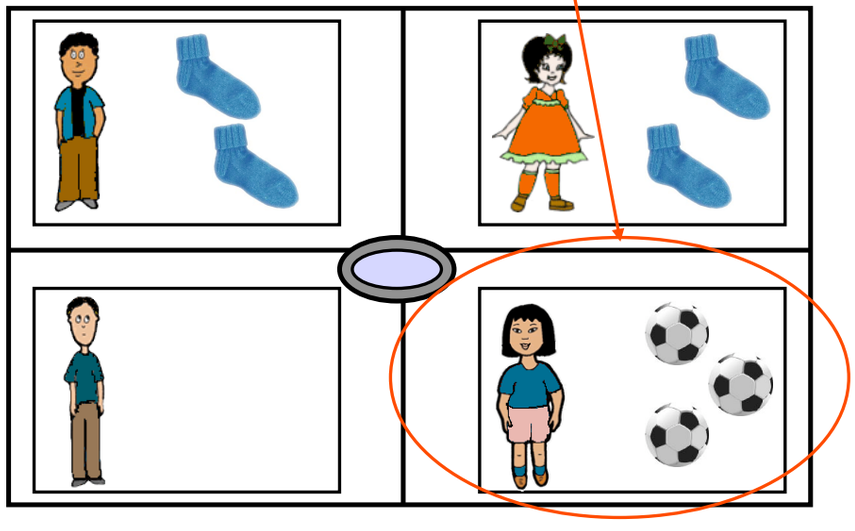
- "Point to the girl that has three of the soccer balls."



control conditions

there is only one possible referent for the verbal description

- "Point to the girl that has all of the soccer balls."



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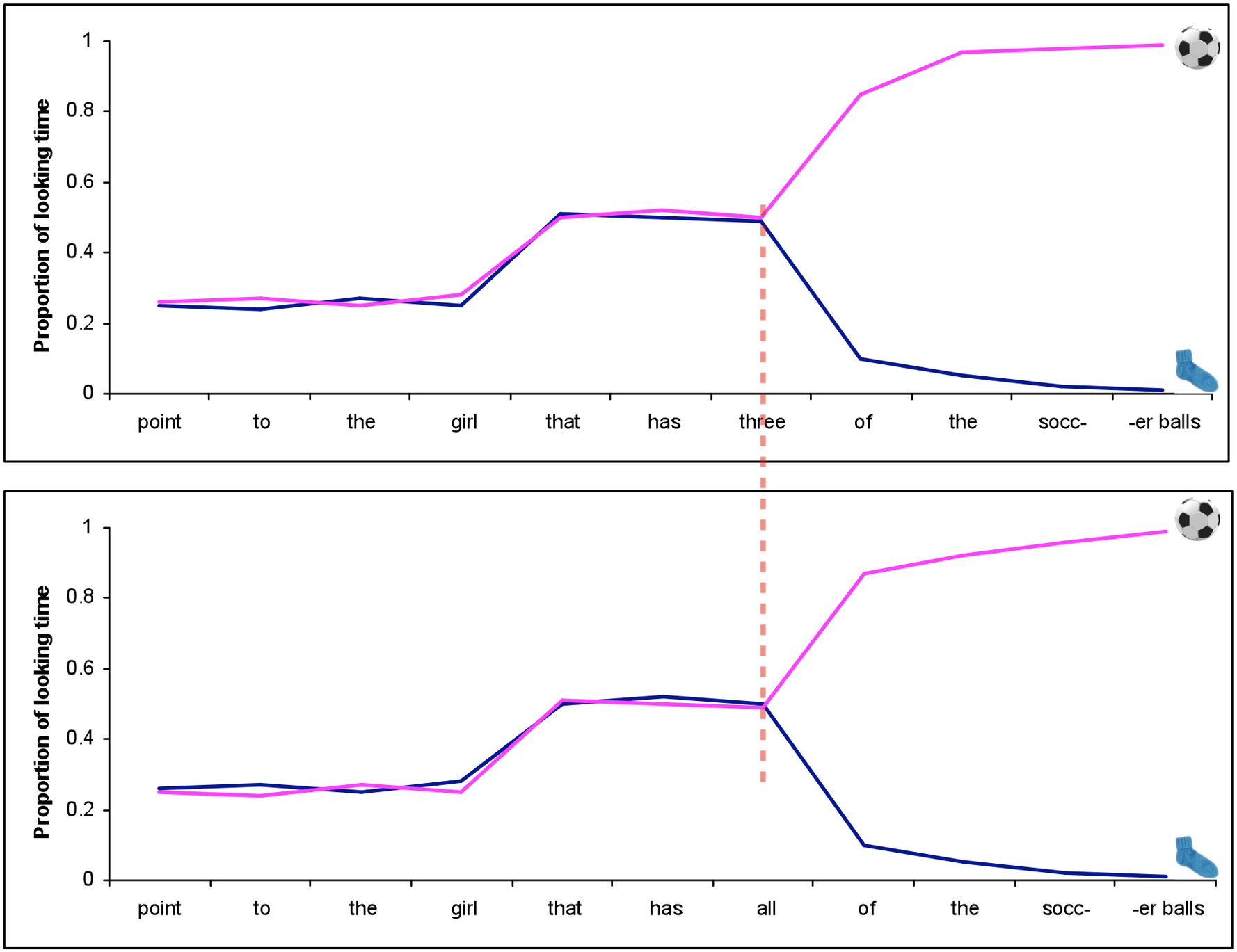
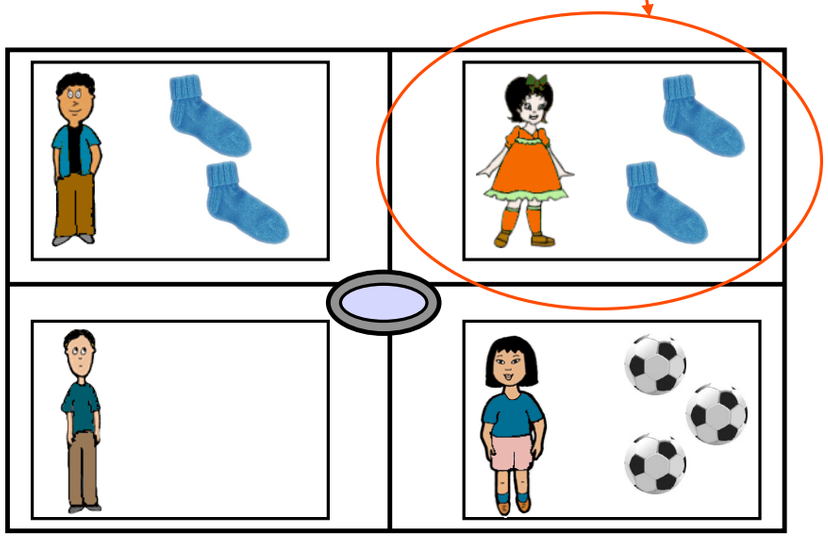


Similar points of disambiguation

Visual Word paradigm

- “Point to the girl that has two of the socks.”



two and not more

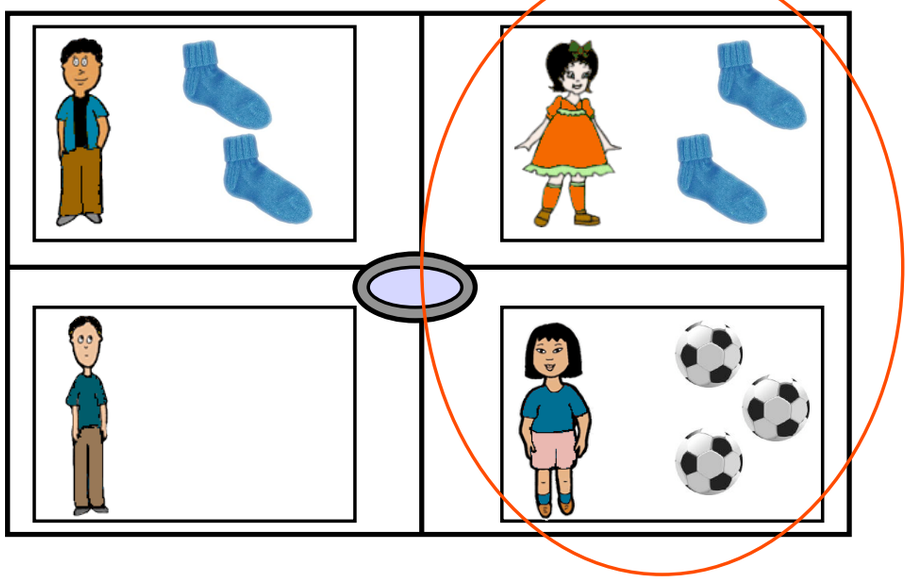
to identify the target before hearing the continuation (sock/ soccer) the computation of an implicature is required

some and not all

test conditions

possible referential ambiguity up to "soc..."

- “Point to the girl that has some of the socks.”



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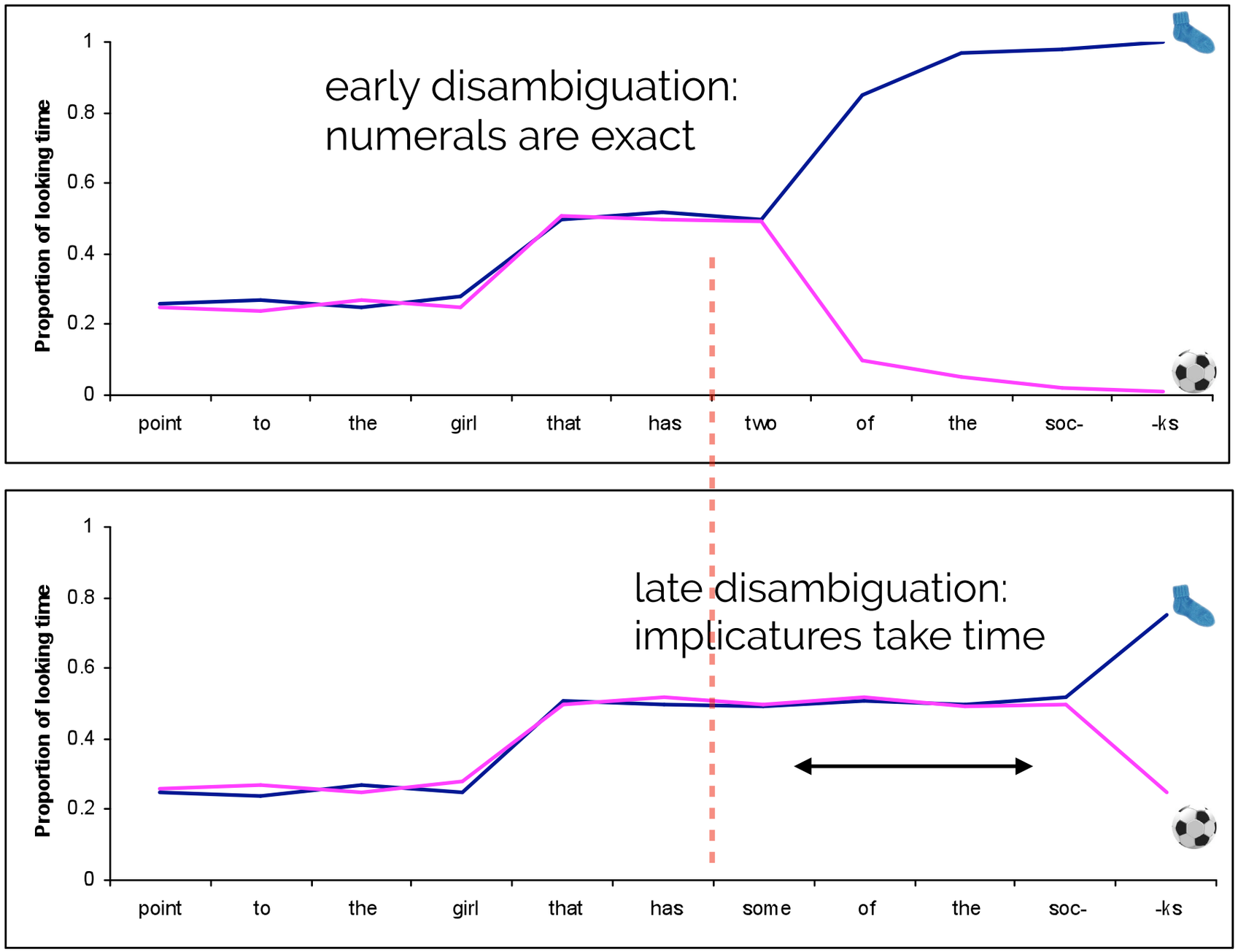

RESULTS

Different points of disambiguation

scalar computation takes time

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why?

- scalar meaning needs to be derived
- effortful Gricean process
- scalar meaning is more complex
- scalar meaning more difficult to integrate
- experiments present confounds

- scalar meaning needs to be derived
- effortful Gricean process

---

neo-Gricean view

assertion

Speaker: "Gianni met *some of the* students"

automatic reasoning

Addressee: **knows** that Speaker observes Gricean maxims

knows that Speaker could have uttered

"Gianni met *all the* students"

infers that Speaker uttered "*some*" because he was not in the position to utter "*all*" (***maxim of quantity***)

implicature: "Gianni met *some of the* students <u>but not all</u>"

defeasible: "Gianni met *some of the* students, in fact he met <u>all of them</u>"

- scalar meaning is more complex than literal meaning

John pressed some of the oranges

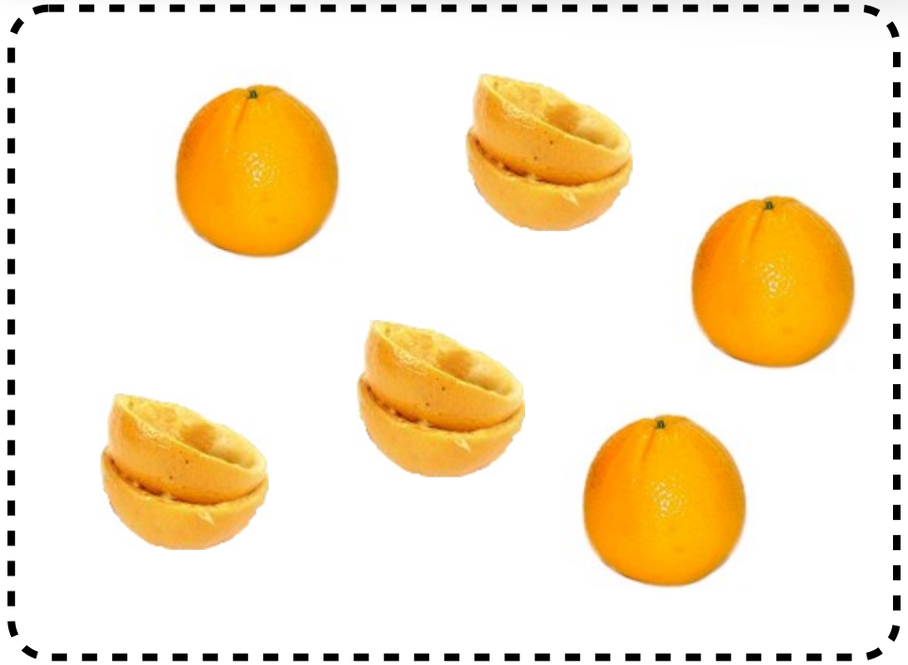
[some and maybe all

∃x]

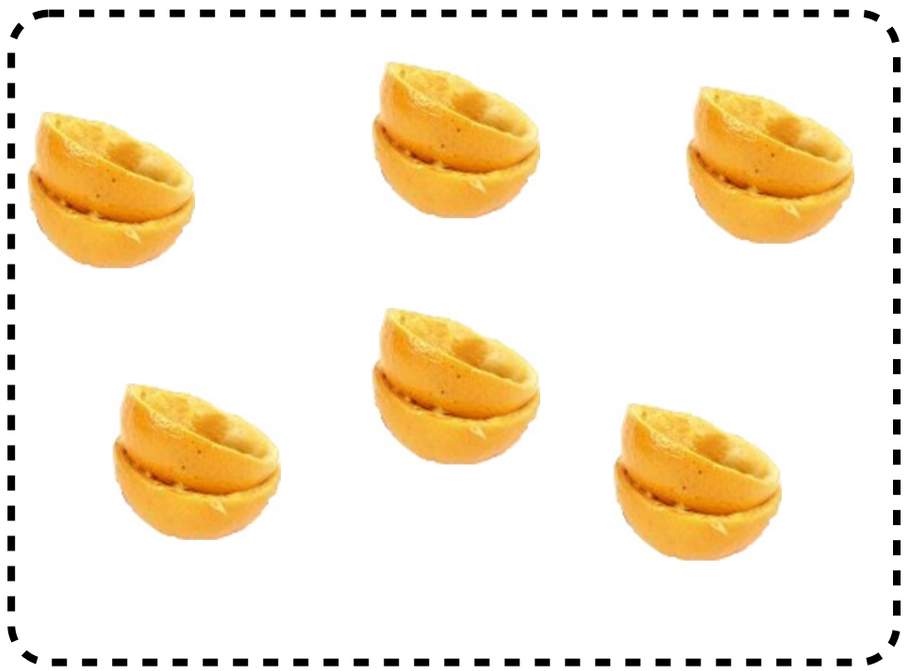
it is sufficient to represent
a set of pressed oranges

no further restrictions
are applied

state a



state b



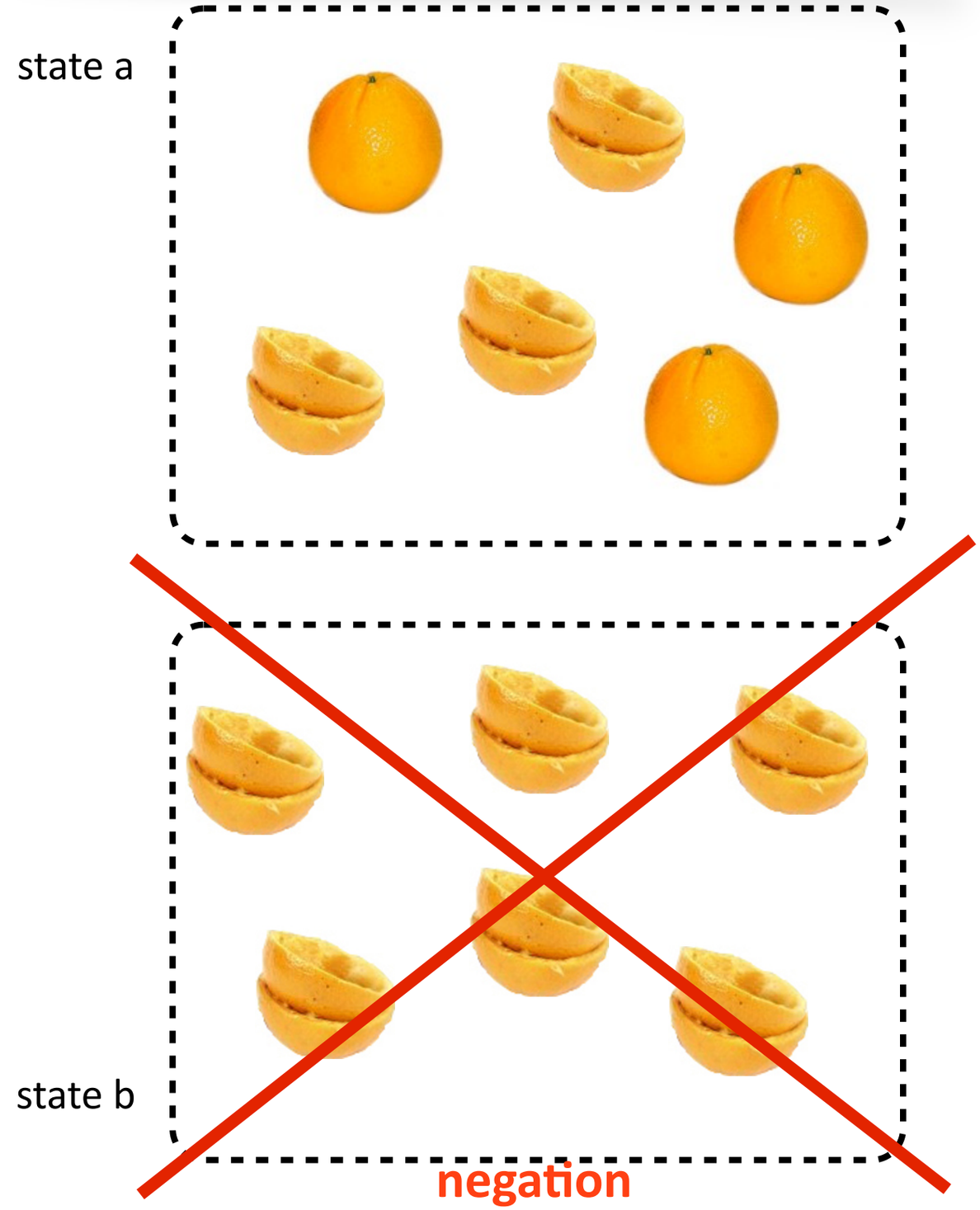
- scalar meaning is more complex than literal meaning

John pressed some of the oranges

[some but not all
$\exists x \wedge \neg \forall x$]

involves negation
of the whole set

more complex!



scalar computation takes time

---

why?

- scalar meaning needs to be derived
- effortful Gricean process
- scalar meaning is more complex
- scalar meaning more difficult to integrate
- early experiments present confounds

Grodner et al. (2010) Breheny et al. (2013)

Grodner et al. (2010) — Some and possibly all scalar inferences are not delayed

---

research question — when do scalar interpretations arise relative to literal content?

- pragmatic meaning not immediately available

  literal meaning must be decoded first in order to decide whether to make the scalar inference

  or

  SI arises by default but it takes time to be computed

- pragmatic meaning immediately available

  scalar terms systematically ambiguous

  or

  context directs the interpretational process towards one or the other interpretation

Grodner et al. (2010)	Some and possibly all scalar inferences are not delayed

experimental design

- replacing *some* with *summa* (phonetically reduced form)

- no number control trials, only quantifiers (some, all, none)

- the attention of participants was drawn on the set of objects by describing them with numbers (e.g. “there are four balloons..”)

Grodner et al. (2010)

Some and possibly all scalar inferences are not delayed

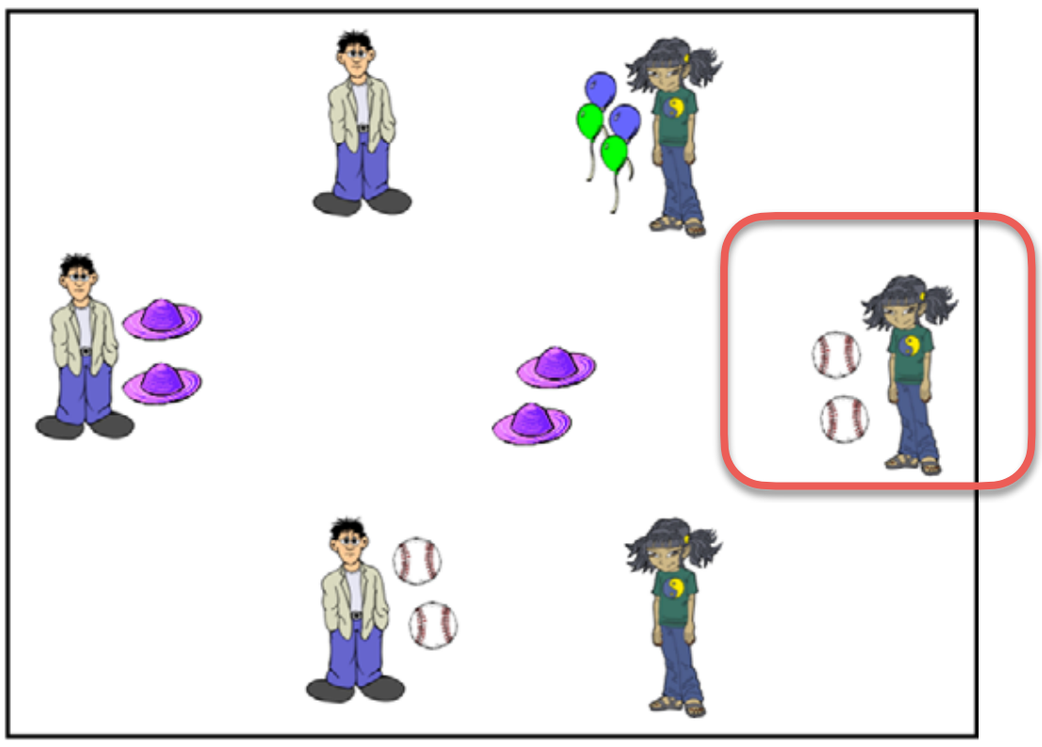
---

experimental design

click on the girl who has some of the… balls

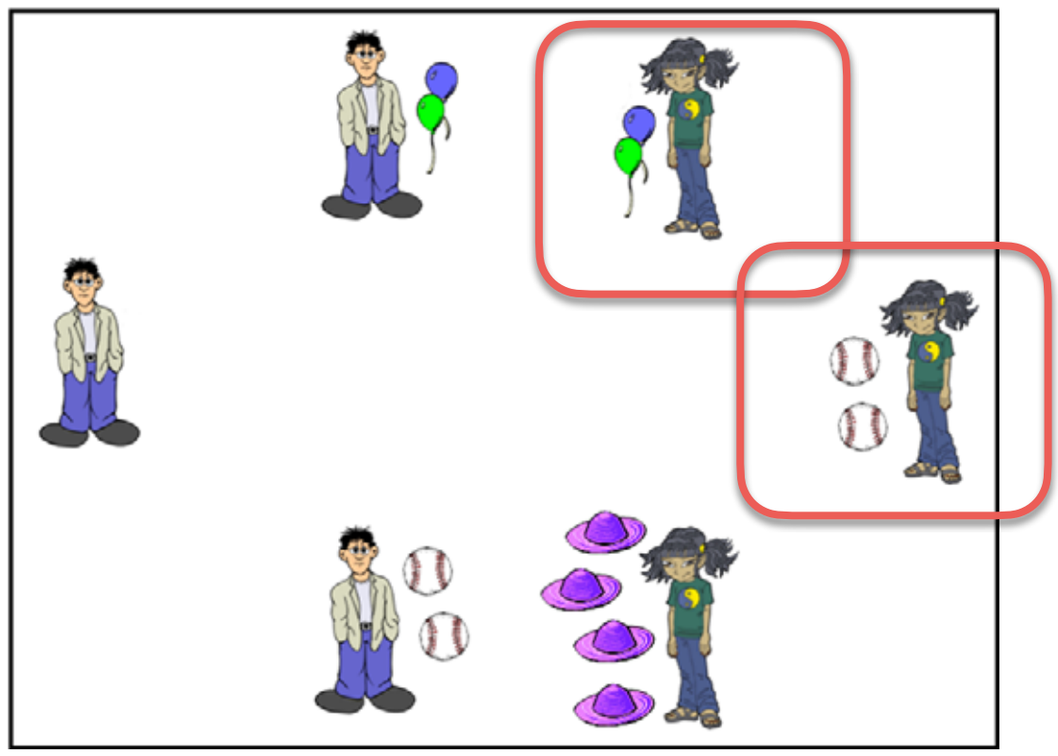
early summa

only one possible referent under pragmatic interpretation



late summa

two possible referents under pragmatic interpretation

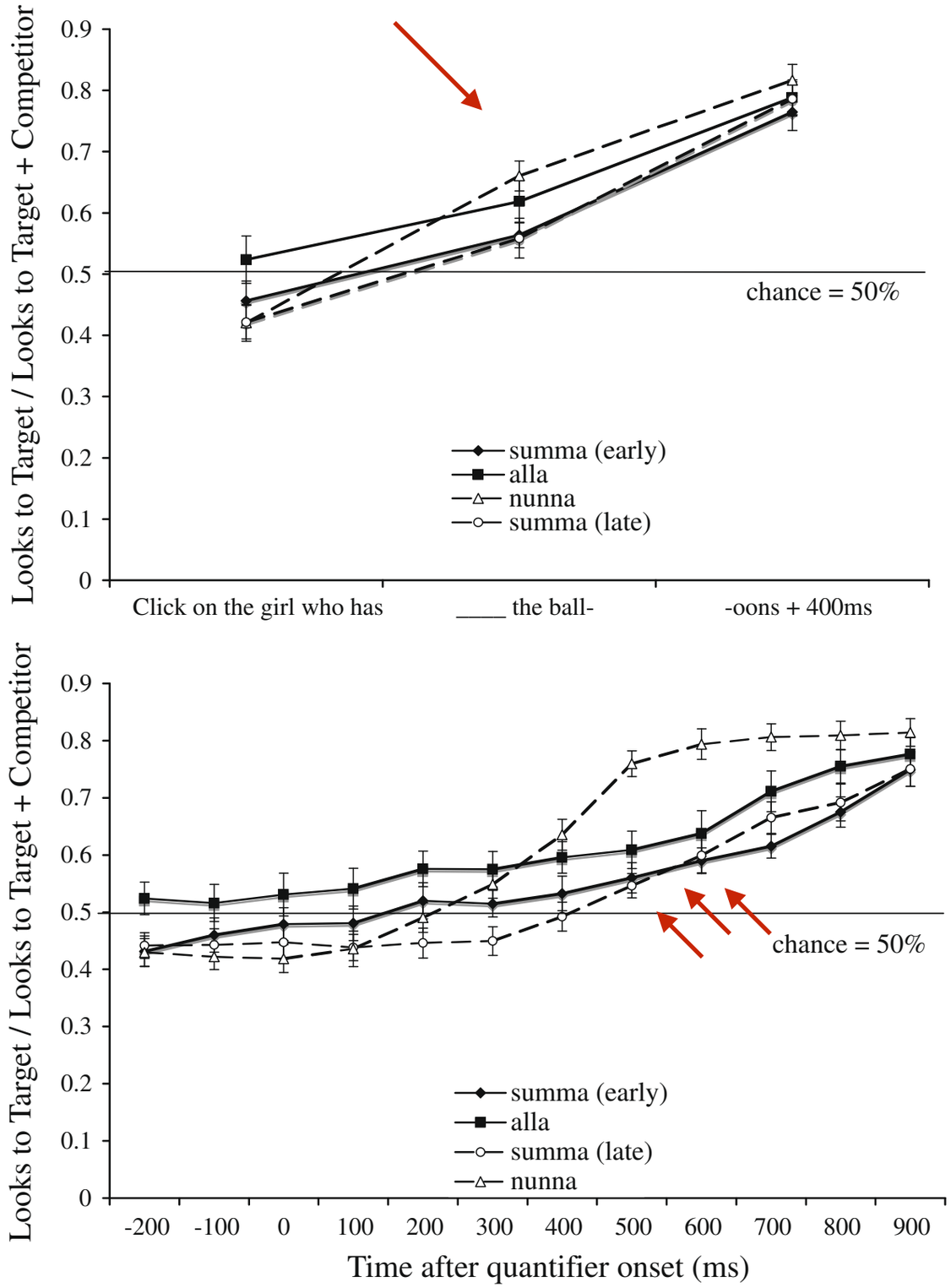


Grodner et al. (2010)

Some and possibly all scalar inferences are not delayed

results

every condition was disambiguated in the quantifier region!



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results

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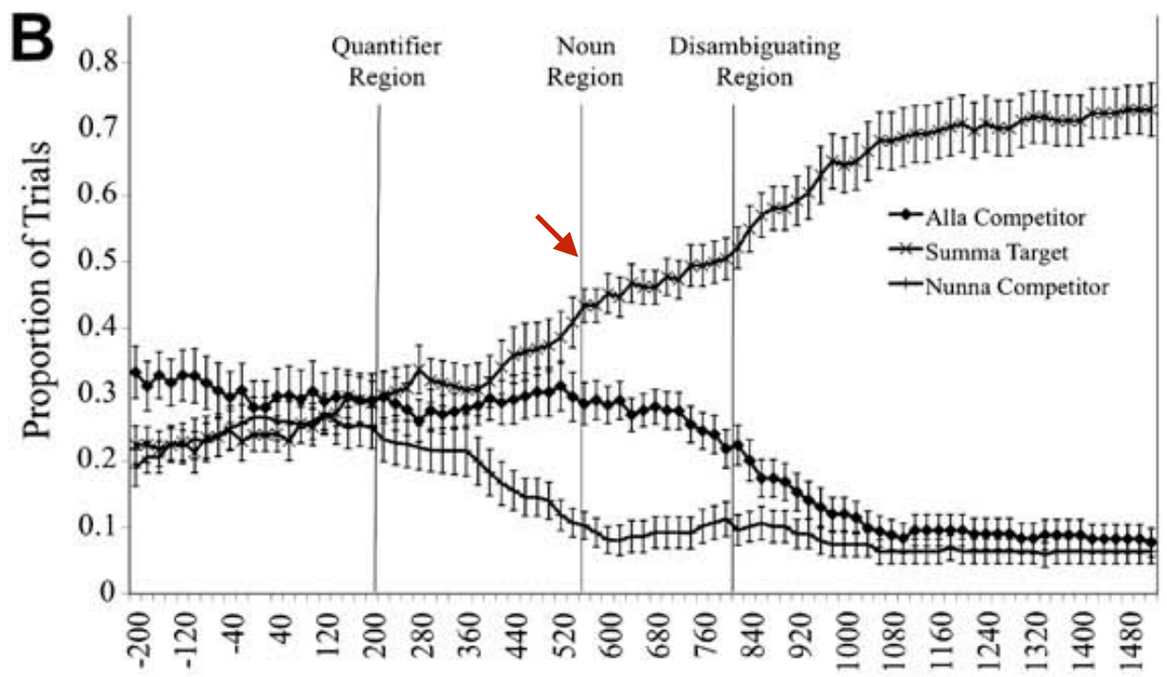
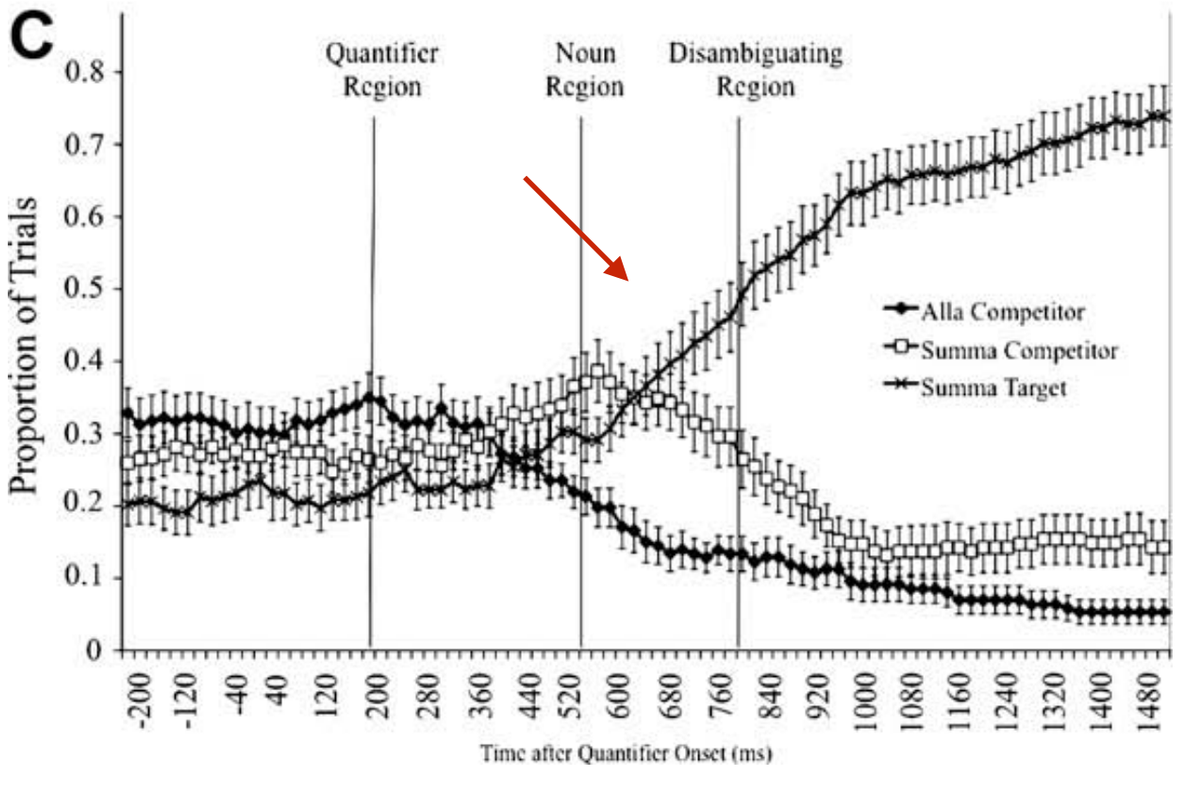
200-400 ms after the onset of the quantifier (all, some, none)



late summa



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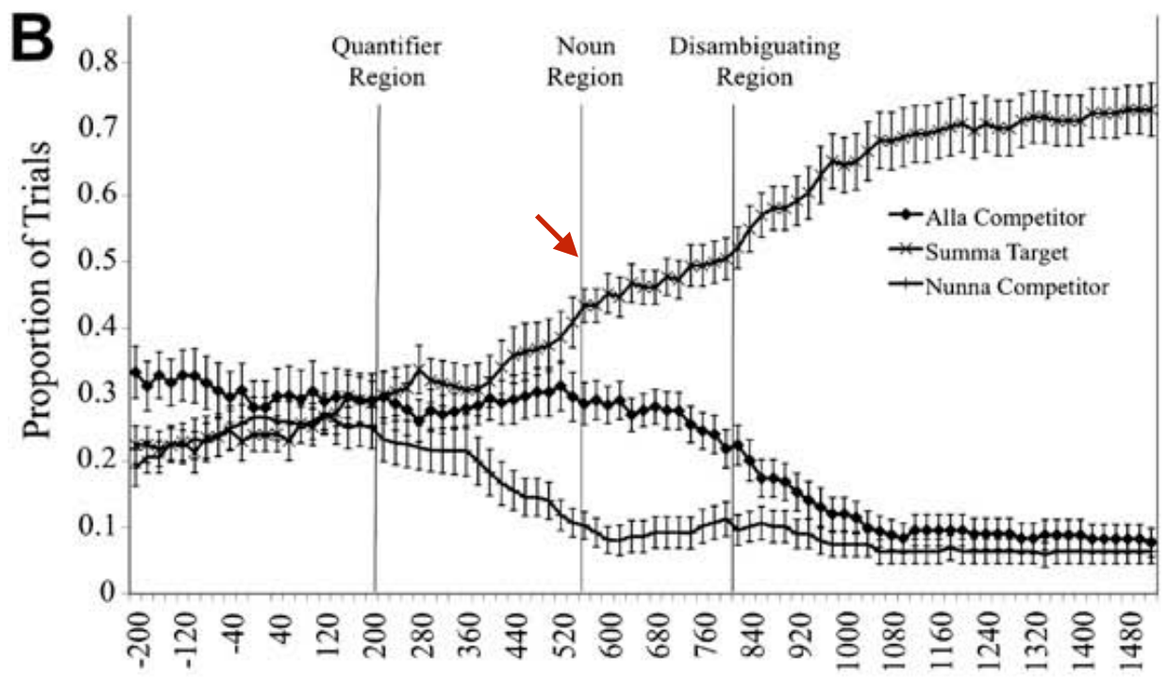
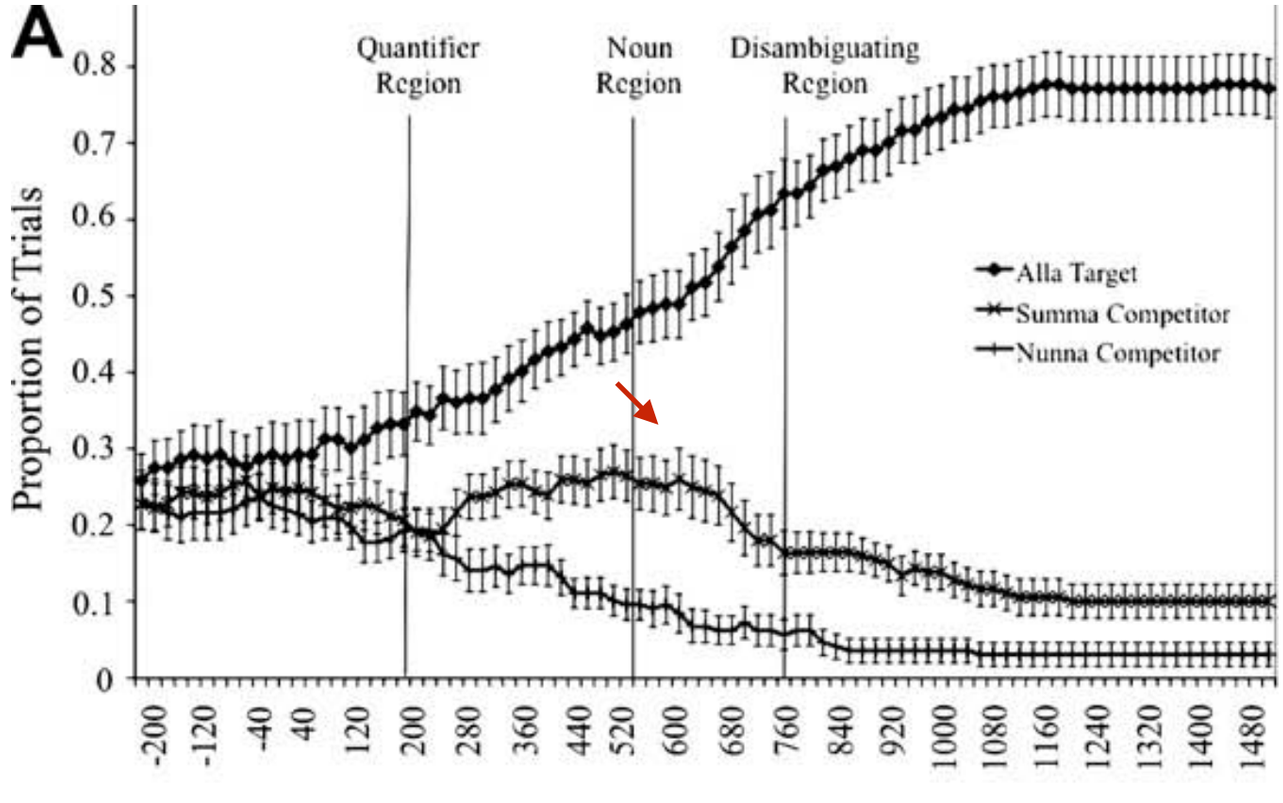


alla

no difference between semantic vs. pragmatic disambiguation (all vs. some)



Grodner et al. (2010)	Some and possibly all scalar inferences are not delayed

discussion

- scalar meaning arises very early

  earlier than previously found delays
  (800-1000 ms in Huang & Snedeker, 600 in Noveck et al.)

- pre encoding of the visual display?

  probably not: even stronger effect in first half of trials

  more than half of fillers included definite descriptions
  (‘*the girl who has the scissors*’)

- presence of partitive (absent in Huang & Snedecker but present in Panizza et al.) and lack of number trials could have brought up the effect

Grodner et al. (2010)	Some and possibly all scalar inferences are not delayed

conclusions

- literal content (some and maybe all) must *not* be computed before pragmatic meaning (some and maybe all)

- when scalar inference requires more processing time, it is because integrating its interpretation with the context may require additional processing

Breheny et al. (2012)

Investigating the timecourse of accessing conversational implicatures during incremental sentence interpretation

---

look and listen task (Altmann & Kamide, 1999)

eye movements are tracked while participants listens to some related discourse

participants **anticipate** the content of the next words based on compositional interpretation (rather than mere lexical association)

ex. "*the man will drink all the beer*" (full glass)
vs. "*the man has drunk all the wine*" (empty glass)

research question:

can participants use scalar implicatures to anticipate the referent of the discourse?

Breheny et al. (2012)

Investigating the timecourse of accessing conversational implicatures during incremental sentence interpretation

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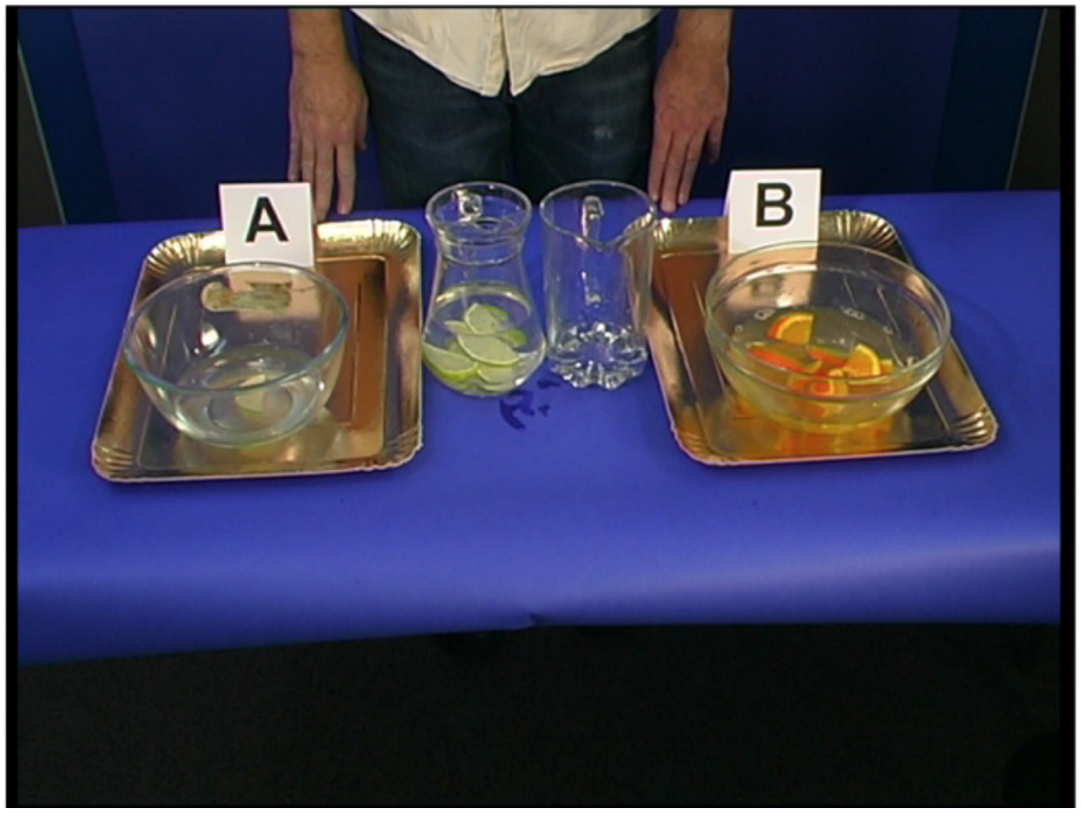
3 experimental conditions (all, early some, late some)

(a)

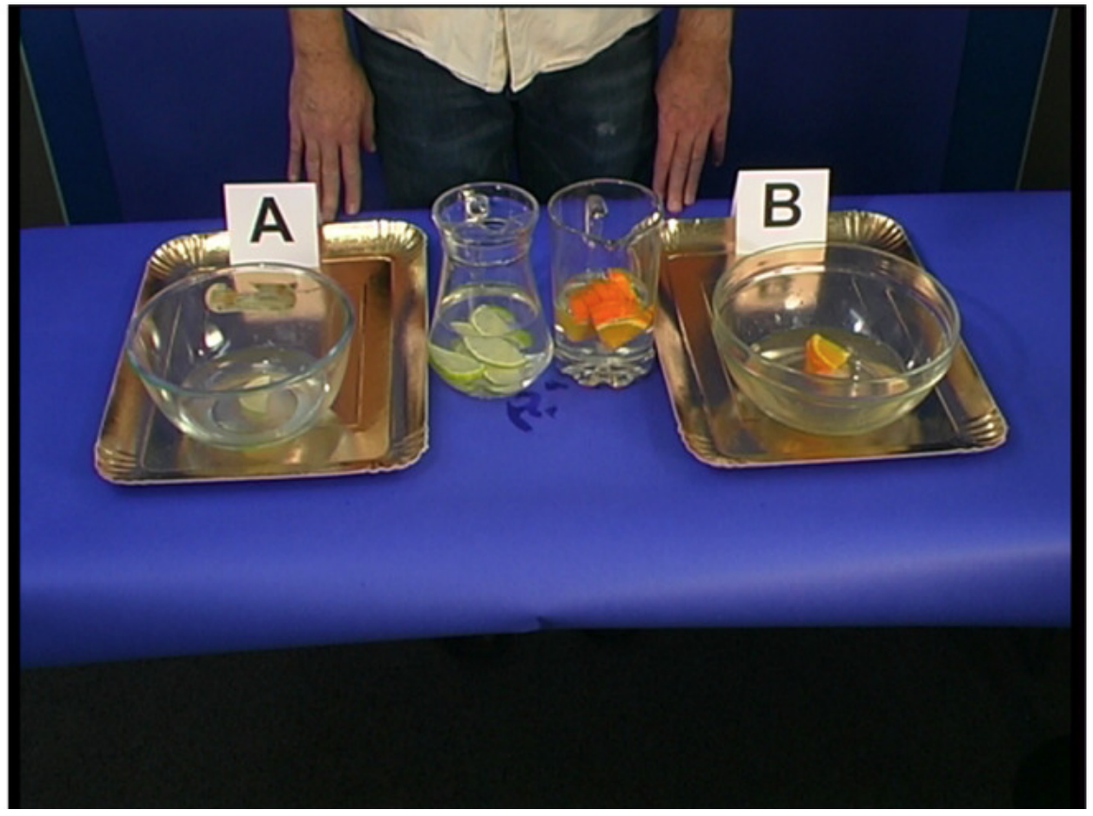


all, early some

The man has poured all of the water with oranges into the bowl on tray B and **some** of the water with limes into the bowl on tray A.

The man has poured **some** of the water with limes into the bowl on tray A and **all** of the water with oranges into the bowl on tray B.

(b)



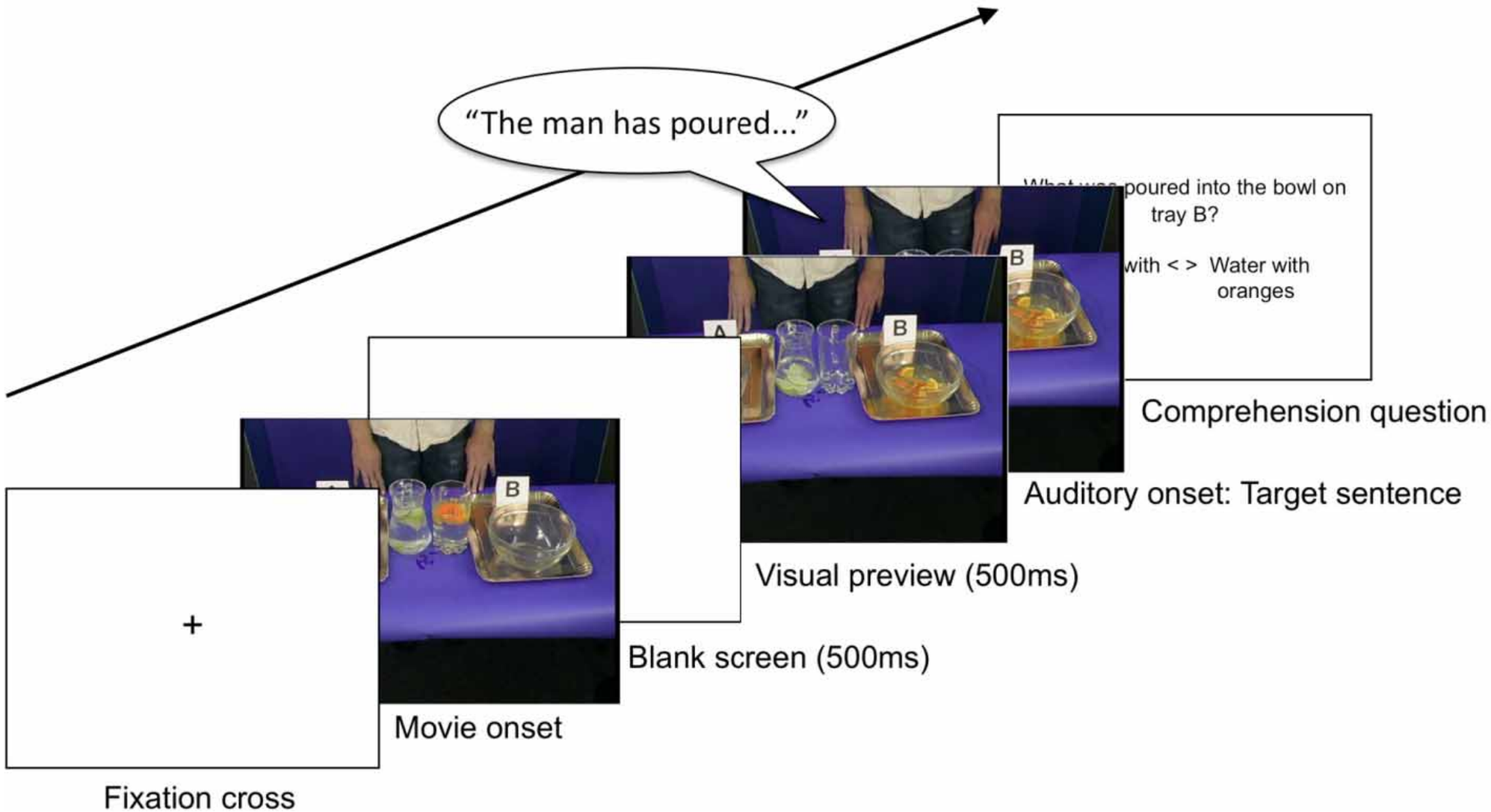
late some

The man has poured **some** of the water with limes into the bowl on tray A and **some** of the water with oranges into the bowl on tray B.

Breheny et al. (2012)

Investigating the timecourse of accessing conversational implicatures during incremental sentence interpretation

exp. procedure



Breheny et al. (2012)

Investigating the timecourse of accessing conversational implicatures during incremental sentence interpretation

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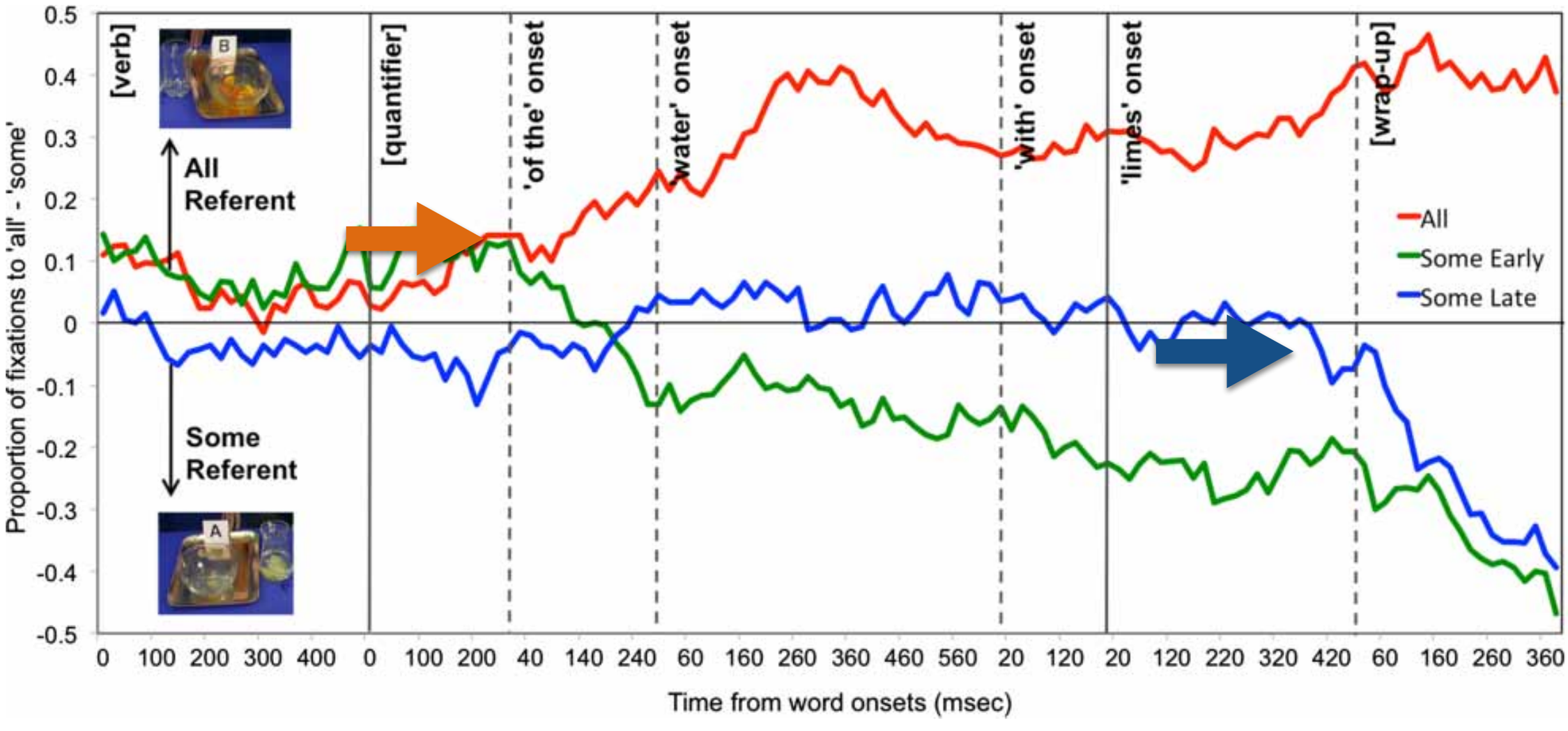
results

general bias for all

early difference between *early some* vs. *all*



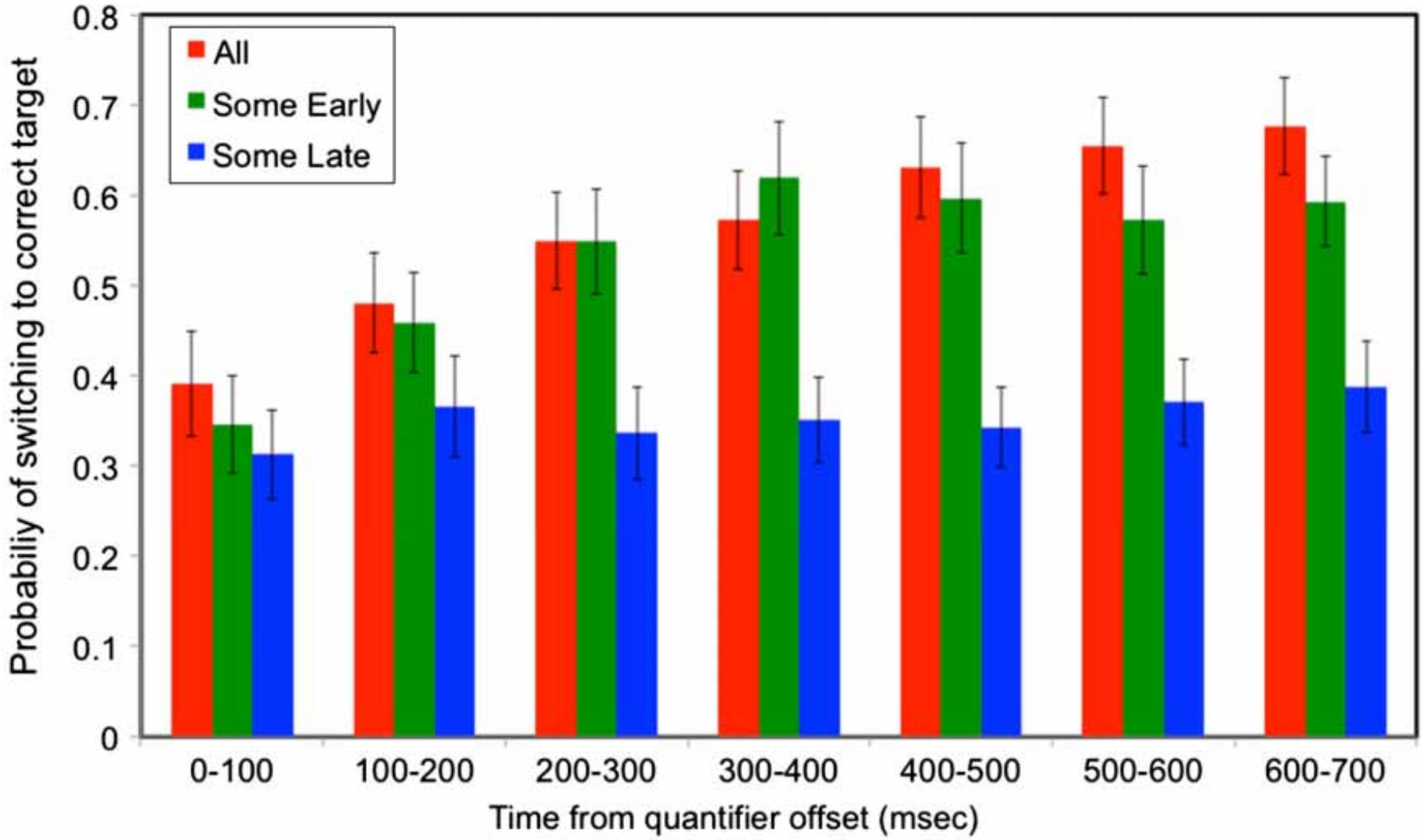
late disambiguation with *late some*

Breheny et al. (2012)

Investigating the timecourse of accessing conversational implicatures during incremental sentence interpretation

results

probability of switching looks to the target



discussion

- can participants use scalar implicatures to anticipate the referent of the discourse?

  ↘ rich context
  look and listen paradigm **yes!**

- no difference in switch of looks between semantic resolution (*all*) and pragmatic driven reference resolution (*some but not all*)

  ↘ timecourse: SEMANTICS = PRAGMATICS

- previous failures (Huang & Snedeker) due to the presence of numerals:
  why using longer term (*some*) when you can use short and unambiguous term (*two*)

Breheny et al. (2012)

Investigating the timecourse of accessing conversational implicatures during incremental sentence interpretation

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conclusions

- no difference in processing between

  "what is said" **"what is implicated"**

- if comprehenders compute automatically

  ↘ context of the semantic interpretation

  ↘ context on how to use the interpretation for communicative purposes

  implicatures automatically triggered.

- not only quantity implicatures can be accessed rapidly

Grodner et al.

- pragmatic meaning does not need literal meaning to be computed first
- how do derive the pragmatic meaning then?

  ↘ you don't! it's always available, it can be retrieved if sufficient contextual support

- constrain-based models: pragmatic inferencing as probabilistic reasoning
  the more support, the faster and effortless inferences
- rapid access to pragmatic meaning only if no numerals around..

  ↘ but in the real world numerals are always around!

  people prefer using unambiguous descriptions

  numerals are always salient alternatives

putting things together & further questions (and problems)

old Breheny

- implicatures are context-dependent!

  → evidence: increased processing cost when context supports the implicature

  ↙ no default-automatic computation

  ↘ the context determines the availability of pragmatic inferences

    they are costly

new Breheny

- implicatures are rapid, can be used to anticipate future discourse referents

  → evidence: anticipatory looks to referent disambiguated through pragmatic inferences

  if context supports implicatures and their use ↙ ↘ automatic computation

    effortless

The saliency of the mentioned argument facilitates the processing of negation: a Visual World study

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How do we understand negation?

DON'T PLAY WITH SPAGHETTI!

How do we understand negation?

DON'T PLAY WITH SPAGHETTI!

?

of a representation
of the argument of negation

theoretical debate

1 step	2 step
immediate inhibition of the argument  full activation not required	full-fledged activation of the argument  inhibition of the argument 

How do we understand negation?

theoretical debate

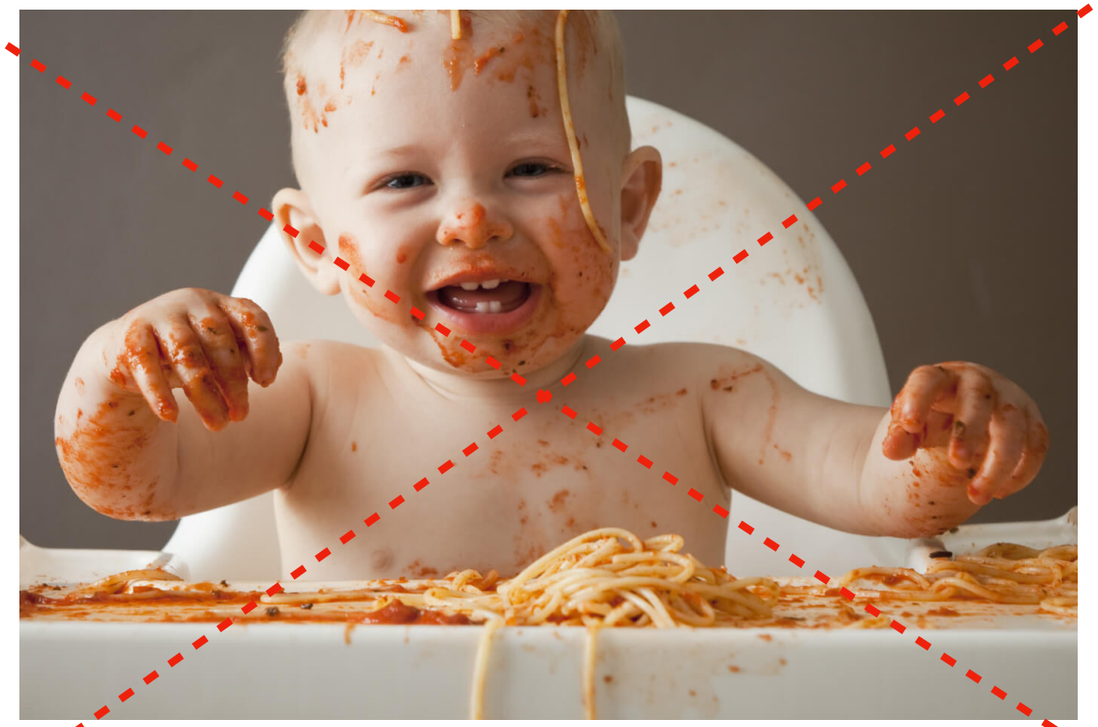
1 step	incremental	2 step	non-incremental
immediate inhibition of the argument  full activation not required	processing of negation = affermative sentences	full-fledged activation of the argument  inhibition of the argument 	processing of negation <u>necessarily more costly</u>

Papeo & Hochmann (2012) – Different brain networks are activated by positive and corresponding negative statements including action verbs (e.g. *I am (not) writing*) immediately after the verb onset

Kaup et. al (2007) – Priming effect of the argument of negation: after reading the negative sentence «*There was no eagle in the sky*» participants were faster in recognizing the picture of an eagle with outstretched wings (corresponding to the negated situation) than that of an eagle with its wings folded.

How do we understand negation? referential context

LOOK AT THE BABY THAT DOES NOT <u>PLAY WITH SPAGHETTI</u>



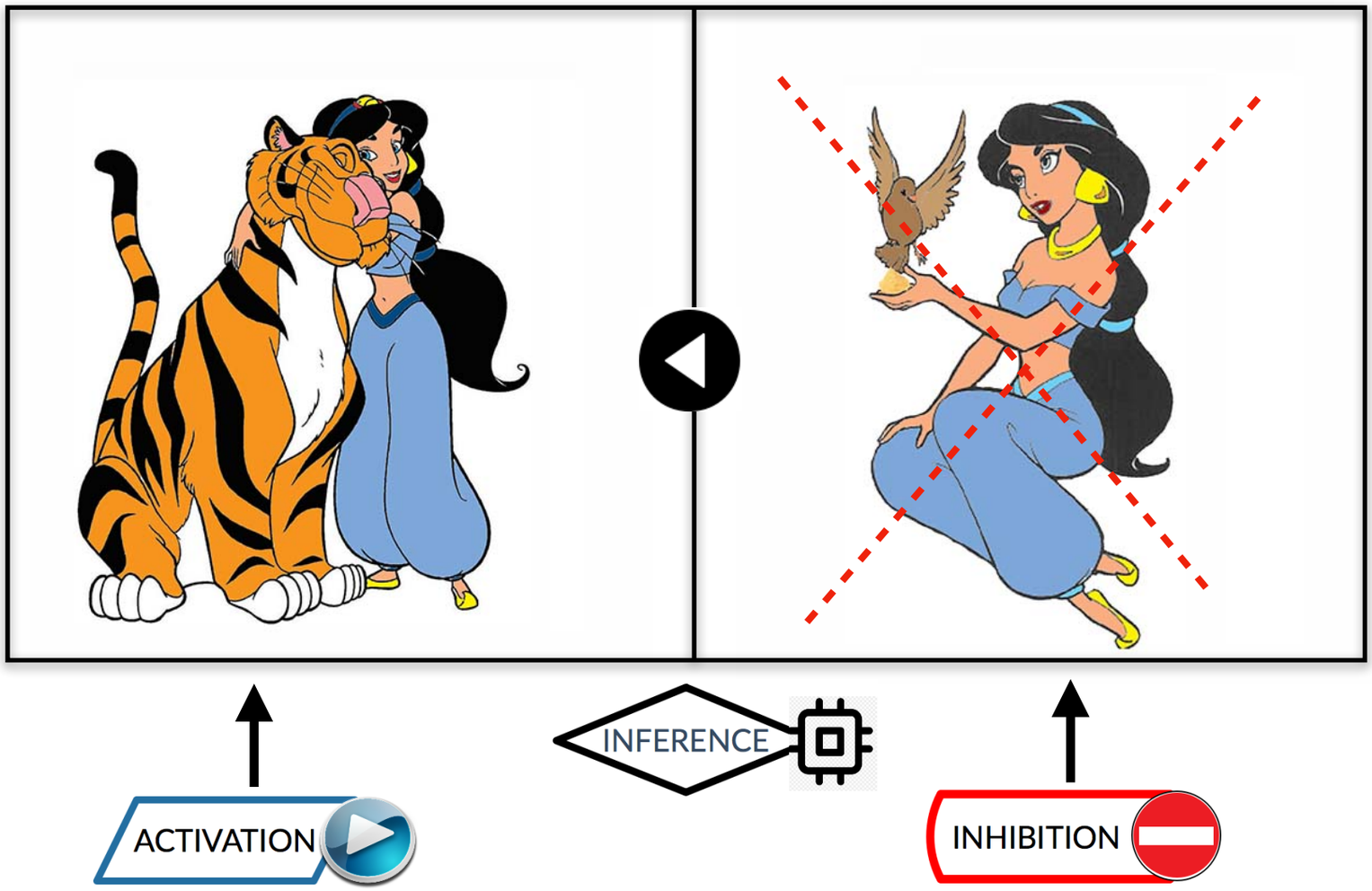
ACTIVATION identification of the <u>mentioned argument</u> in the context

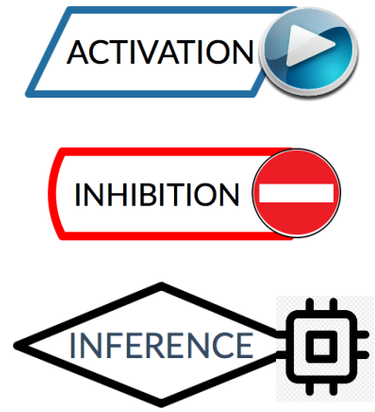
INHIBITION inhibition of the <u>mentioned argument</u> (don't look at it)

INFERENCE inference to the right action (look at the other baby)

goal of this study: investigate the role of the MA how?

visual world paradigm

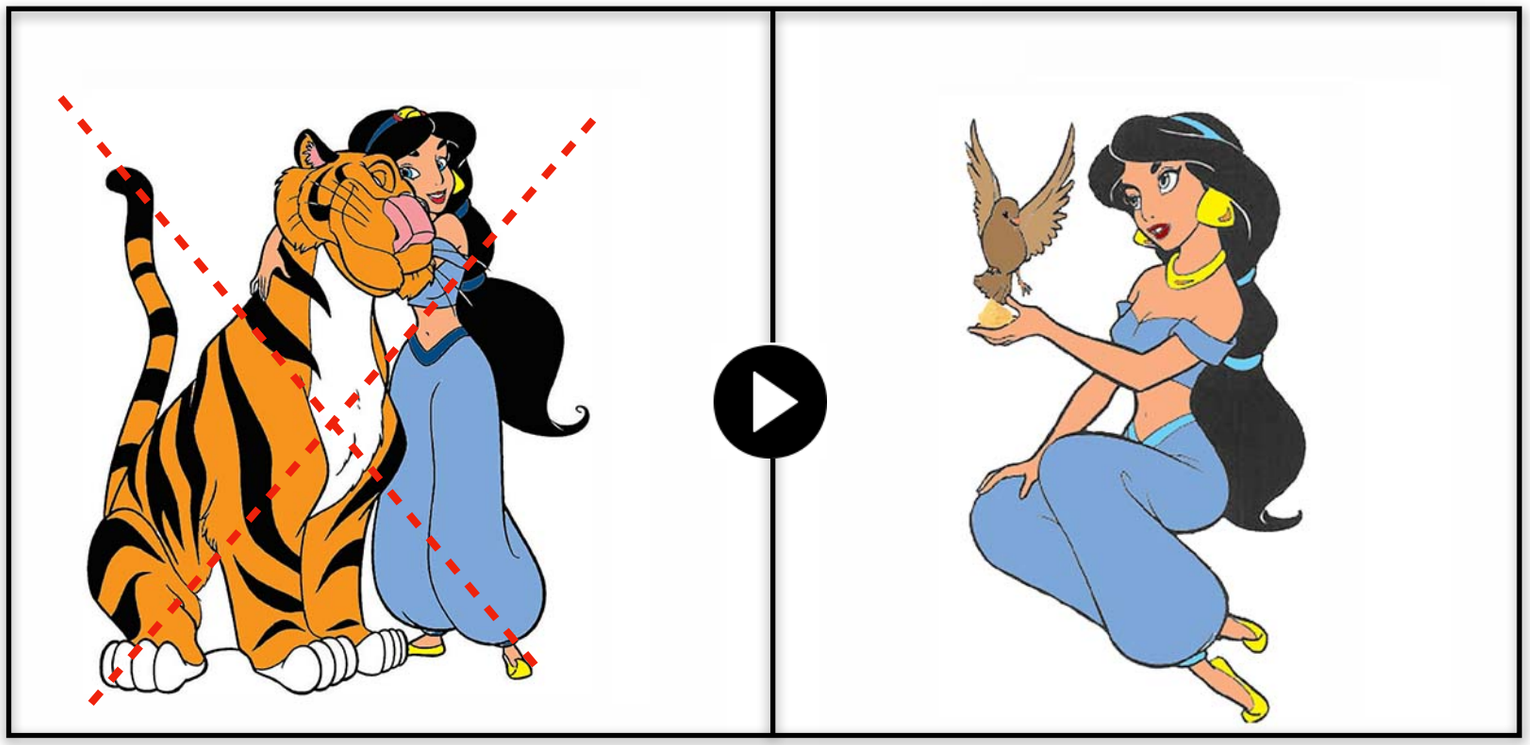




affirmative sentence

PICK THE QUADRANT IN WHICH JASMINE IS <u>CUDDLING A TIGER</u>

visual world paradigm



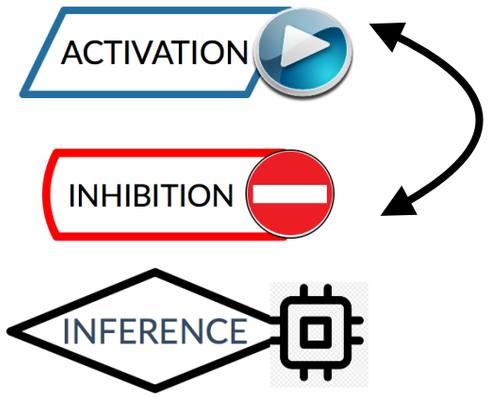
negative sentence

PICK THE QUADRANT IN WHICH JASMINE IS NOT <u>CUDDLING A TIGER</u>

Visual World: optimal mean to investigate online reference resolution

→ interplay of the three processes: **ACT/INH/INF**

in negative sentences ACTIVATION and INHIBITION <u>compete</u> with each other



1. the more active the MA is, the more difficult to inhibit it

2. lexical interference

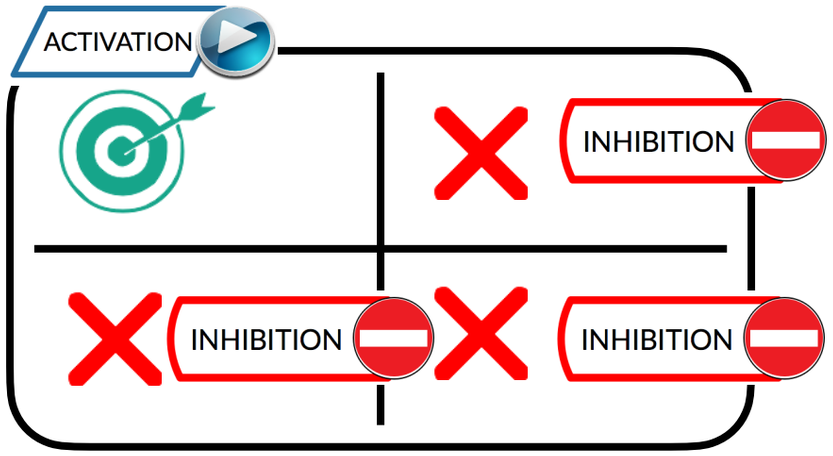
intrinsic problem wrt investigation of processing of negation

- it cannot be balanced out
- it can be studied

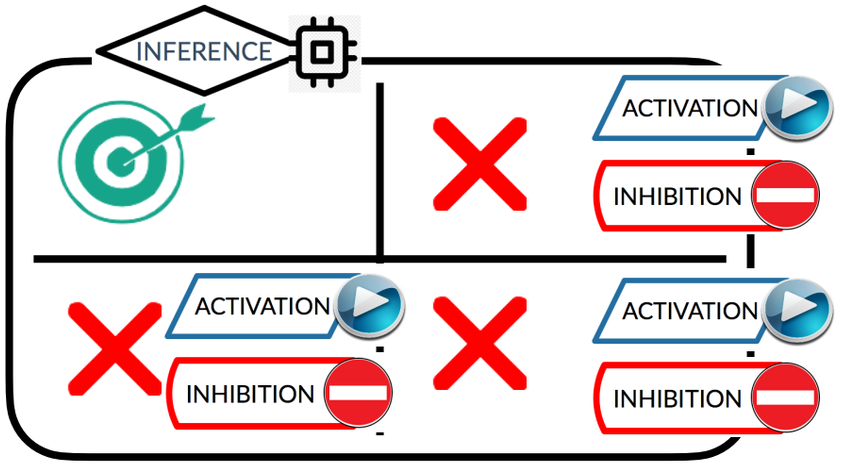
by manipulating the prominence of the MA

visual world paradigm

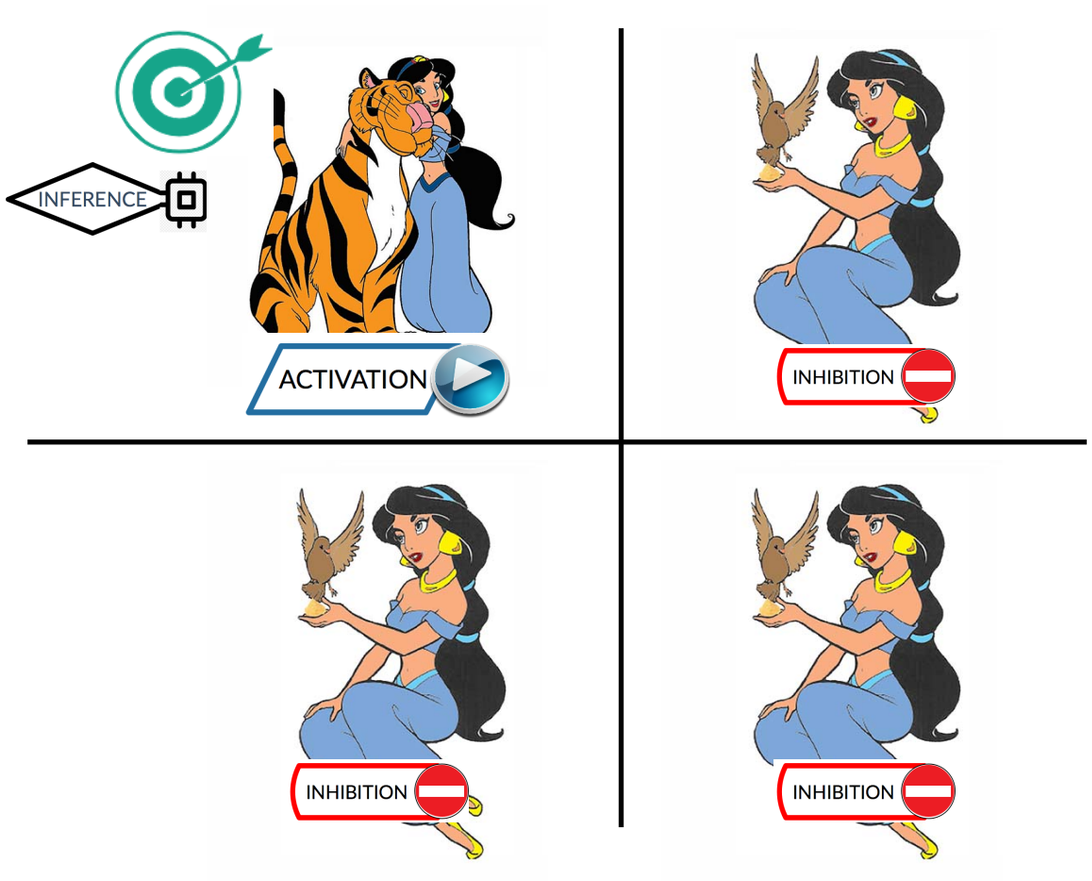
affirmative +

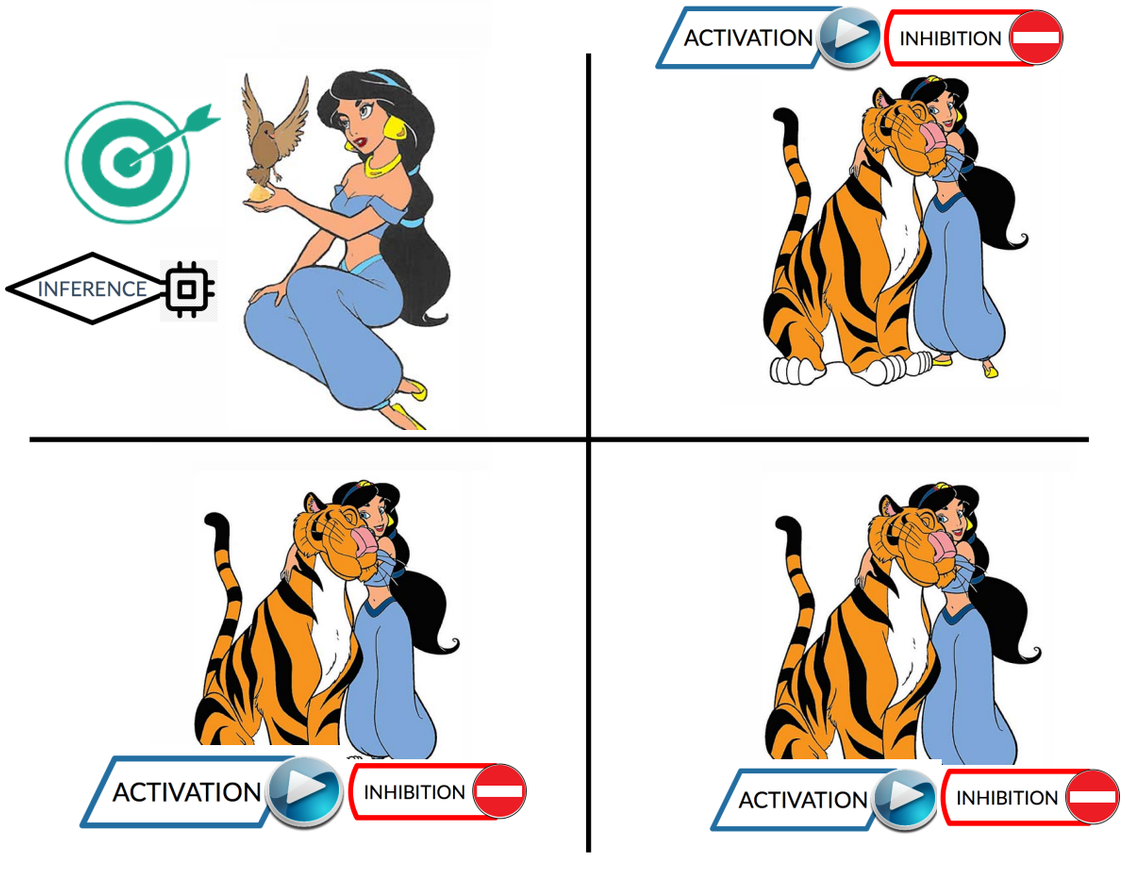


negative -



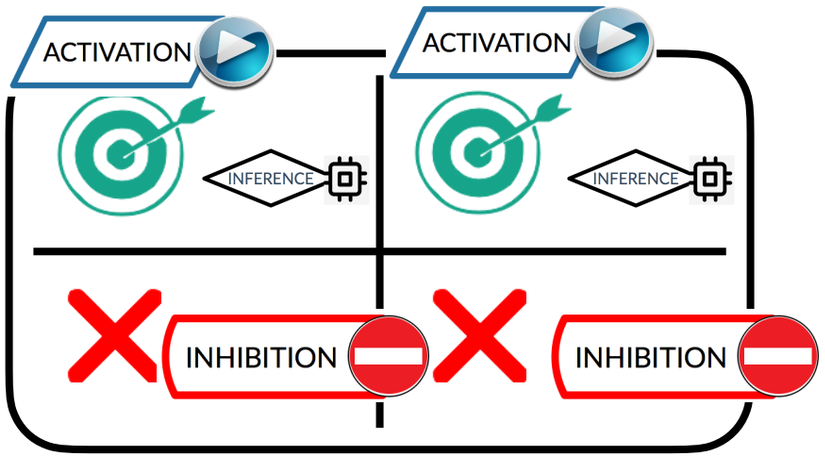
PICK THE QUADRANT IN WHICH JASMINE IS (NOT) CUDDLING A TIGER



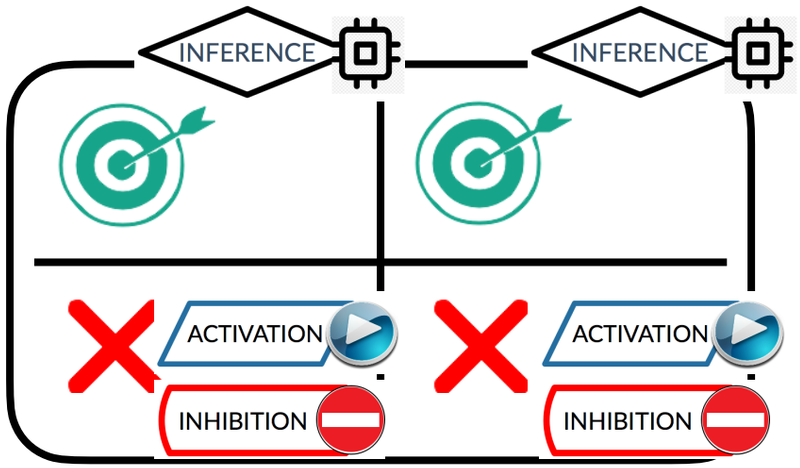


visual world paradigm

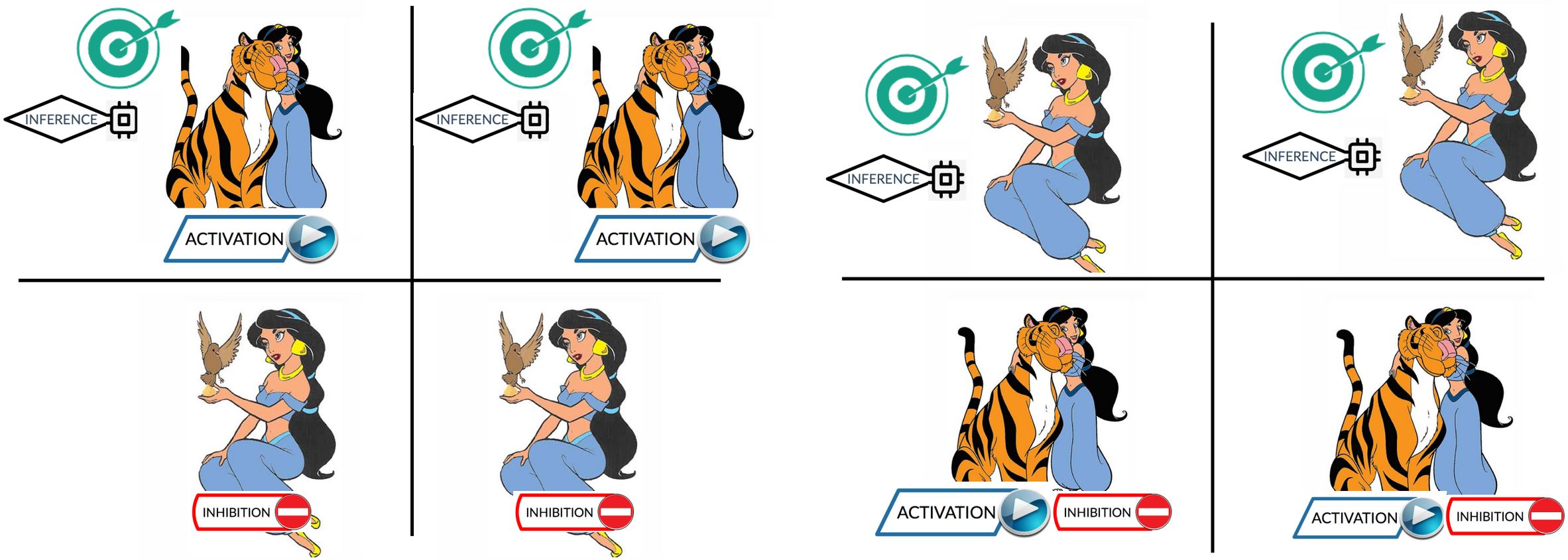
affirmative +



negative -

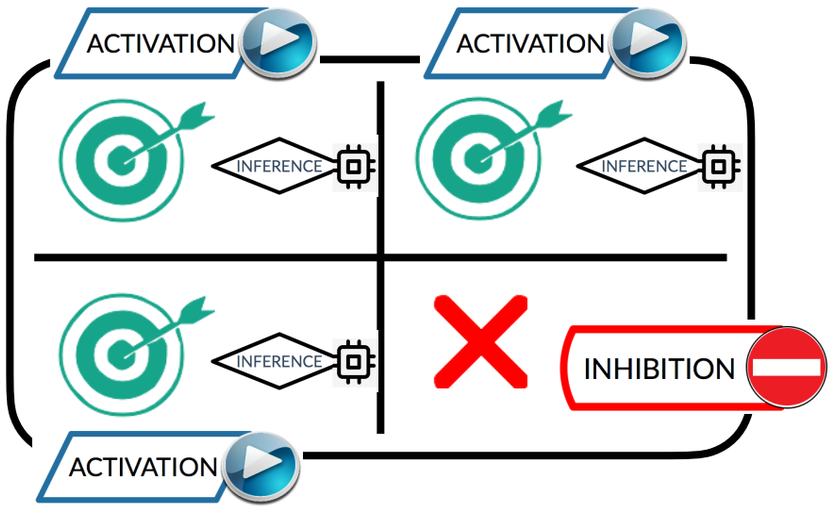


PICK THE QUADRANT IN WHICH JASMINE IS (NOT) CUDDLING A TIGER

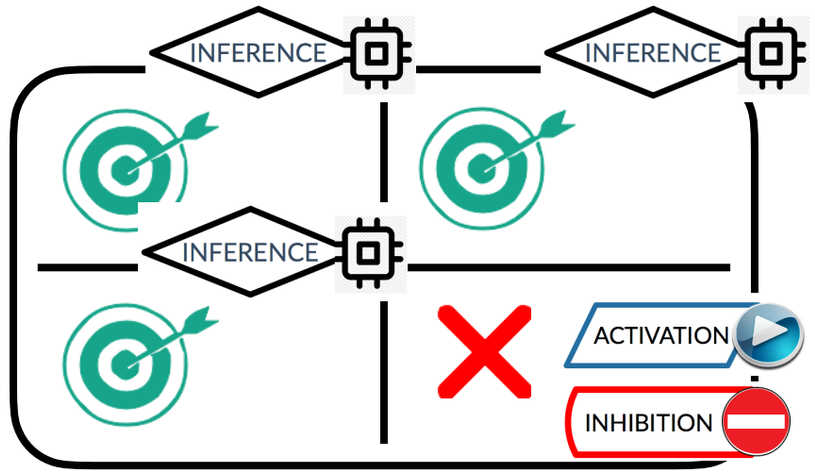


visual world paradigm

affirmative +



negative -



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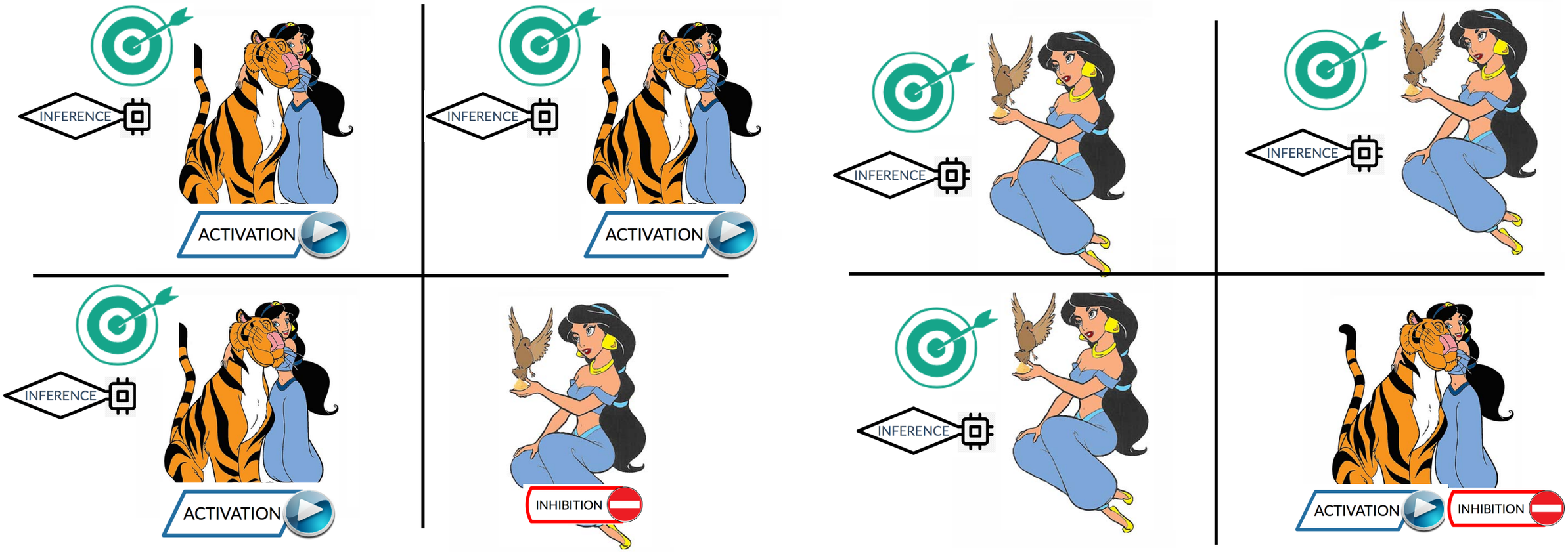
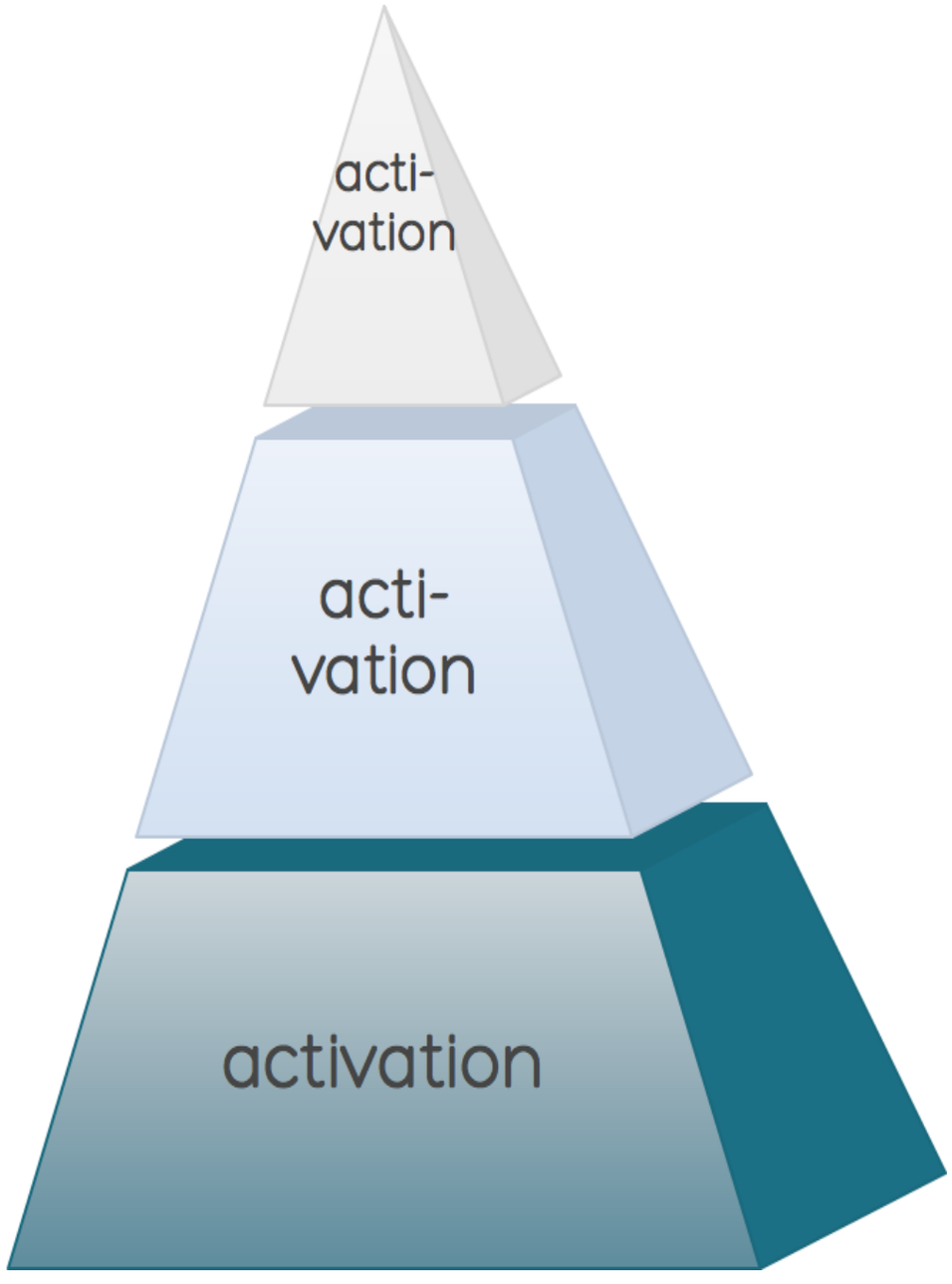
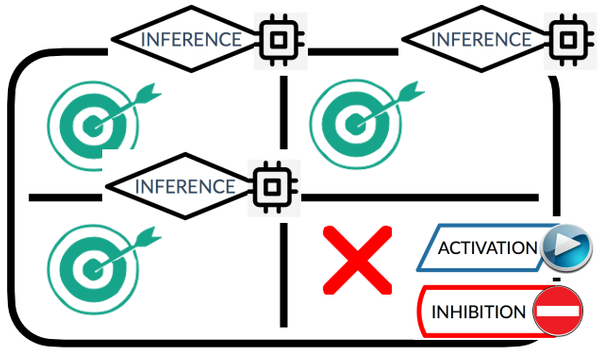
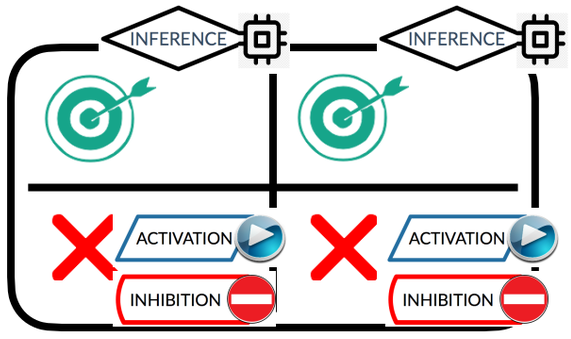


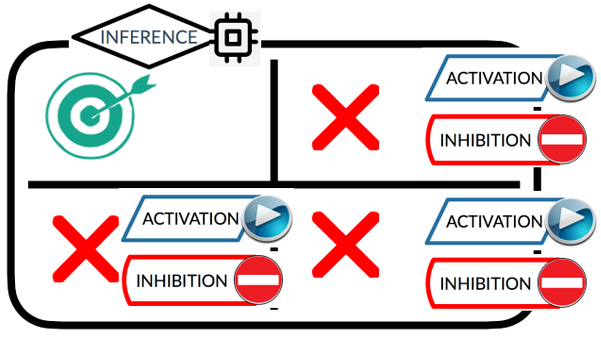
visual world paradigm

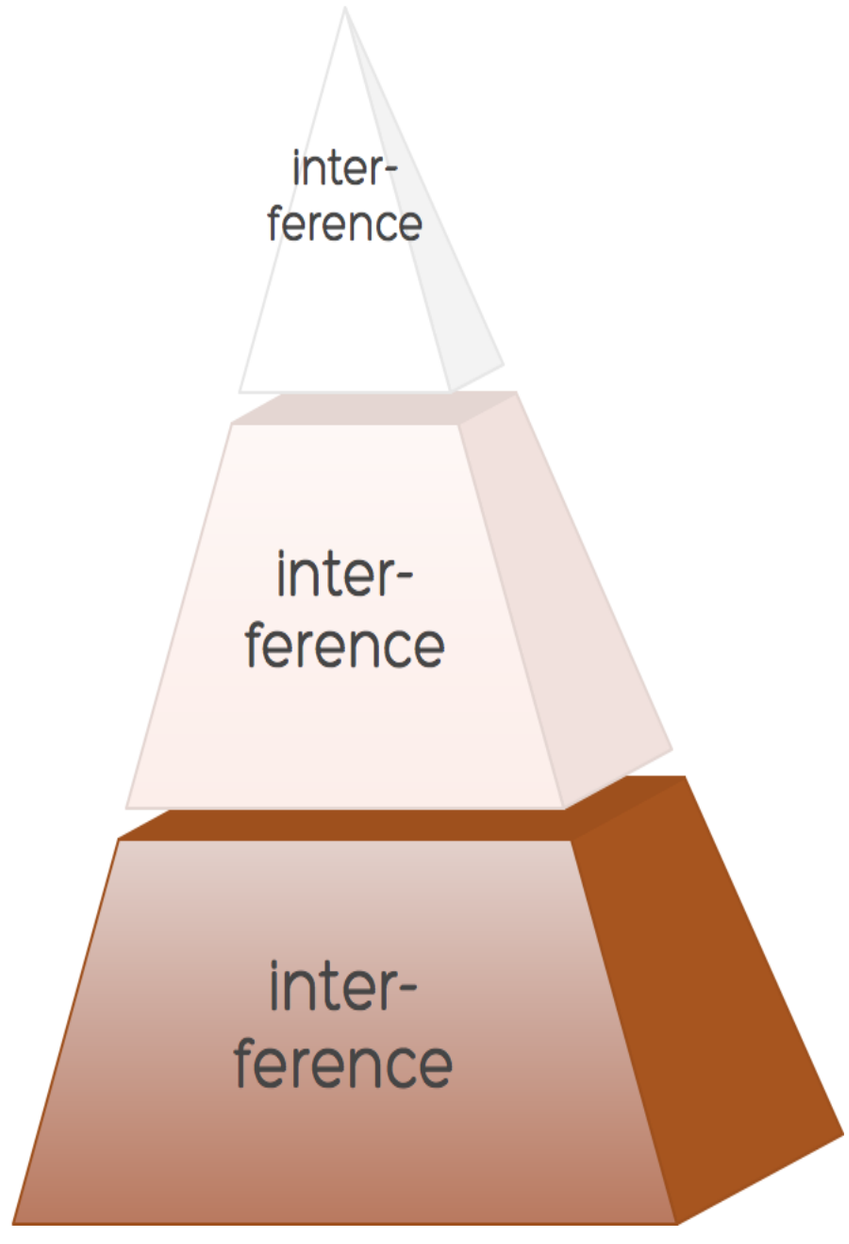
negative sentences



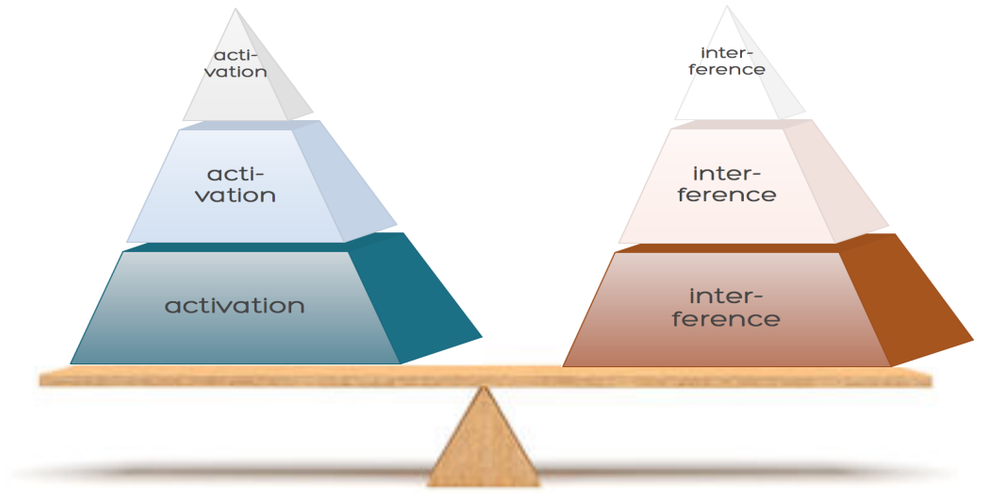




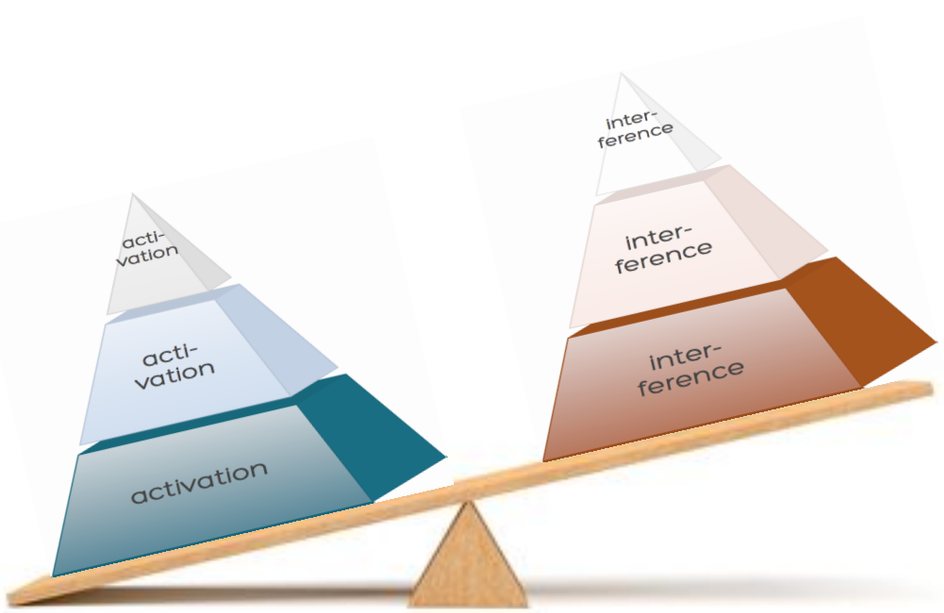




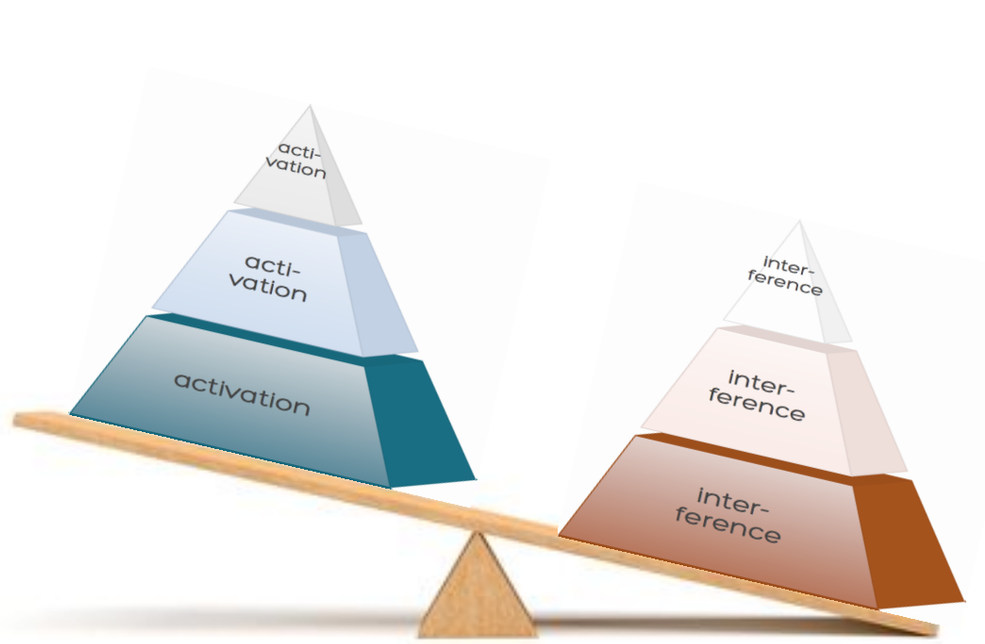
what weighs more on the budget in processing negation?



perfect balance

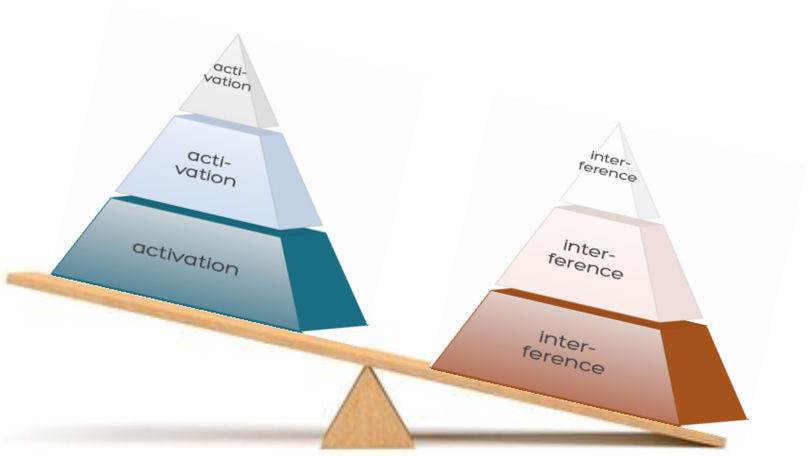


facilitation due to
activation/identification of MA



interference due to
lexical activation + inhibition of MA

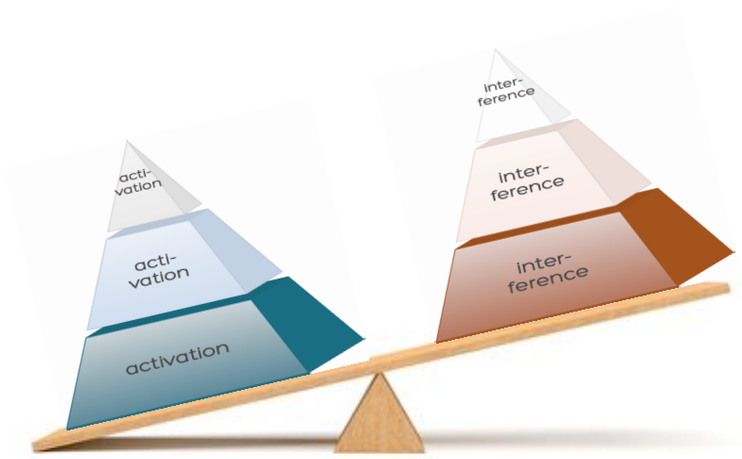
what weighs more on the budget in processing negation?



interference
+ inhibition

support for 1-step theories

- focus on INHIBITION
- cost for processing negation can be <u>eliminated</u> by facilitating inhibition of MA, reducing interference

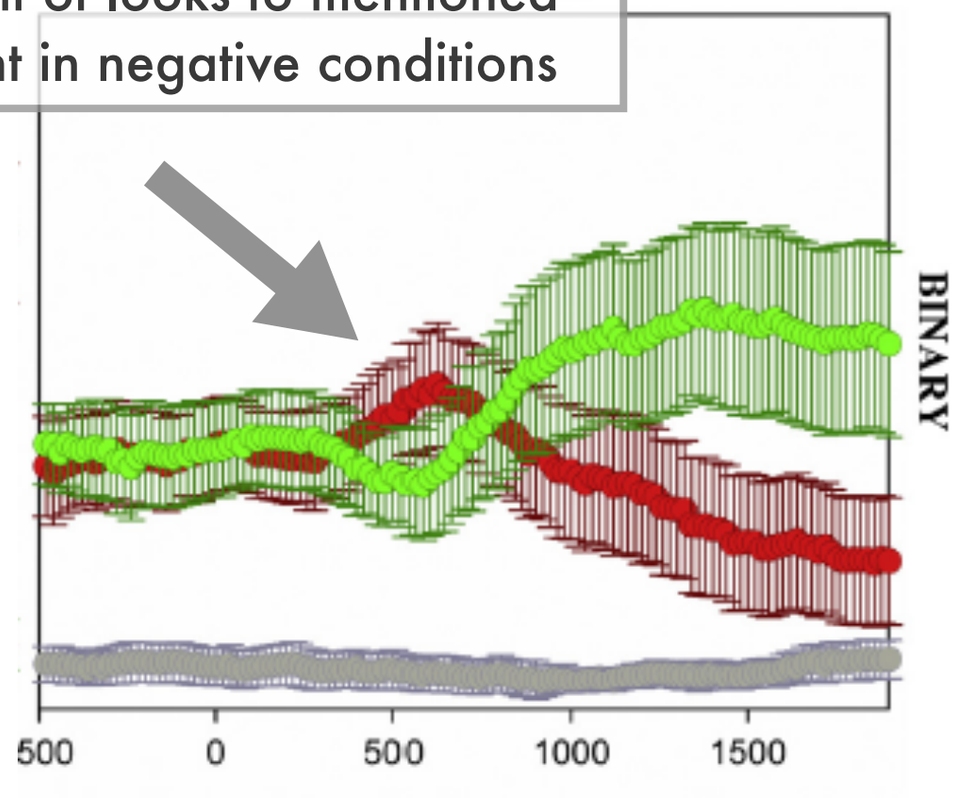


activation/
identification

support for 2-step theories

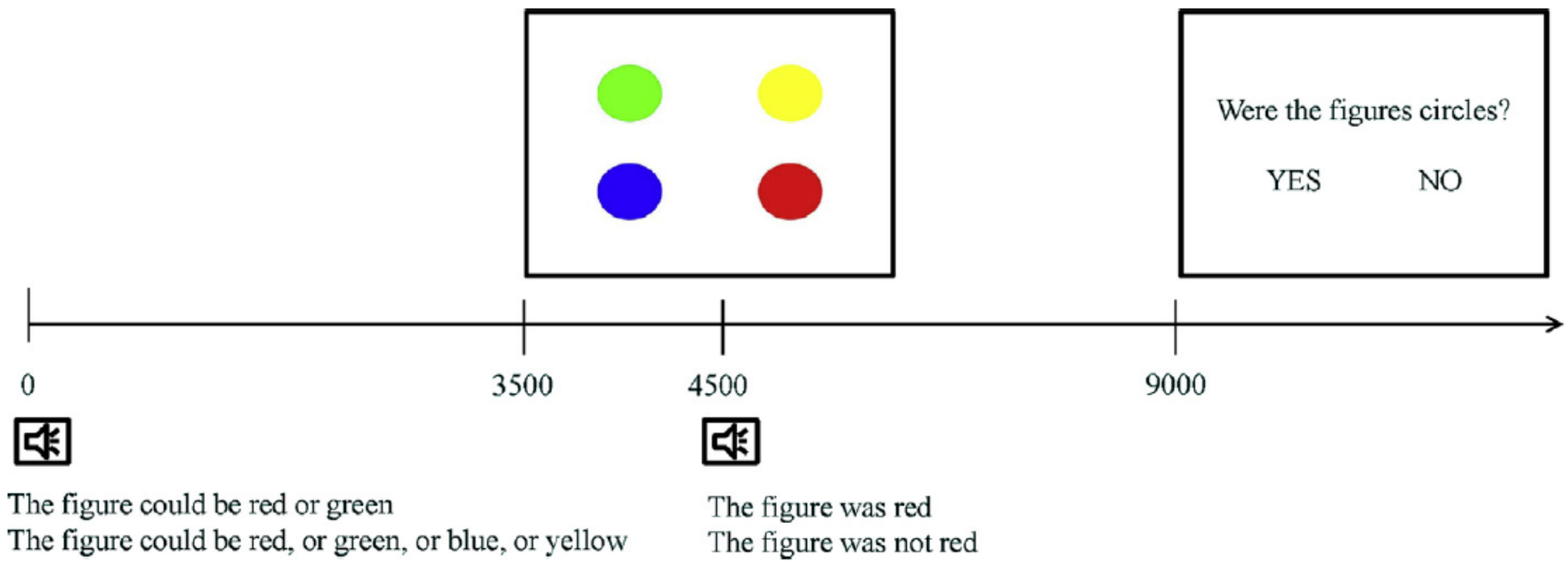
- full-fledged activation of MA
- cost for processing negation can be <u>reduced but not eliminated</u> by facilitating activation of MA

increment of looks to mentioned argument in negative conditions

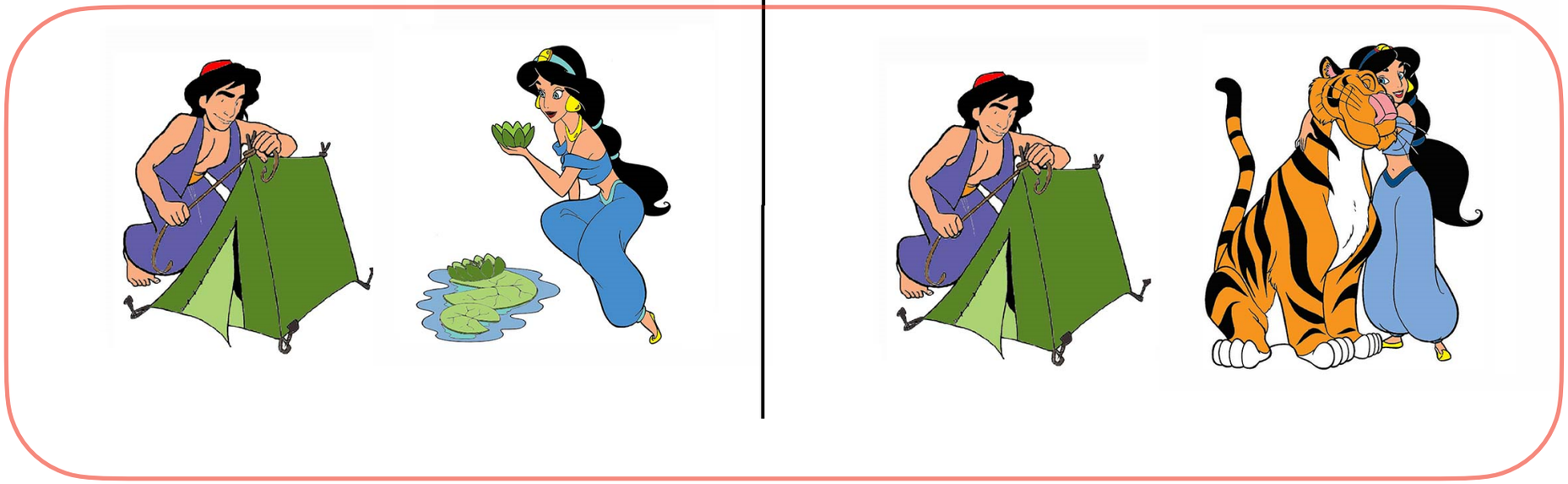


more looks to the MA
delayed target identification

measure of processing cost



example of experimental scenario

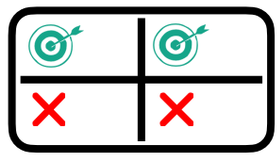


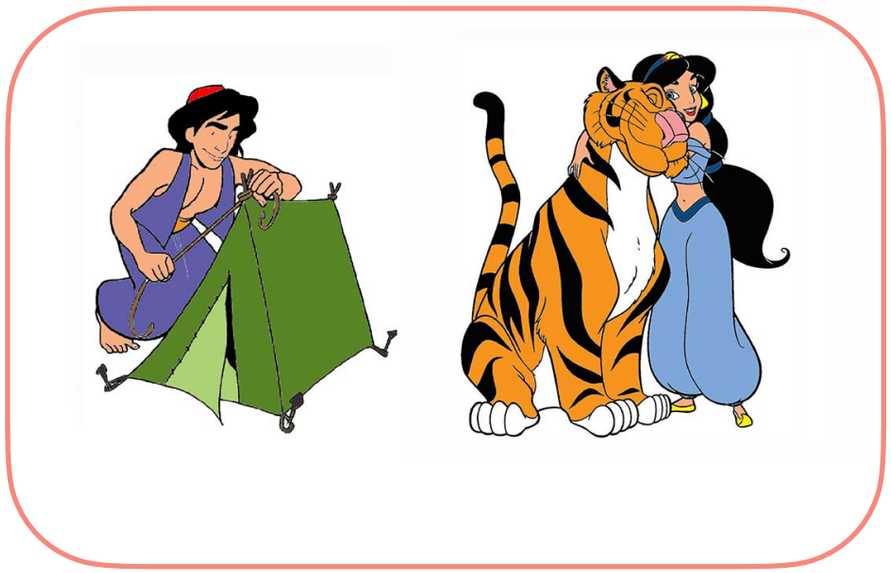
PICK THE QUADRANT IN WHICH ALADDIN IS (NOT) CLOSING THE DOOR...

... AND JASMINE IS CUDDLING A TIGER

2 potential targets / 2 mentioned arguments

example of experimental scenario



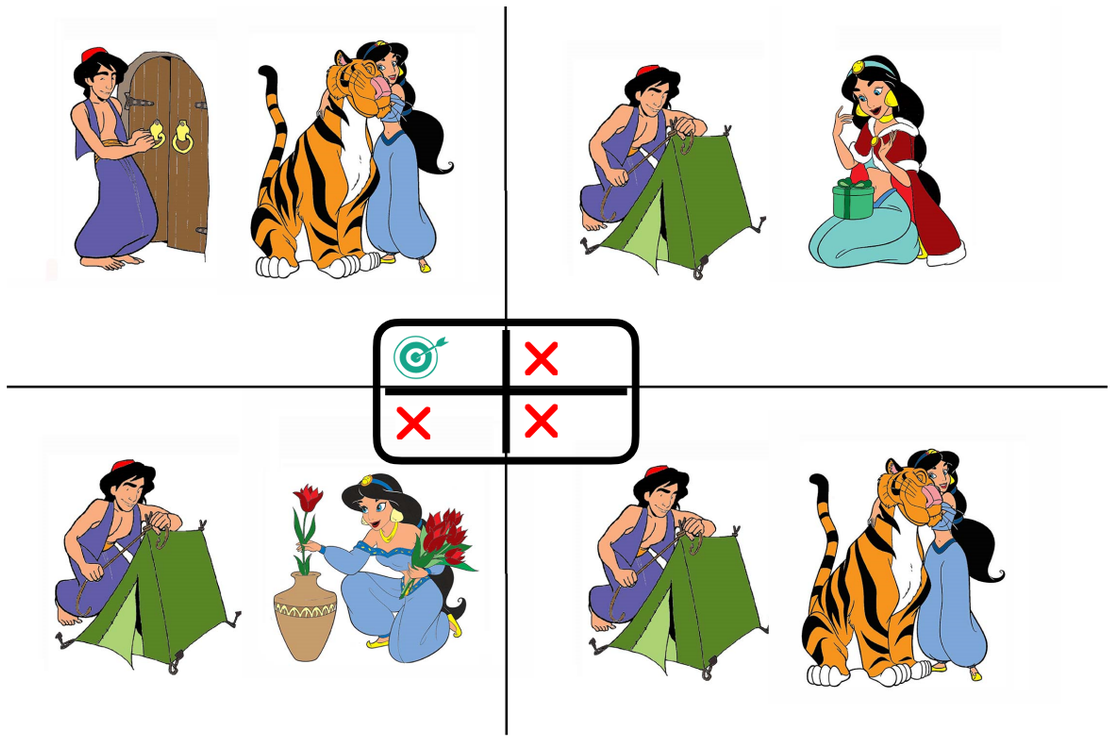


PICK THE QUADRANT IN WHICH ALADDIN IS (NOT) CLOSING THE DOOR...

... AND JASMINE IS CUDDLING A TIGER

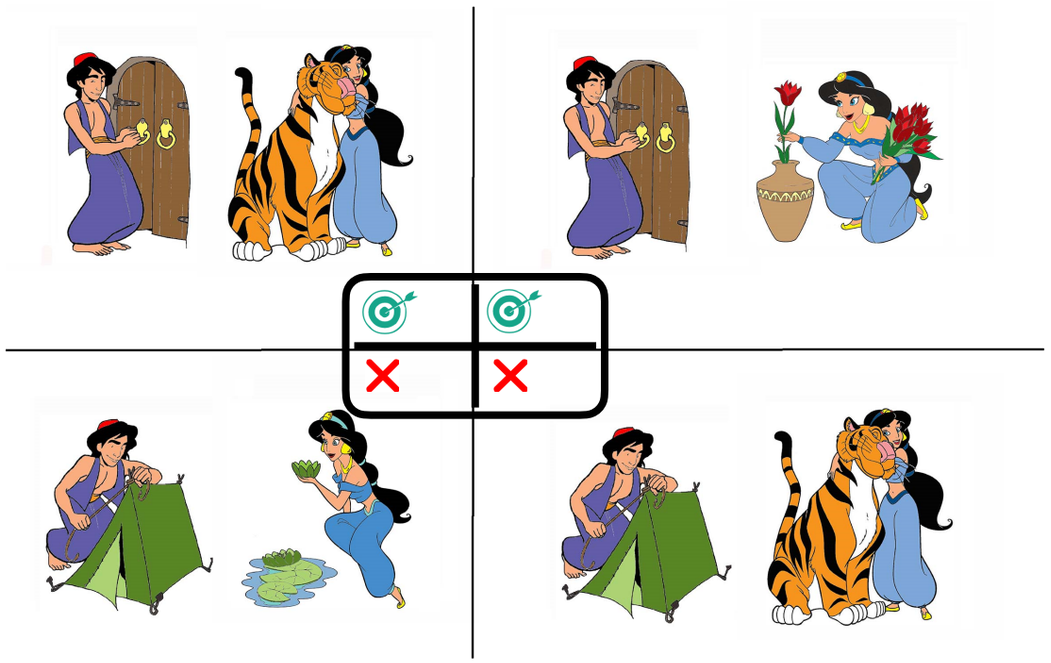
2 potential targets / 2 mentioned arguments

experimental scenarios: n° of (potential) Targets vary parametrically



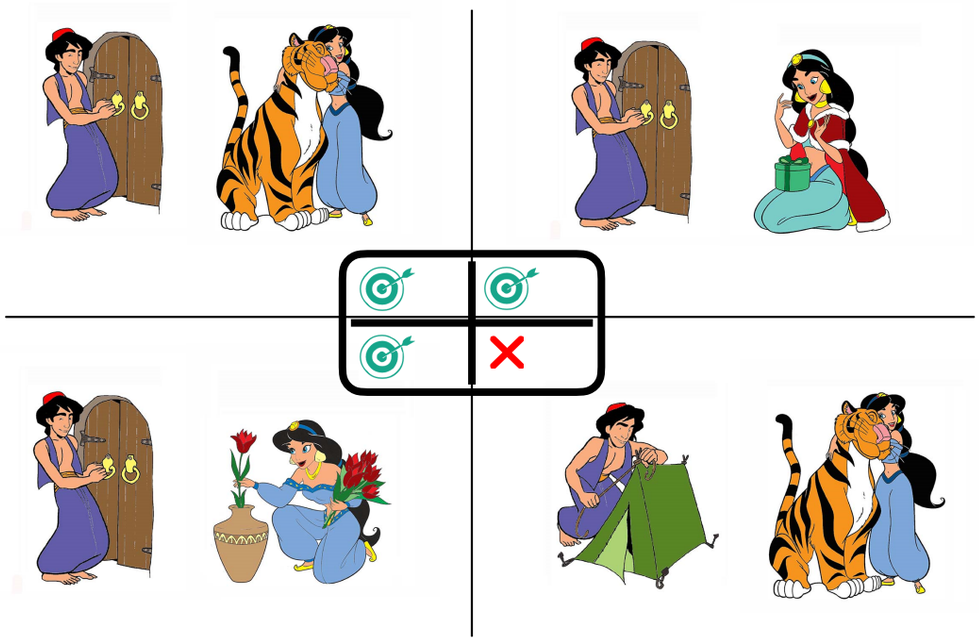
ALADDIN IS CLOSING THE DOOR
ALADDIN IS NOT BUILDING A TENT

1 target



ALADDIN IS CLOSING THE DOOR
ALADDIN IS NOT BUILDING A TENT

2 targets



ALADDIN IS CLOSING THE DOOR
ALADDIN IS NOT BUILDING A TENT

3 targets

Experimental Design

- Identification task with eye-recording
  (second conjunct makes reference resolution always felicitous)

  time pressure: find the target as soon as you can

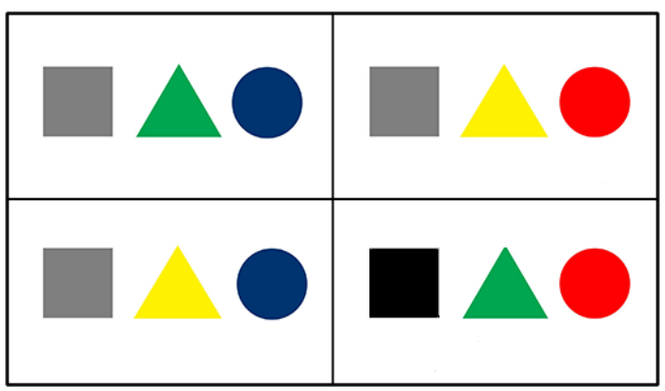
- Counterbalanced: order, characters, sentences

- 62 adult participants (speakers of Italian, recruited at UniVR)
- 120 items in 6 conditions (and 3 types of stimuli)
- EyeLink 1000 (1000 Hz, desktop mounted)
- Main factors: POLARITY (aff/neg) x N°TARGET/MAs (1,2,3) x TYPES OF STIMULI

Cartoons
(action verbs)

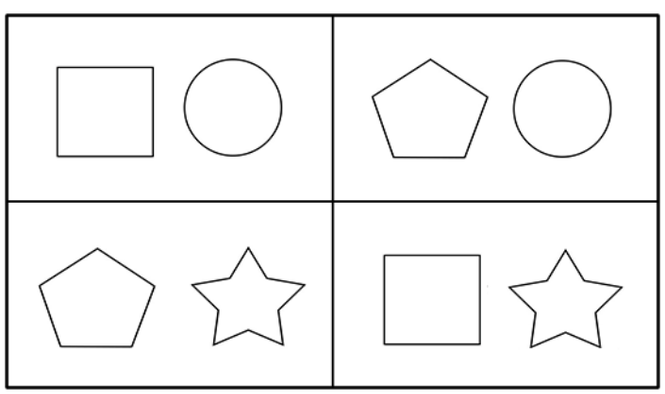
«ALADDIN IS (NOT) CLOSING THE DOOR AND JASMINE IS CUDDLING A TIGER»

Color shapes
(definite descriptions)



«THE CIRCLE IS (NOT) BLUE AND THE TRIANGLE IS GREEN »

B/W shapes
(Existential statements)

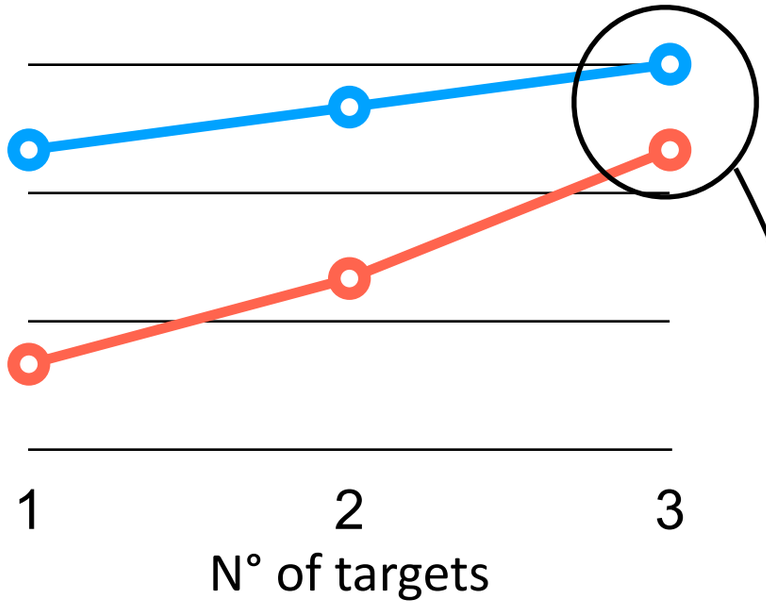


«THERE IS (NOT) A CIRCLE AND/(BUT) A SQUARE»

predictions

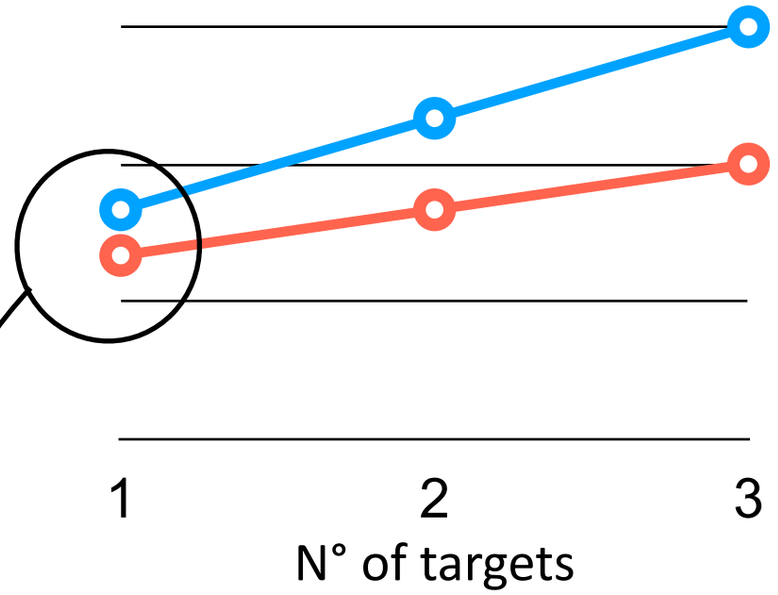
prop. of looks to the target (T/T+D) at disambiguation

PICK THE QUADRANT IN WHICH ALADDIN IS (NOT) | CLOSING THE DOOR...

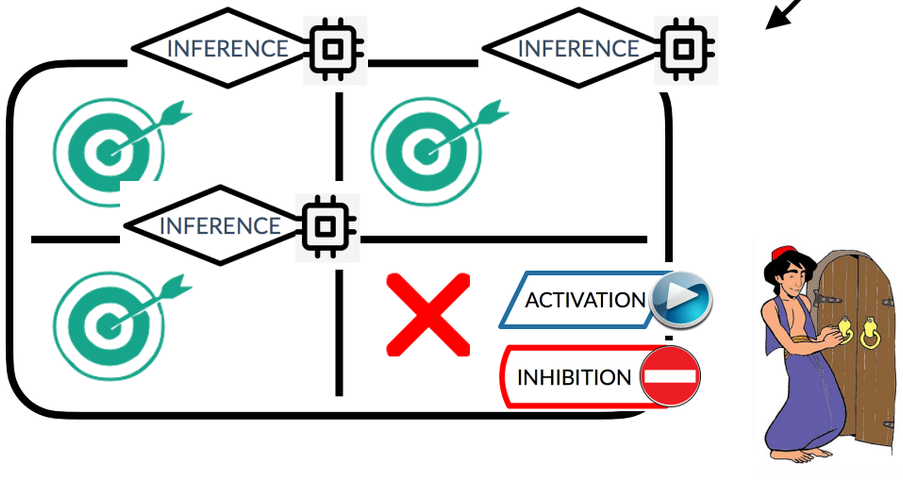


affirmative
negative

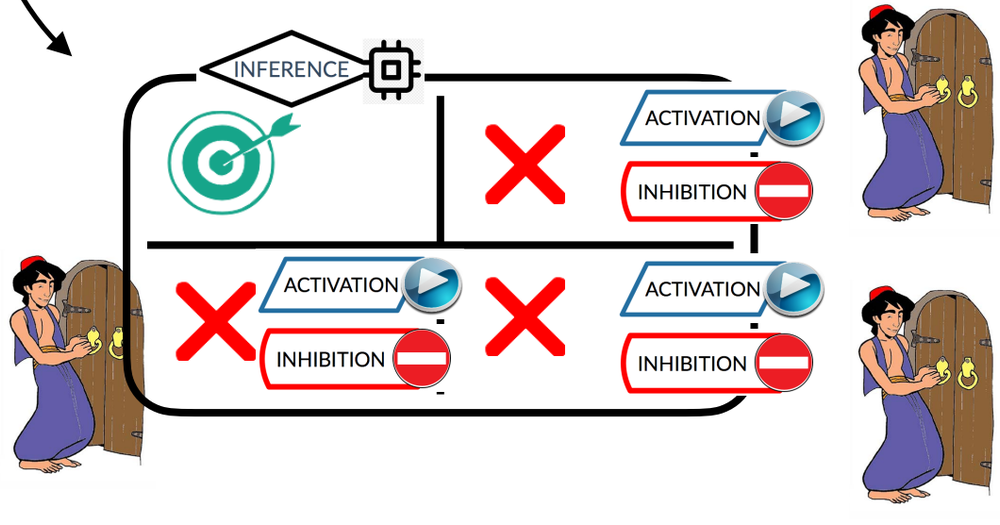
strong support for 2-step



INHIBITION + INTERFERENCE
+ penalty for NEG



facilitation for ACTIVATION
+ penalty for NEG

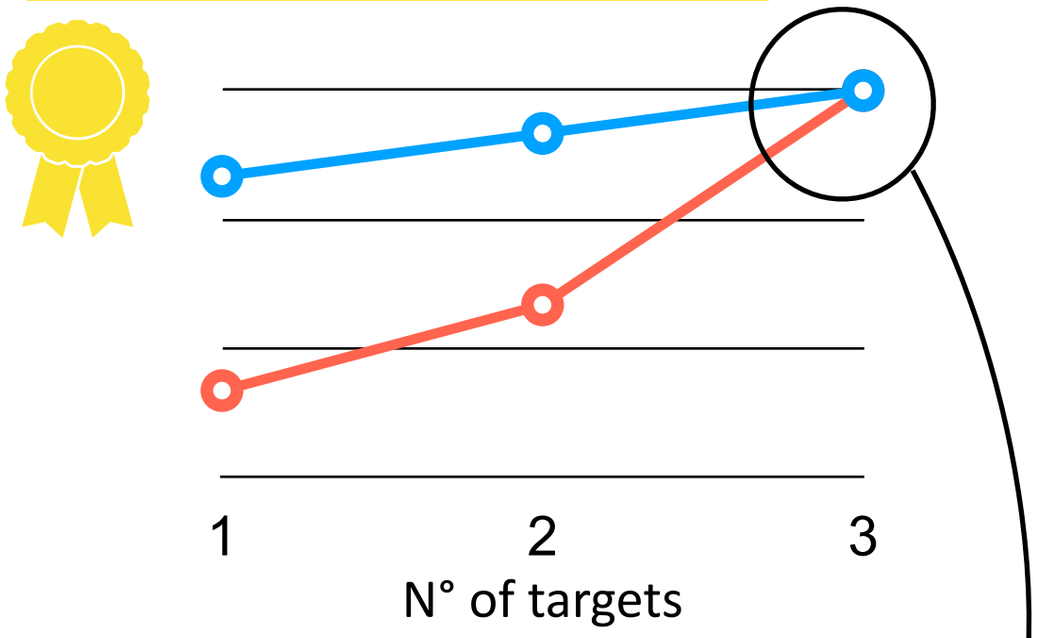


predictions

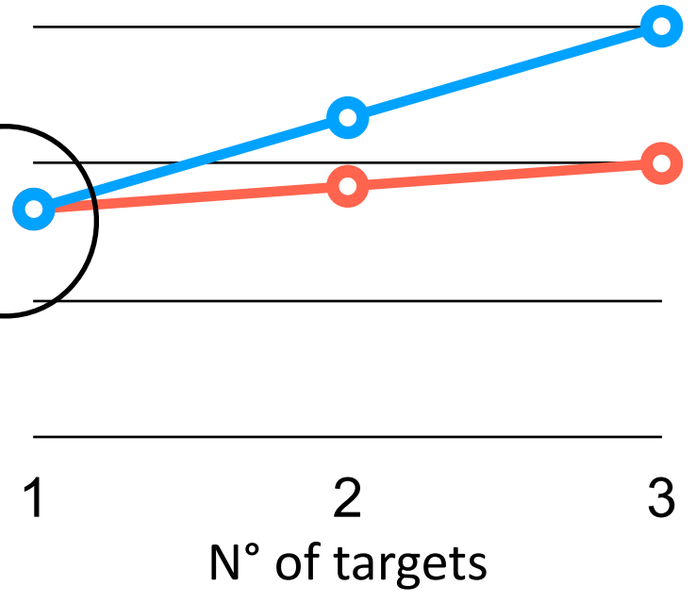
prop. of looks to the target (T/T+D) at disambiguation

PICK THE QUADRANT IN WHICH ALADDIN IS (NOT) | CLOSING THE DOOR...

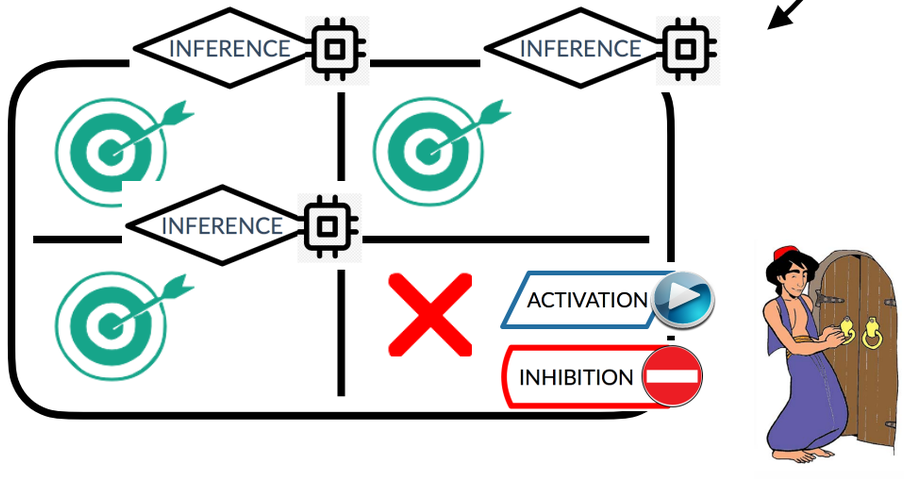
strong support for 1-step



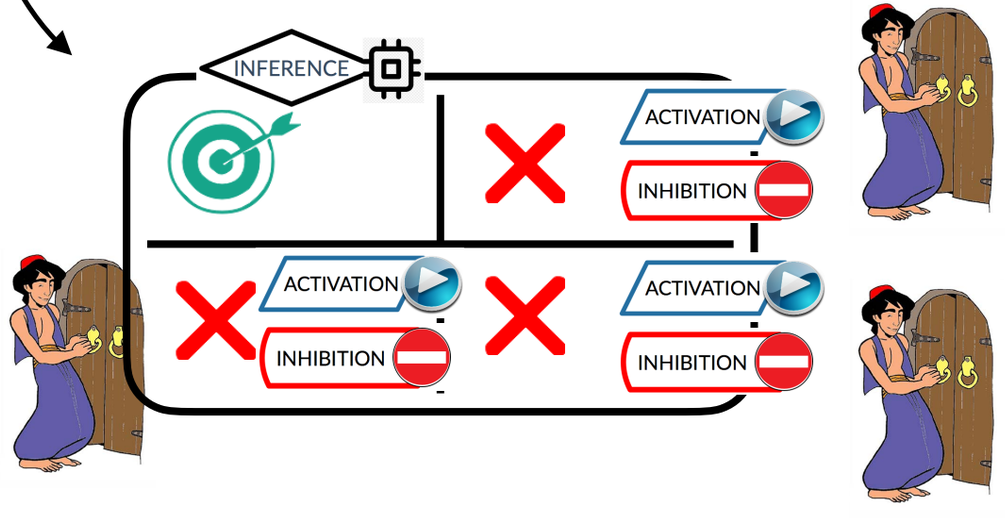
affirmative
negative



INHIBITION + INTERFERENCE:
penalty eliminated



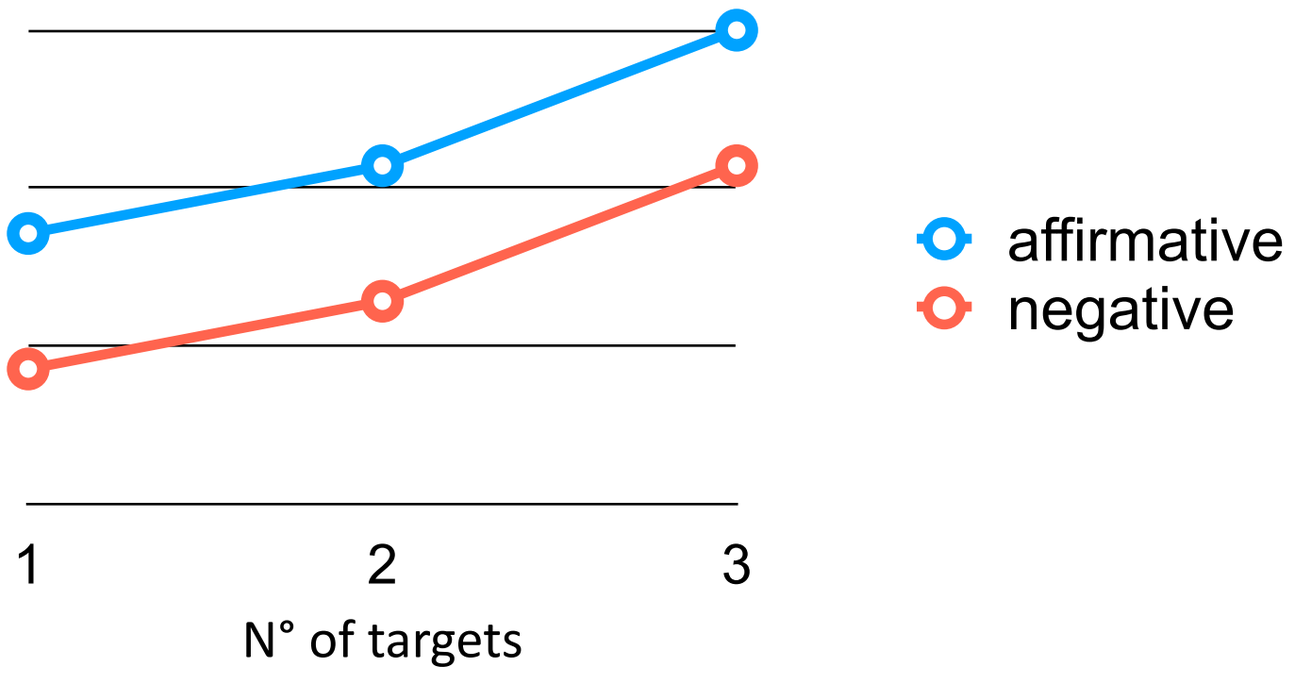
facilitation for ACTIVATION:
penalty eliminated



predictions

prop. of looks to the target (T/T+D) at disambiguation

PICK THE QUADRANT IN WHICH ALADDIN IS (NOT) | CLOSING THE DOOR...



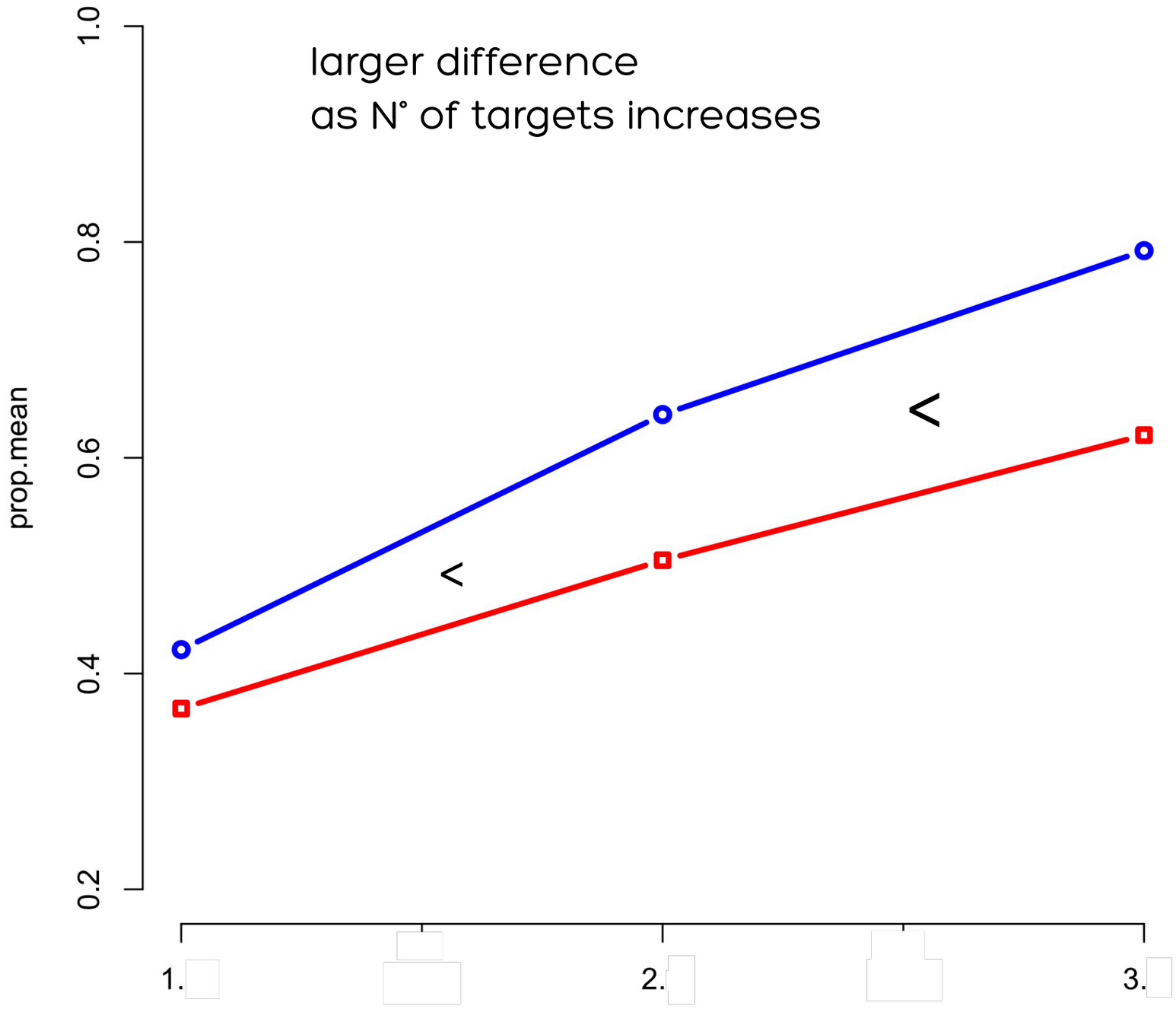
PERFECT BALANCE between activation and interference

results

prop. of looks to the target (T/T+D) at disambiguation

PICK THE QUADRANT IN WHICH ALADDIN IS (NOT) | CLOSING THE DOOR...

larger difference
as N° of targets increases



LMM on log target proportion

n° target: p<.001

polarity: p<.001

target*polarity: p<.001

cartoons

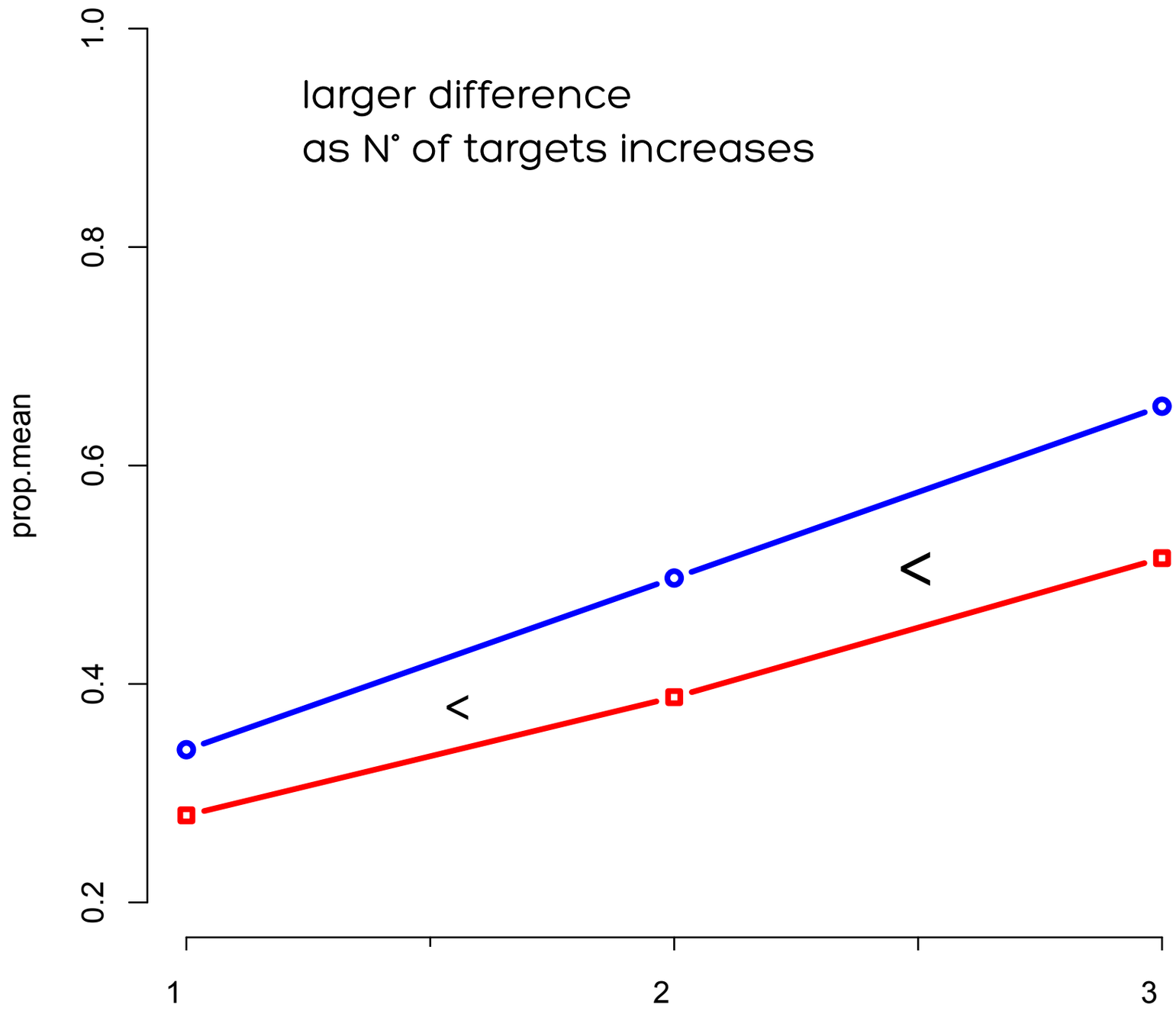
results

prop. of looks to the target (T/T+D) at disambiguation

PICK THE QUADRANT IN WHICH THERE IS (NO)

A CIRCLE

STAR



larger difference
as N° of targets increases

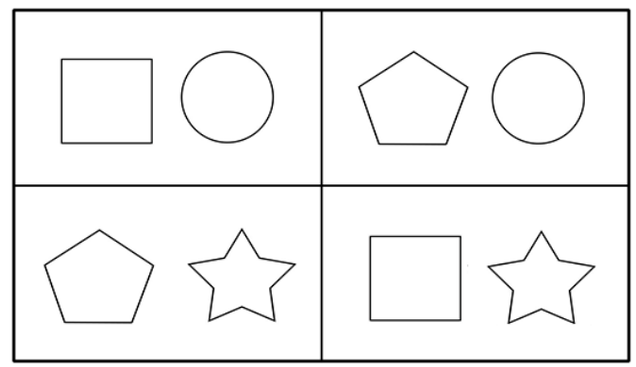
LMM on log target proportion

n° target: p<.001

polarity: p<.001

target*polarity: p<.001

b/w shapes



results

prop. of looks to the target (T/T+D) at disambiguation

PICK THE QUADRANT IN WHICH THE CIRCLE IS (NOT)

BLUE...

RED...

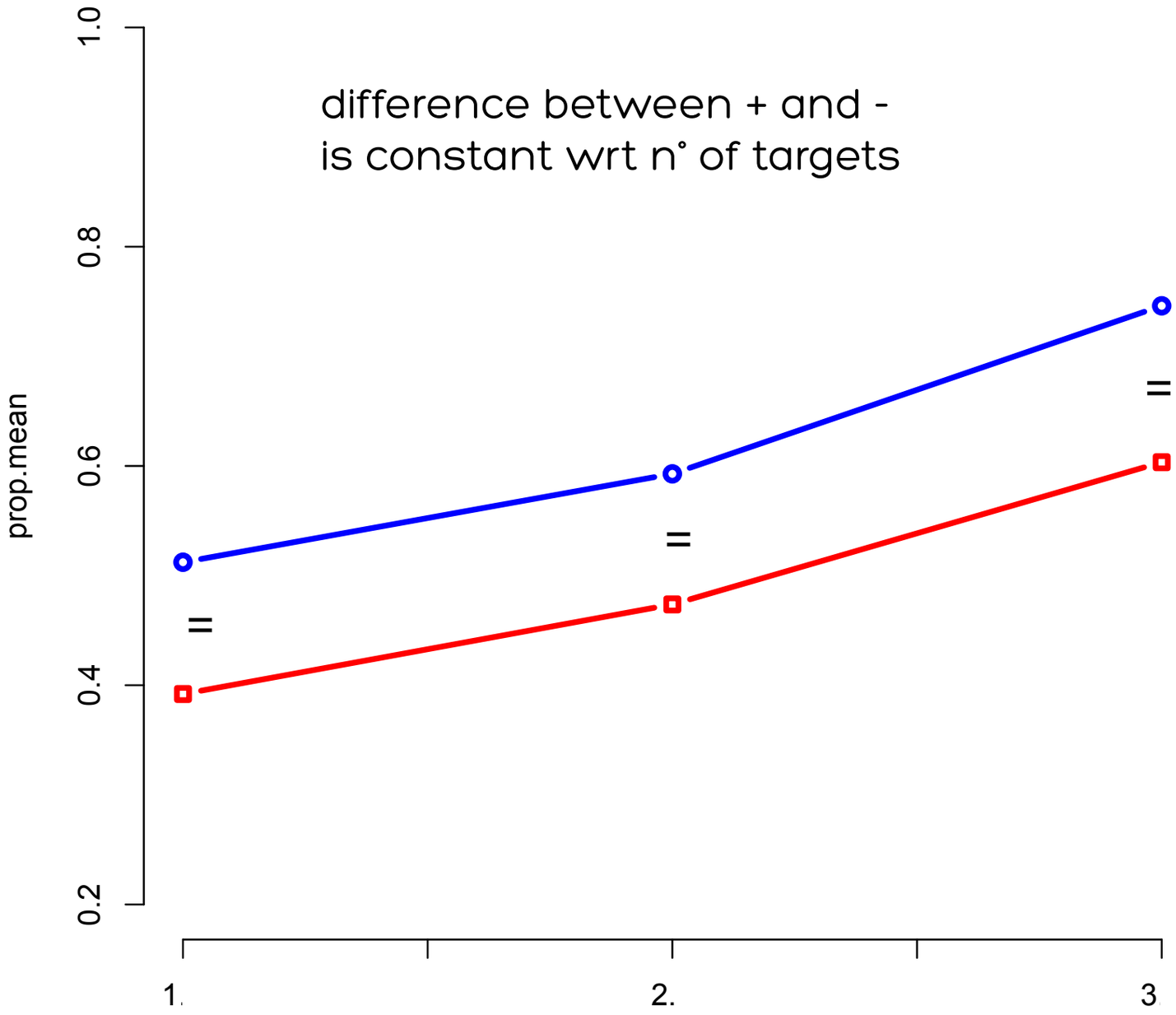
LMM on log target proportion

n° target: p<.001

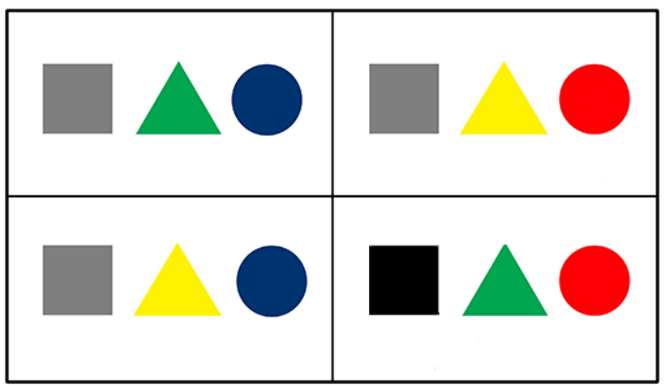
polarity: p<.001

target*polarity: p>.1

difference between + and -
is constant wrt n° of targets



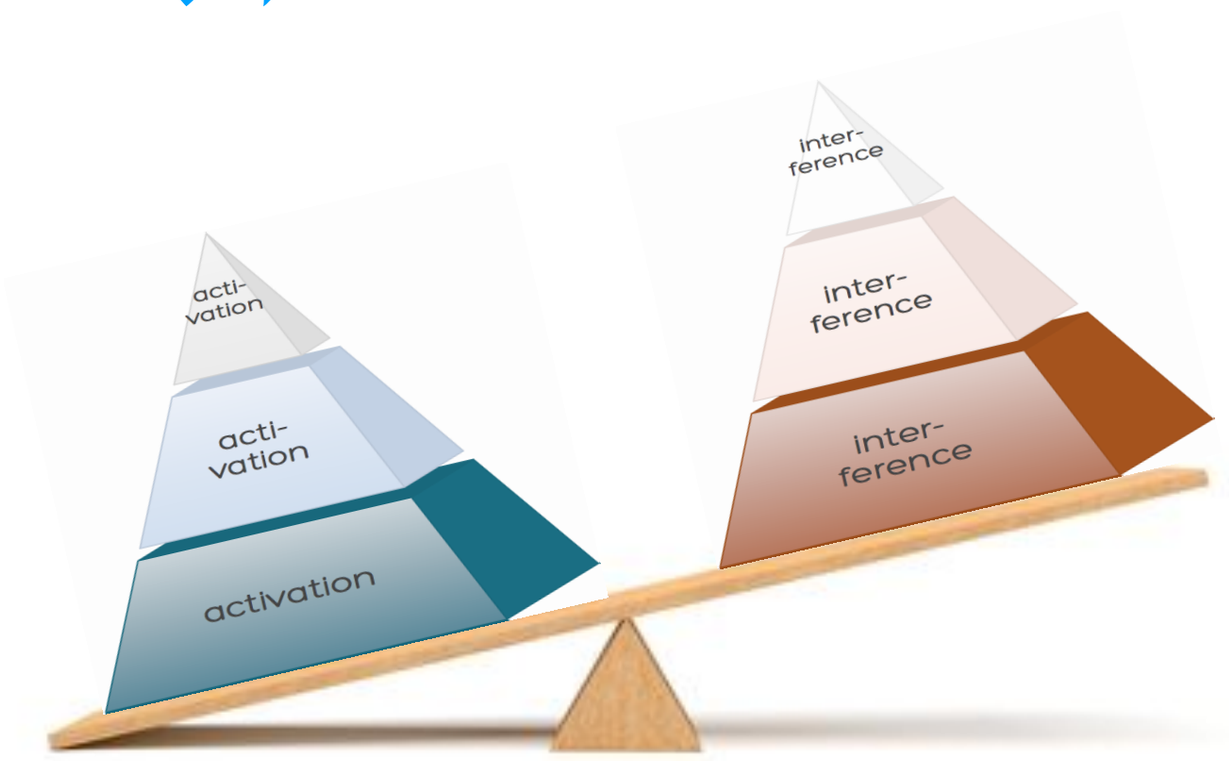
color shapes



results

- negation always displayed processing penalty
- penalty increases as n° of target increases (with cartoons & b/w shapes)
  = n° of MAs decreases in negative sentences

ACTIVATION of mentioned argument > INTERFERENCE



the greater the n° of target, the higher the base probability of fixating a target

inflate difference between POS & NEG

results

cartoons

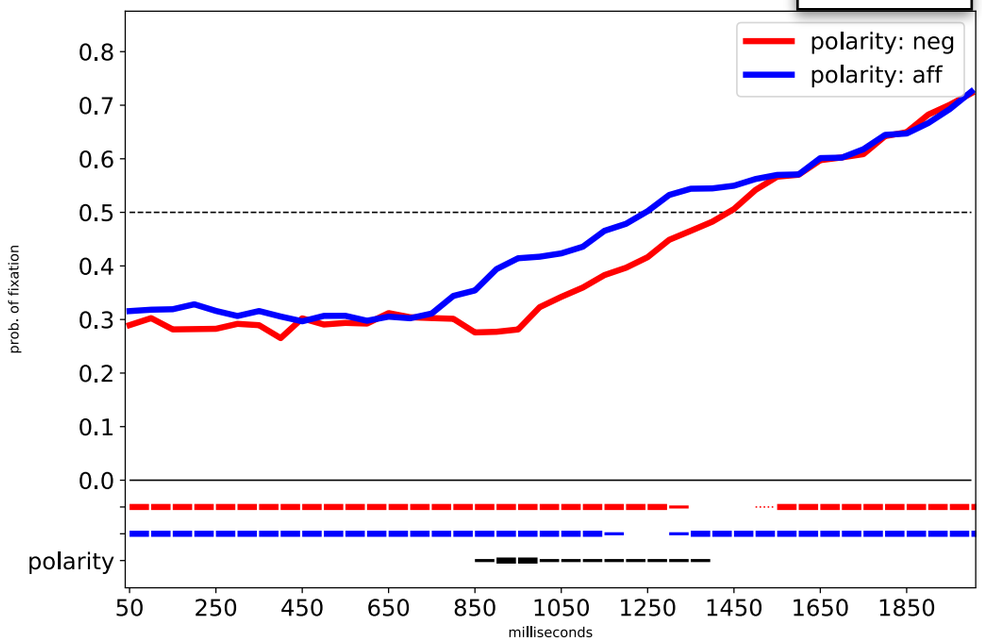
prop. of looks to the target (0 = disambiguation) in 50 ms bins

PICK THE QUADRANT IN WHICH ALADDIN IS (NOT)

CLOSING THE DOOR...

BUILDING A TENT...

1 target



results

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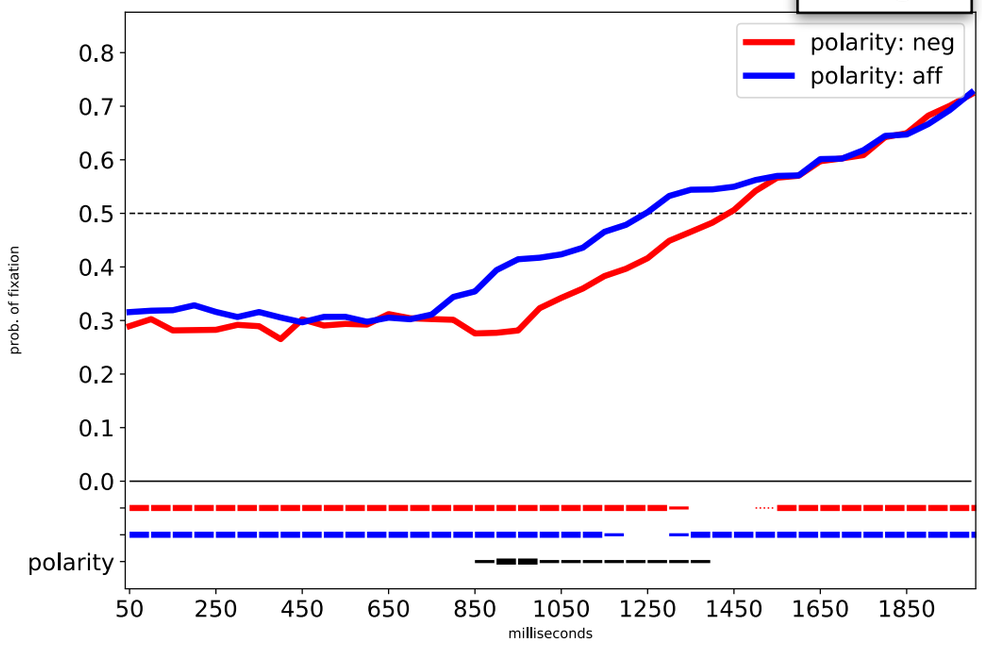
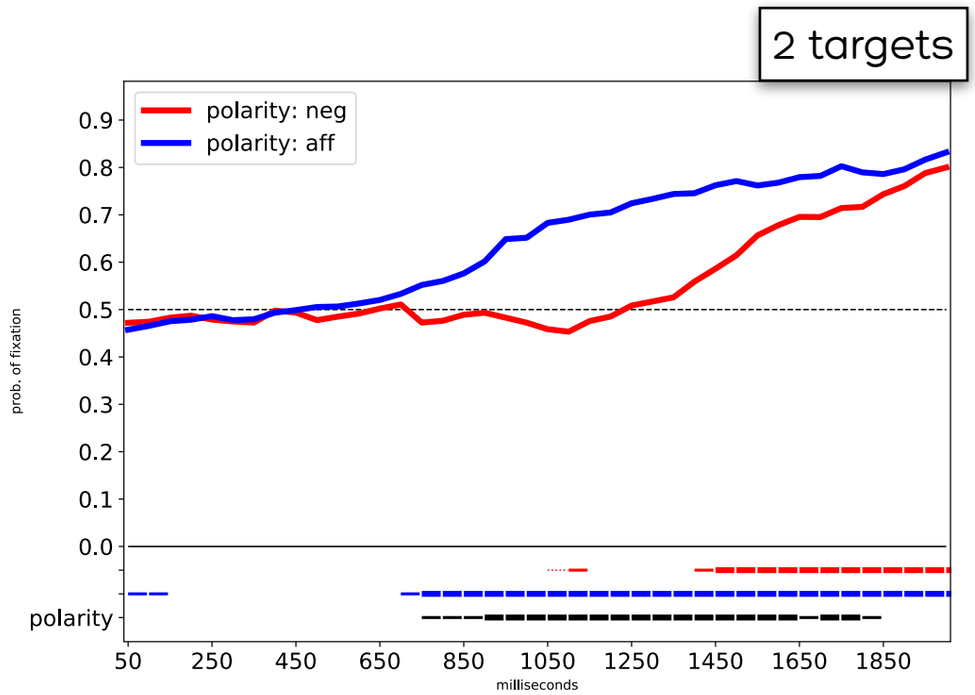
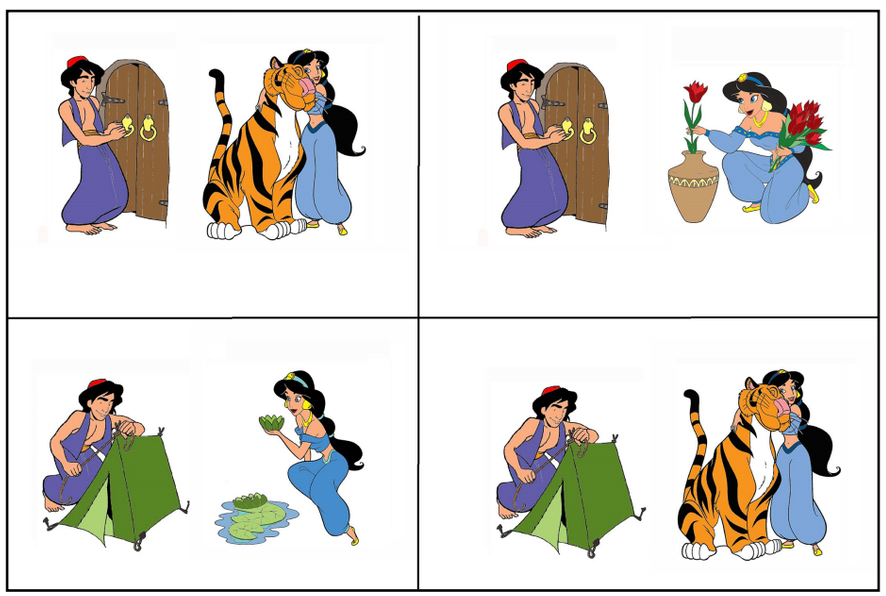


2 targets





results

cartoons

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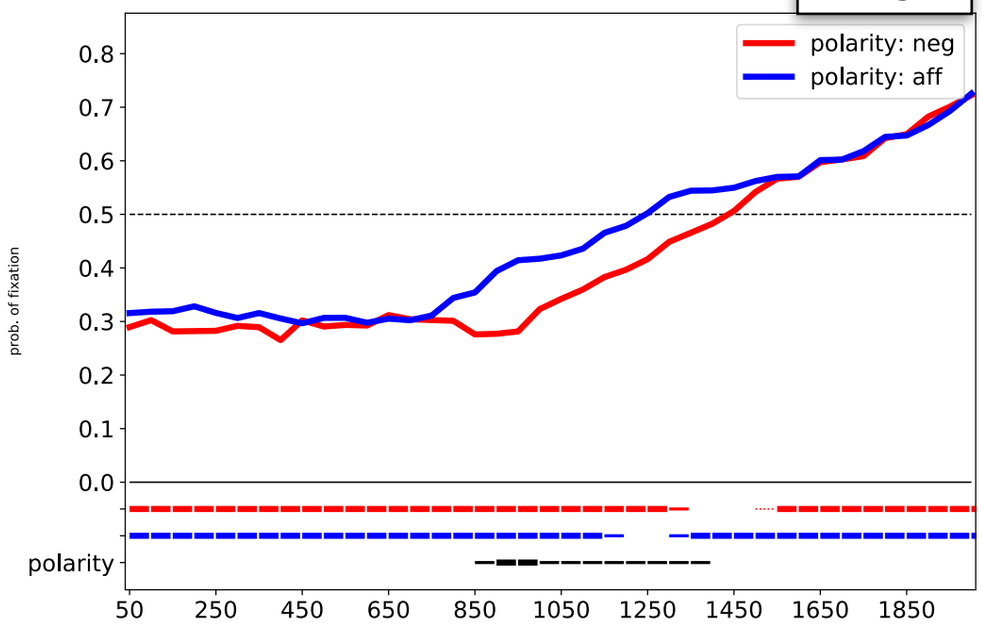
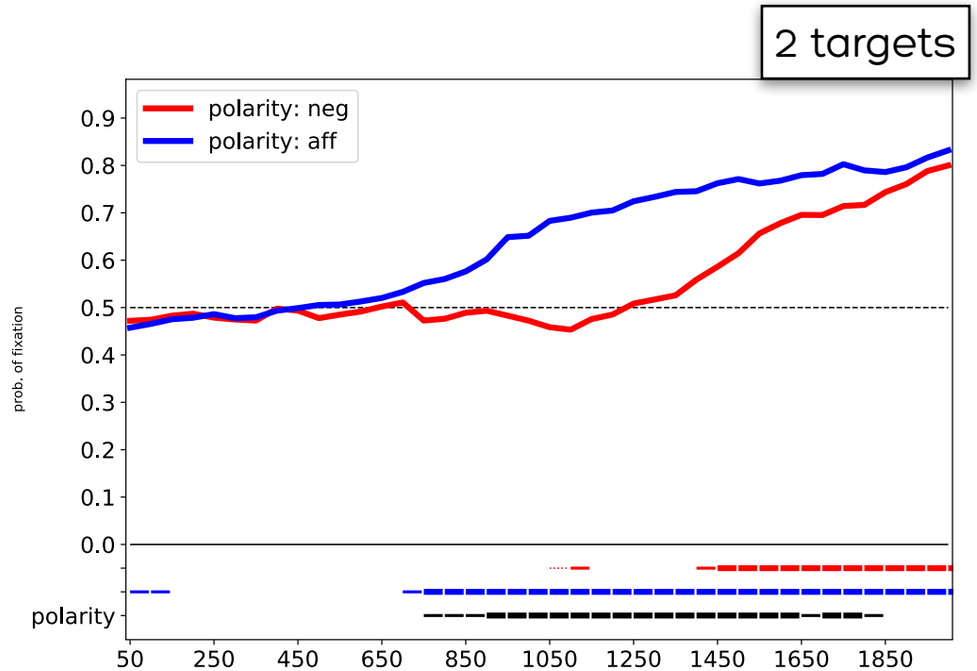
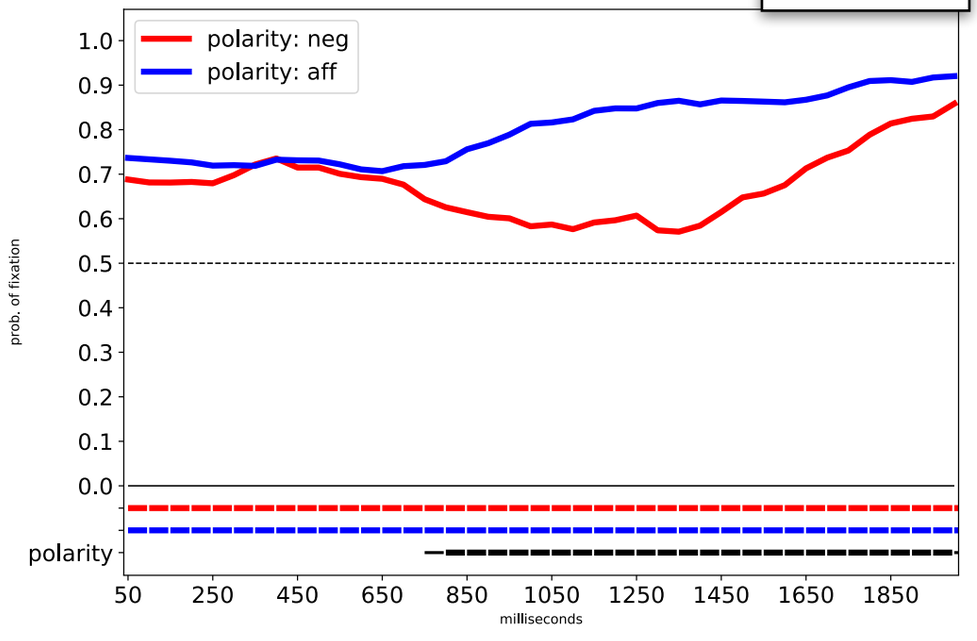


2 targets



3 targets



decrement in looks to the target with negative sentences with more than one target

results

b/w shapes

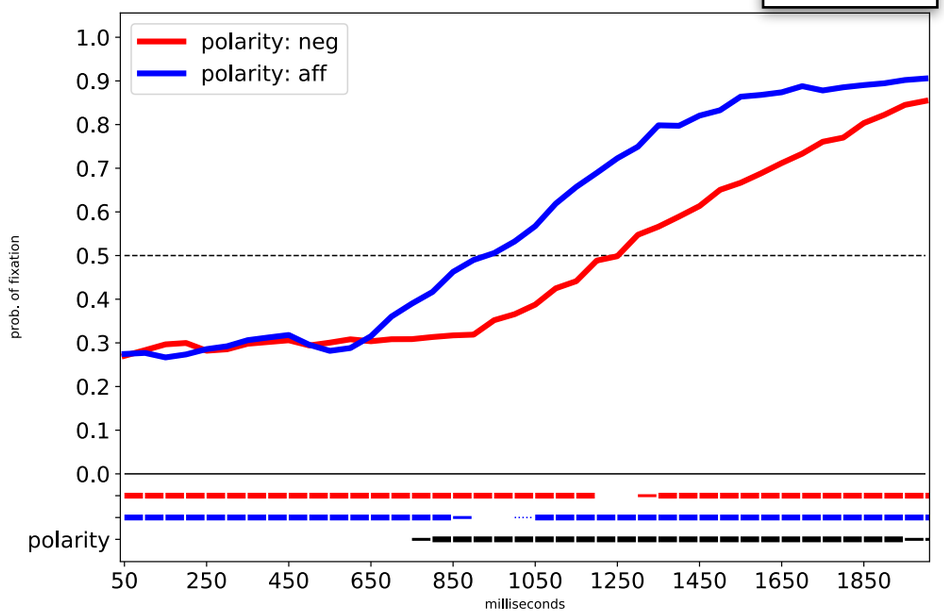
prop. of looks to the target (0 = disambiguation) in 50 ms bins

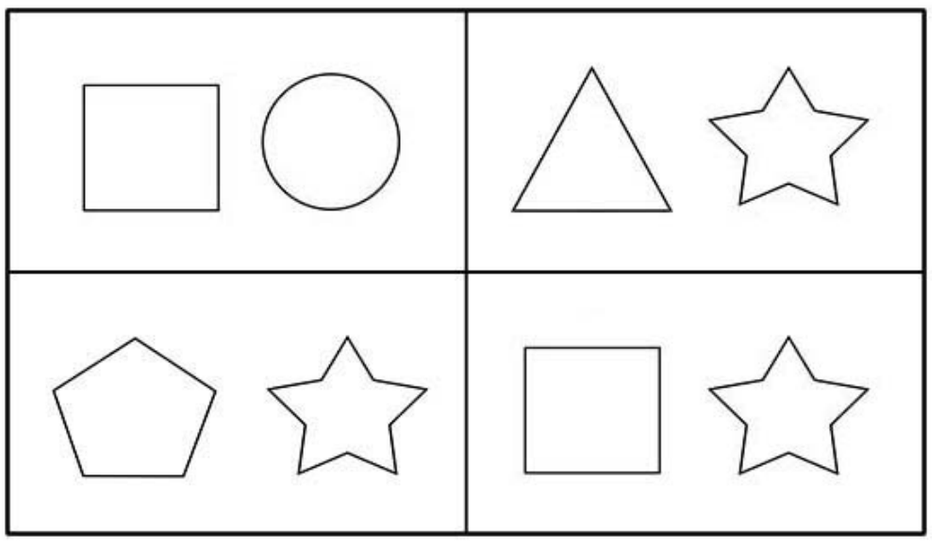
PICK THE QUADRANT IN WHICH THERE IS (NO)

A CIRCLE

STAR

1 target





results

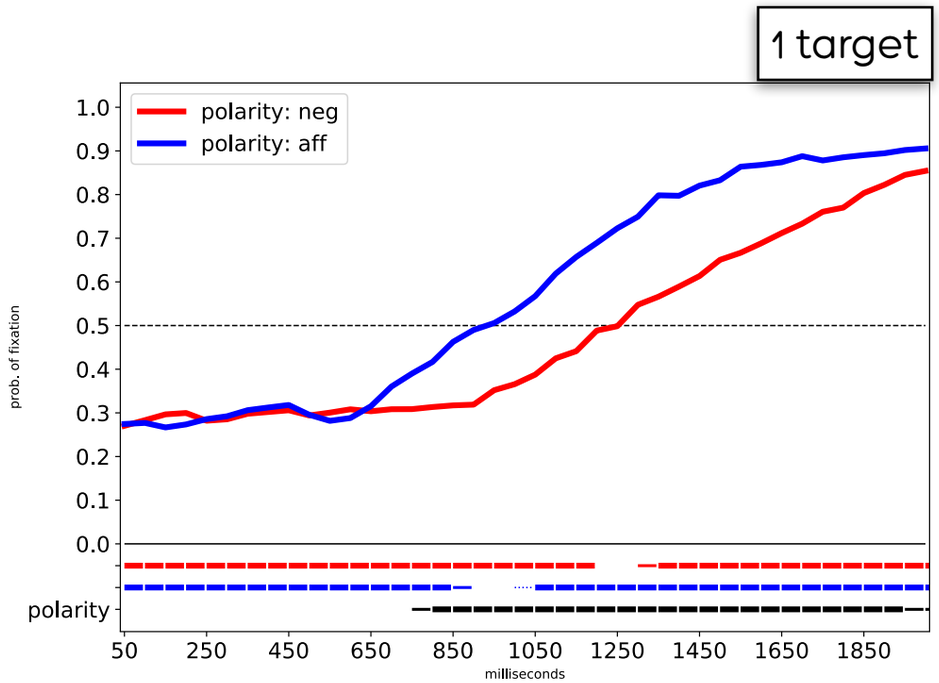
prop. of looks to the target (0 = disambiguation) in 50 ms bins

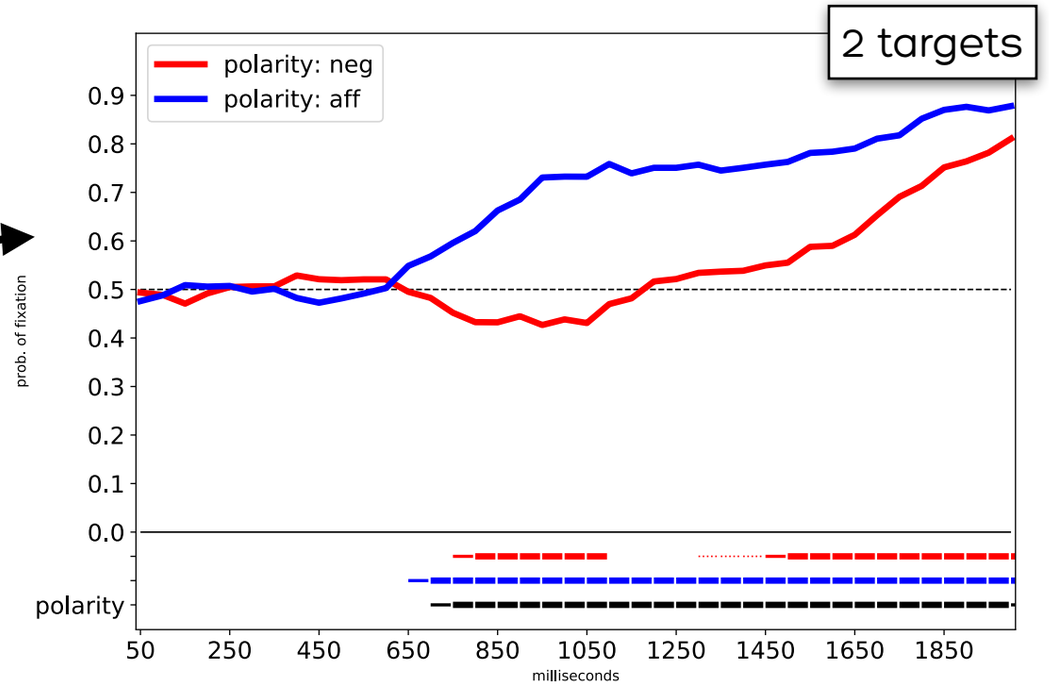
b/w shapes

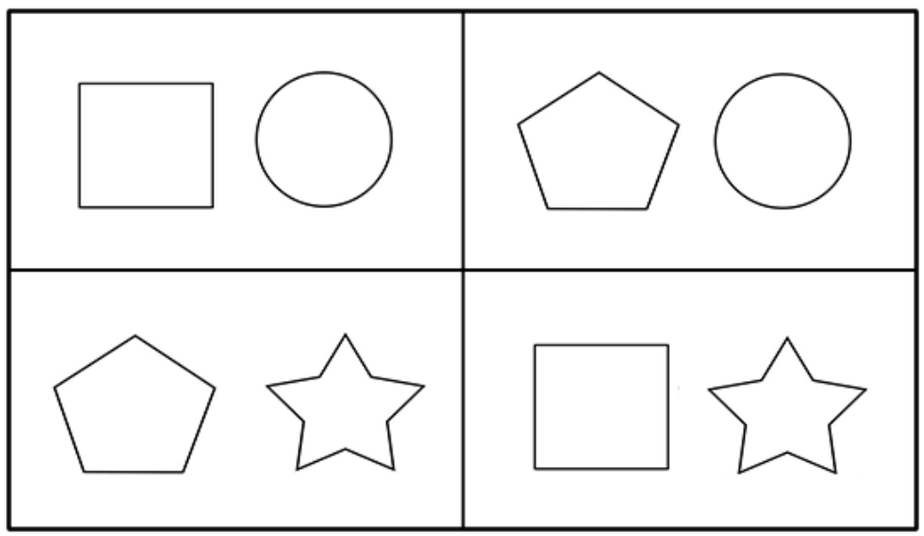
PICK THE QUADRANT IN WHICH THERE IS (NO)

A CIRCLE...

STAR...







results

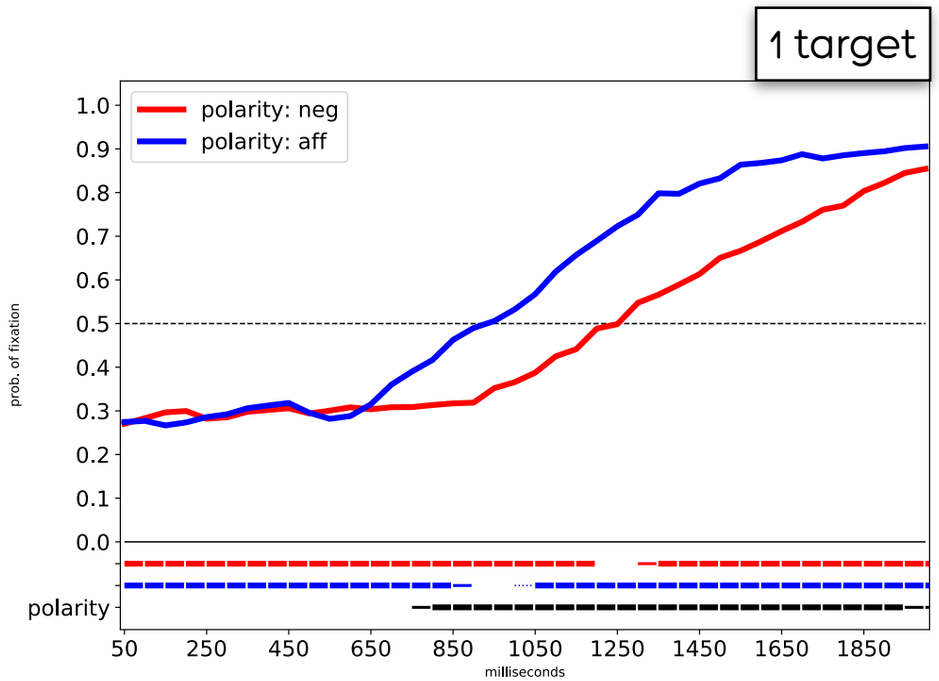
prop. of looks to the target (0 = disambiguation) in 50 ms bins

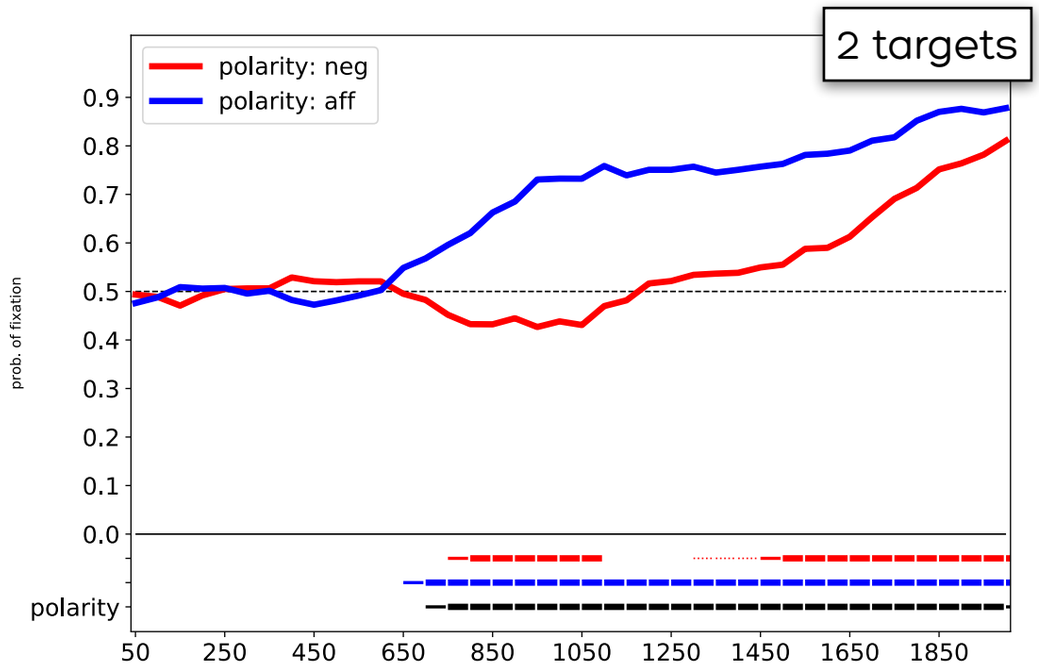
b/w shapes

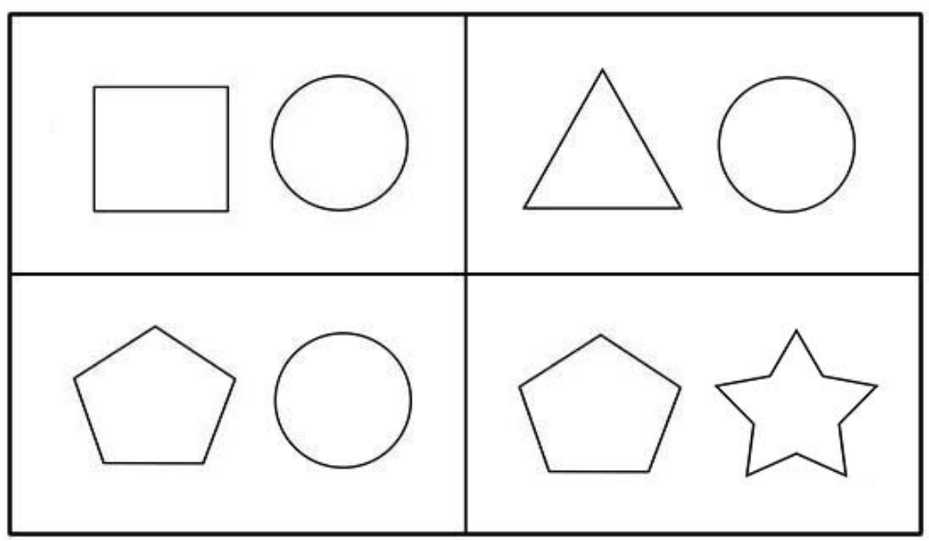
PICK THE QUADRANT IN WHICH THERE IS (NO)

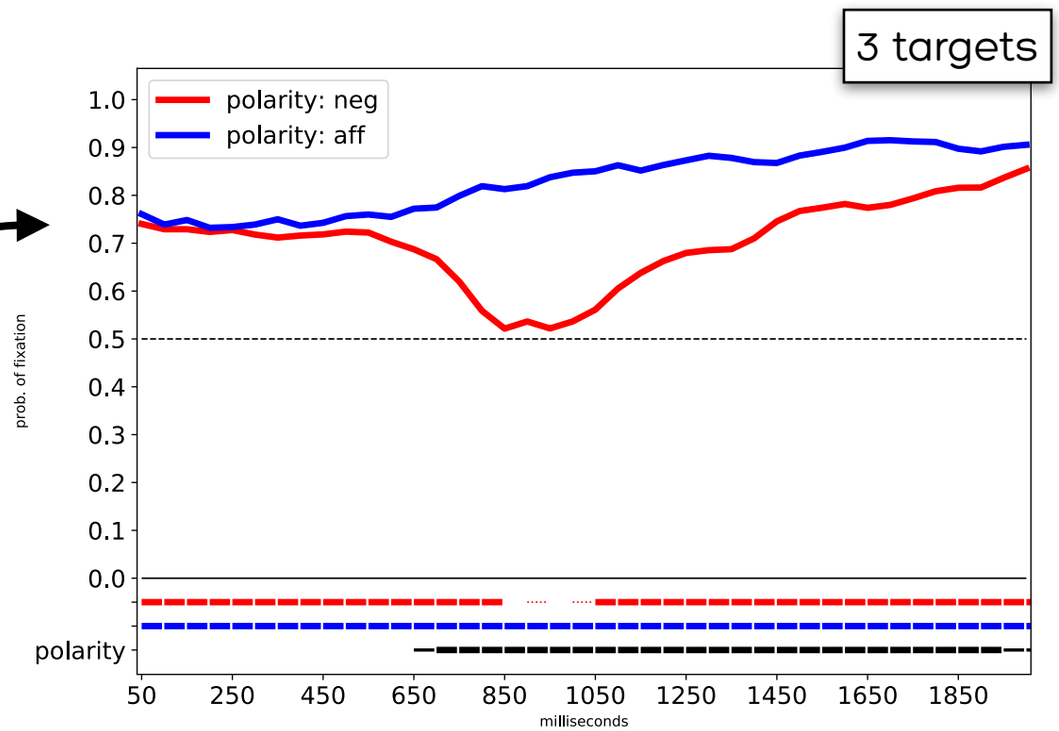
A CIRCLE...

STAR...









decrement in looks to the target with negative sentences with more than one target

results

color shapes

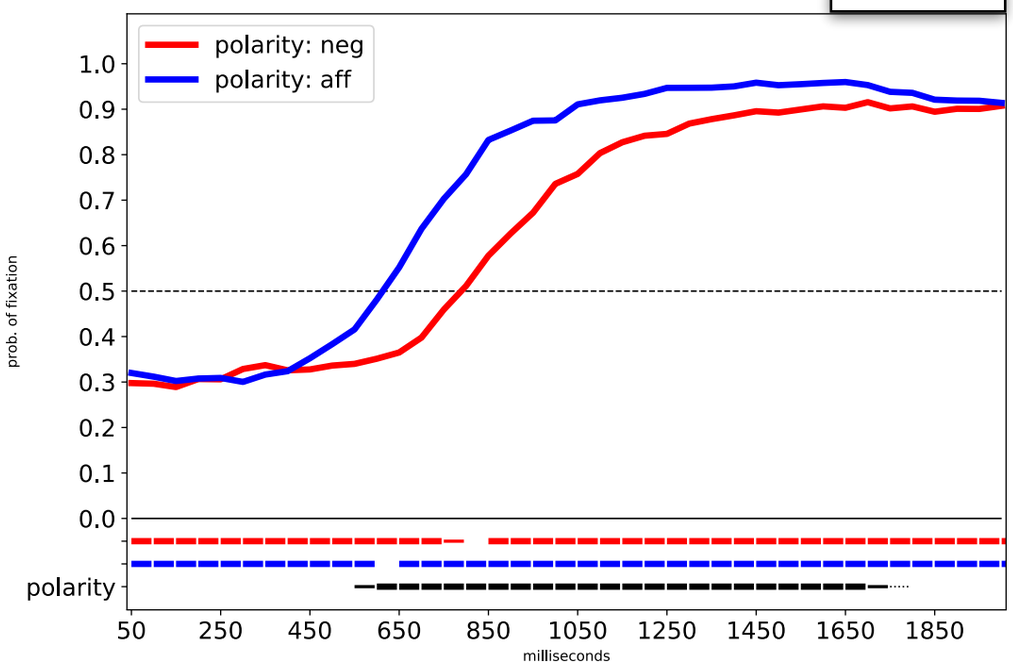
prop. of looks to the target (0 = disambiguation) in 50 ms bins

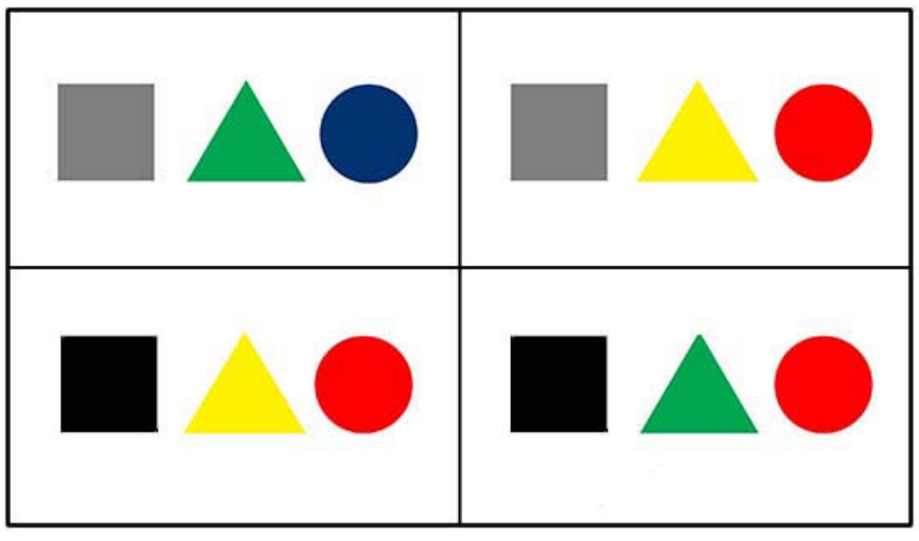
PICK THE QUADRANT IN WHICH THE CIRCLE IS (NOT)

BLUE...

RED...

1 target





small difference between 2 and 3 targets

results

color shapes

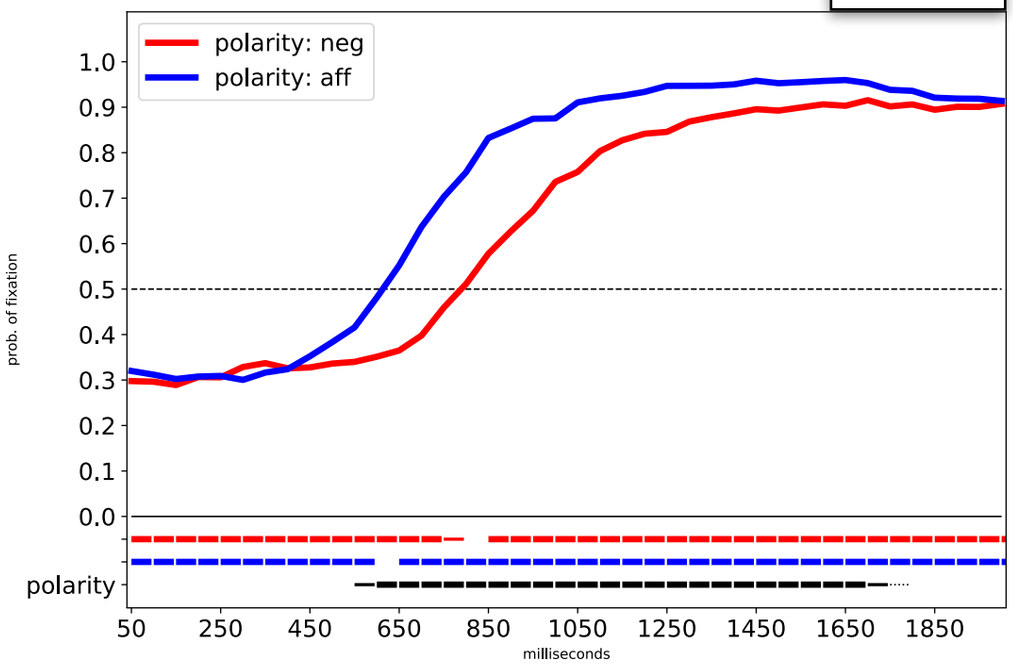
prop. of looks to the target (0 = disambiguation) in 50 ms bins

PICK THE QUADRANT IN WHICH THE CIRCLE IS (NOT)

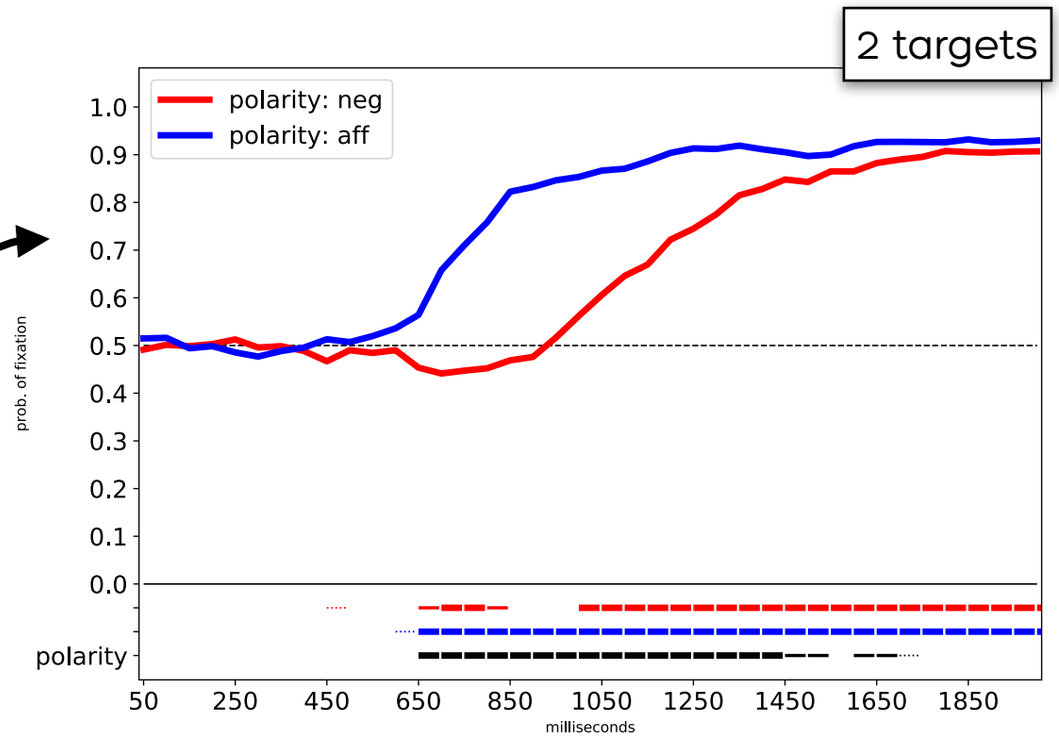
BLUE...

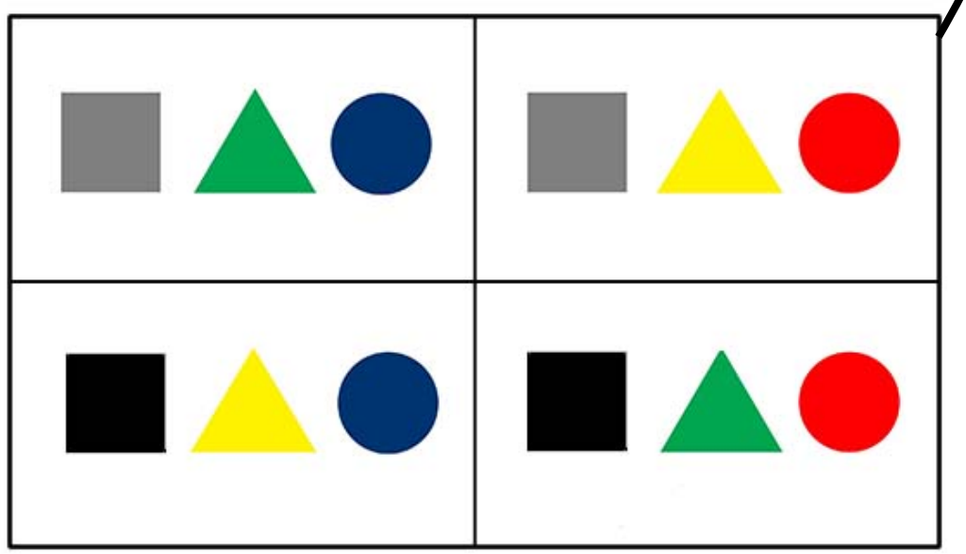
RED...

1 target



2 targets





results

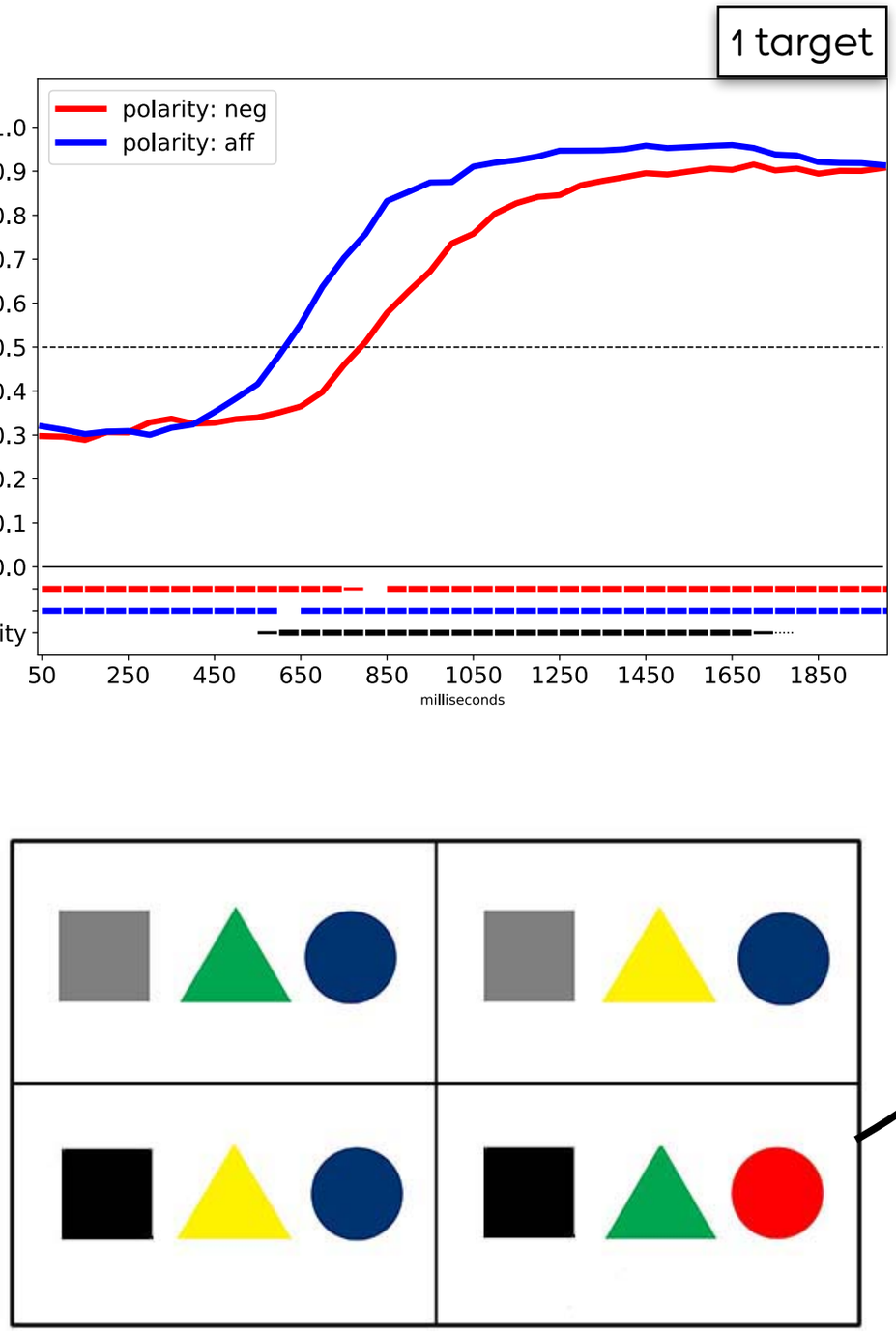
prop. of looks to the target (0 = disambiguation) in 50 ms bins

BLUE...

RED...

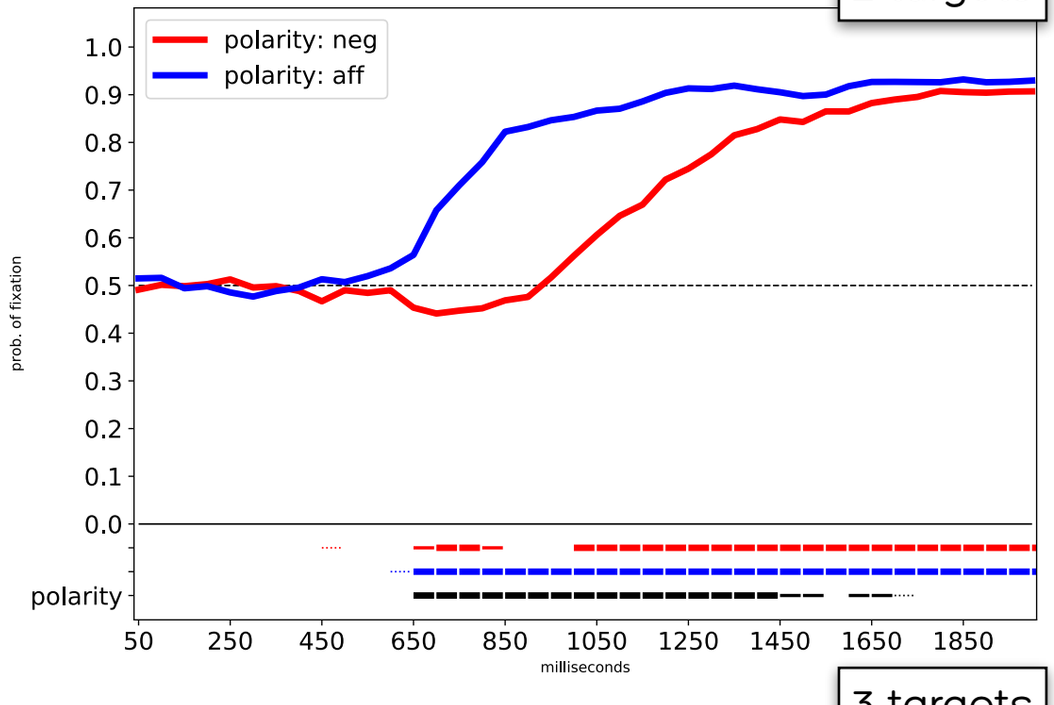
color shapes

PICK THE QUADRANT IN WHICH THE CIRCLE IS (NOT)

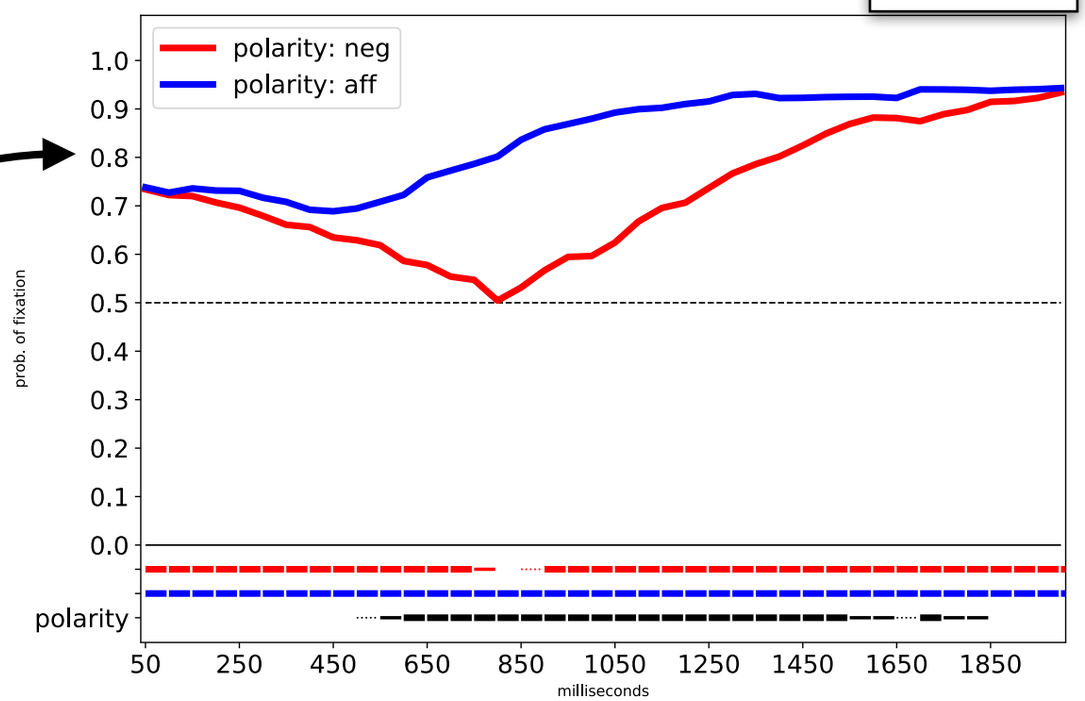


1 target

2 targets



3 targets

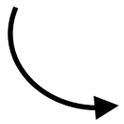


small difference between 2 and 3 targets

what drives this effect?

proportion of looks to the MENTIONED ARGUMENT

- keeps the visual scenario constant
- tells us exactly at which point



negation is integrated during online comprehension

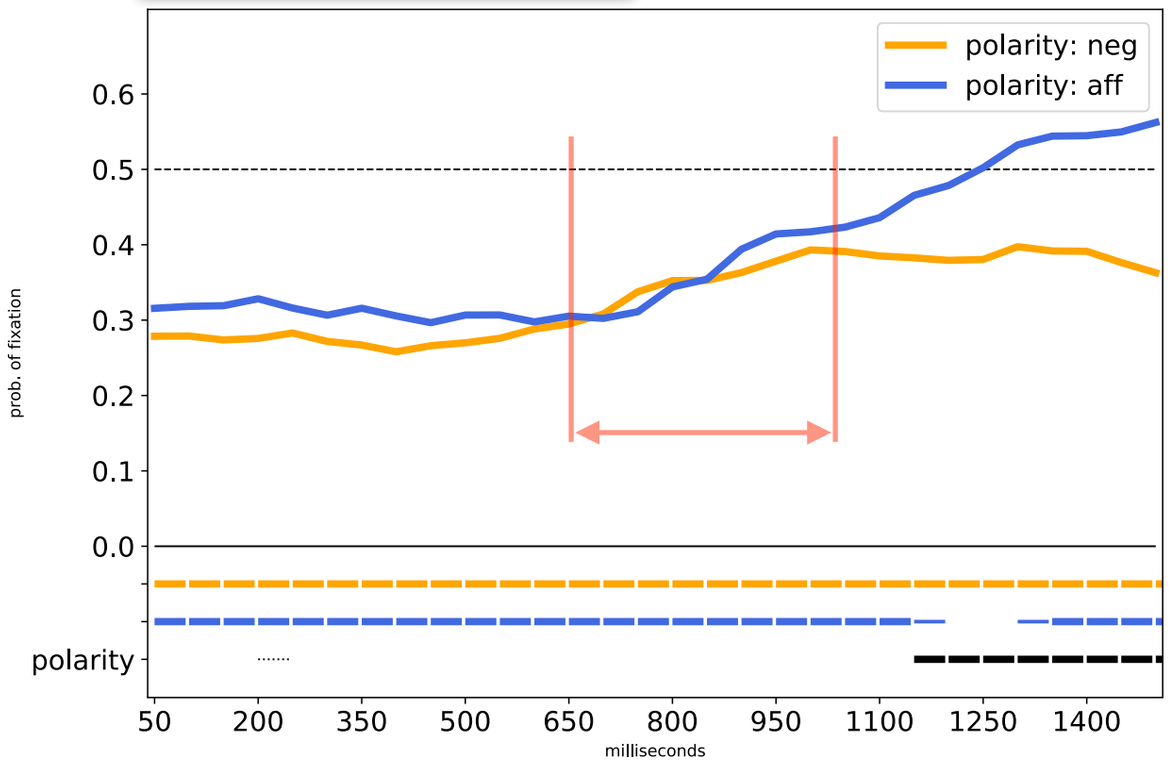
results

prop. of looks to the mentioned argument (0 = disambiguation)

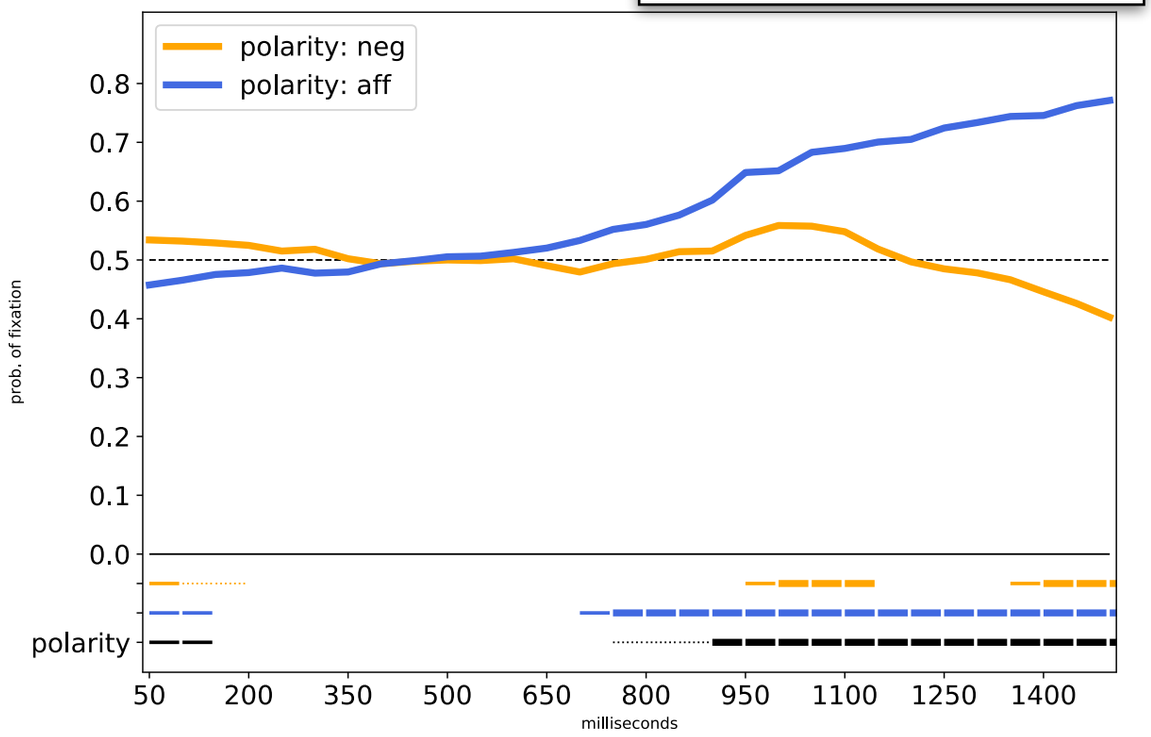
in 50 ms bins

cartoons

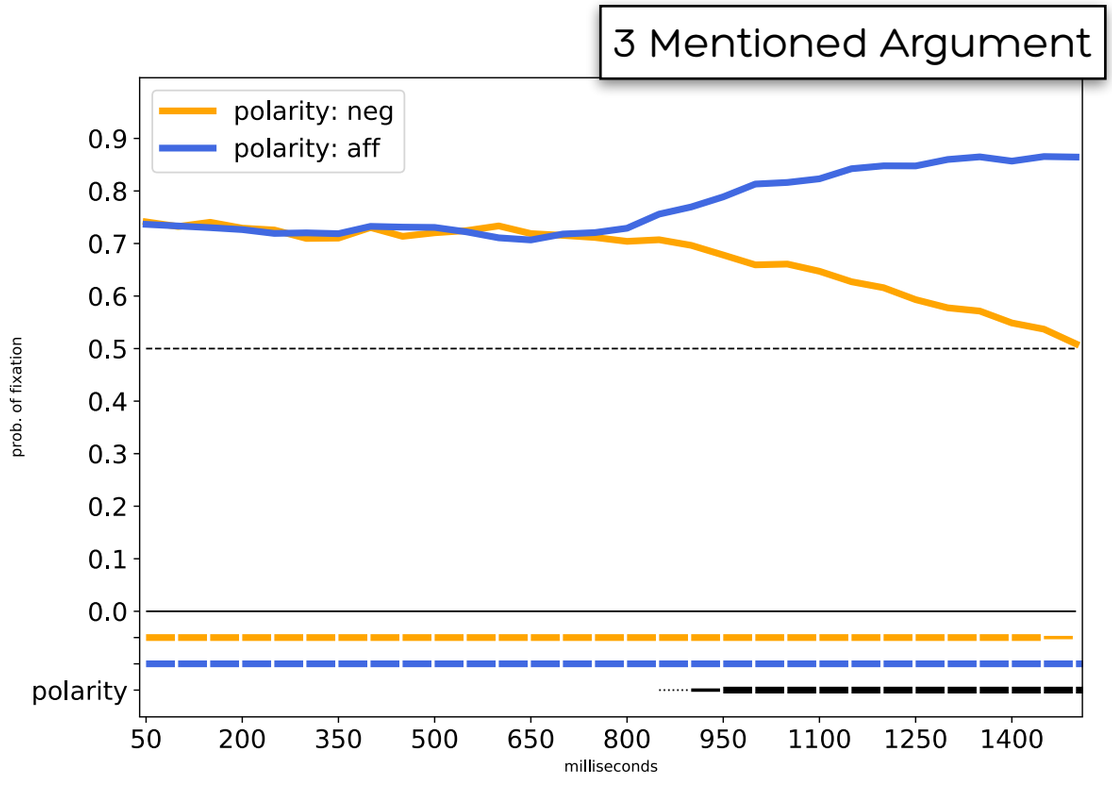
1 Mentioned Argument



2 Mentioned Argument



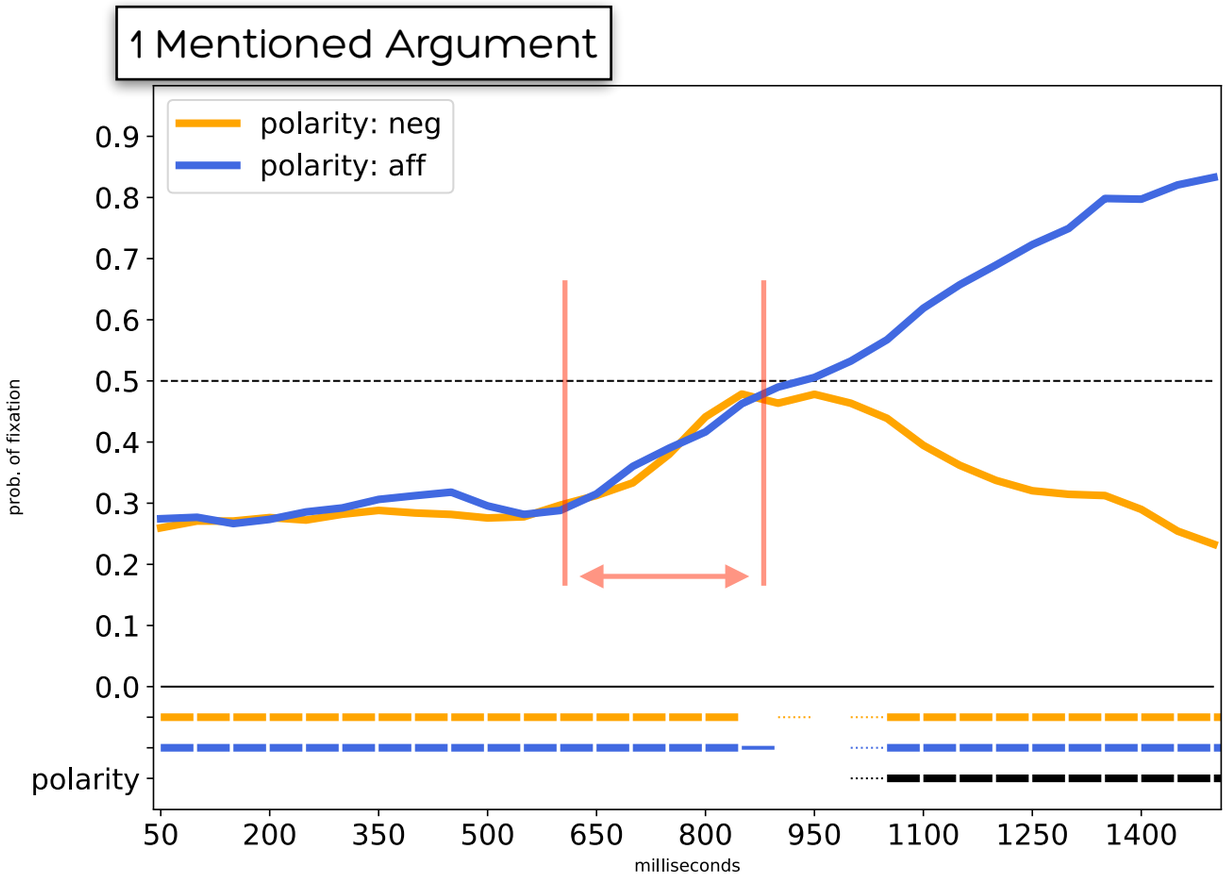
3 Mentioned Argument

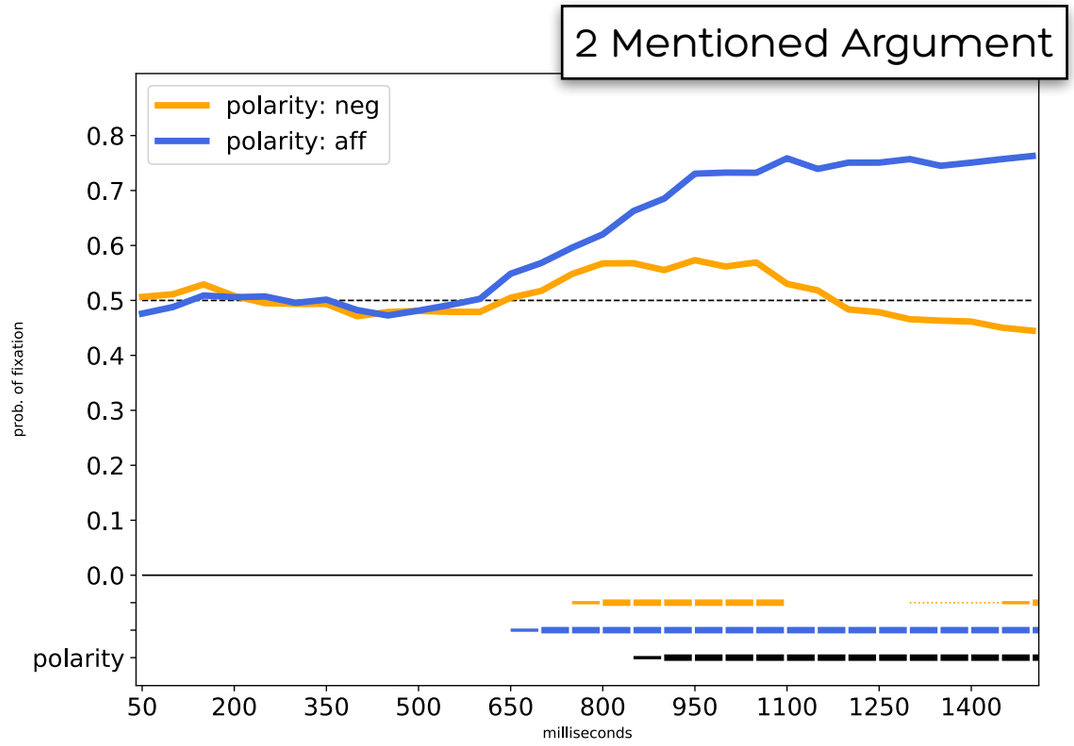


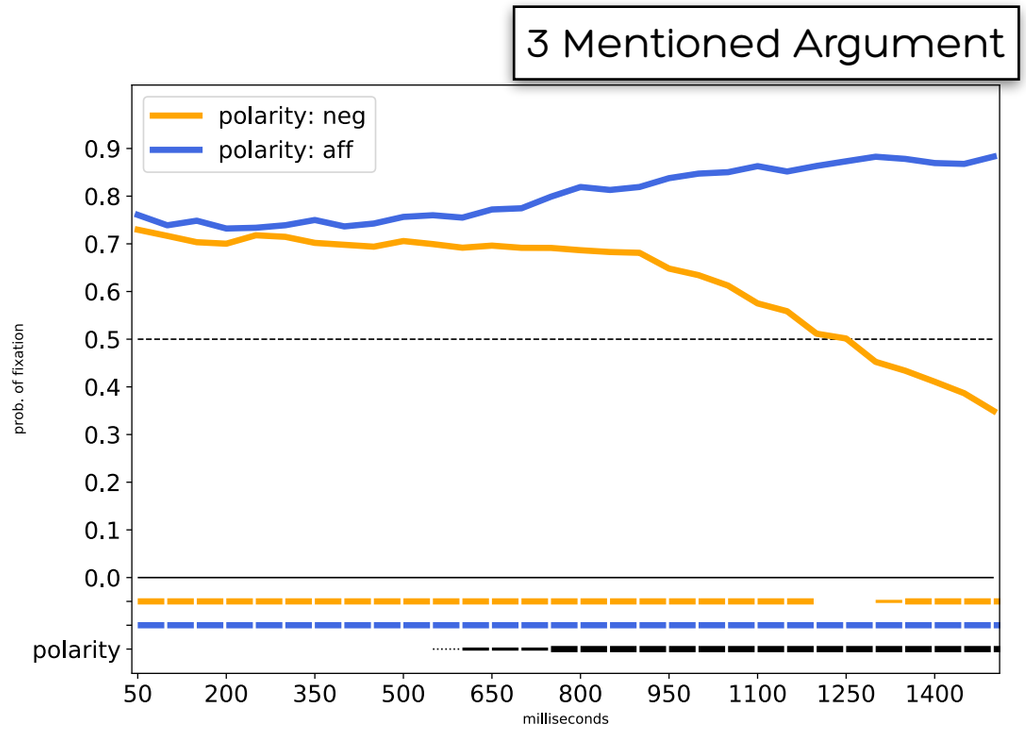
results

prop. of looks to the mentioned argument (0 = disambiguation) in 50 ms bins

b/w shapes







results

prop. of looks to the mentioned argument (0 = disambiguation)

in 50 ms bins

color shapes

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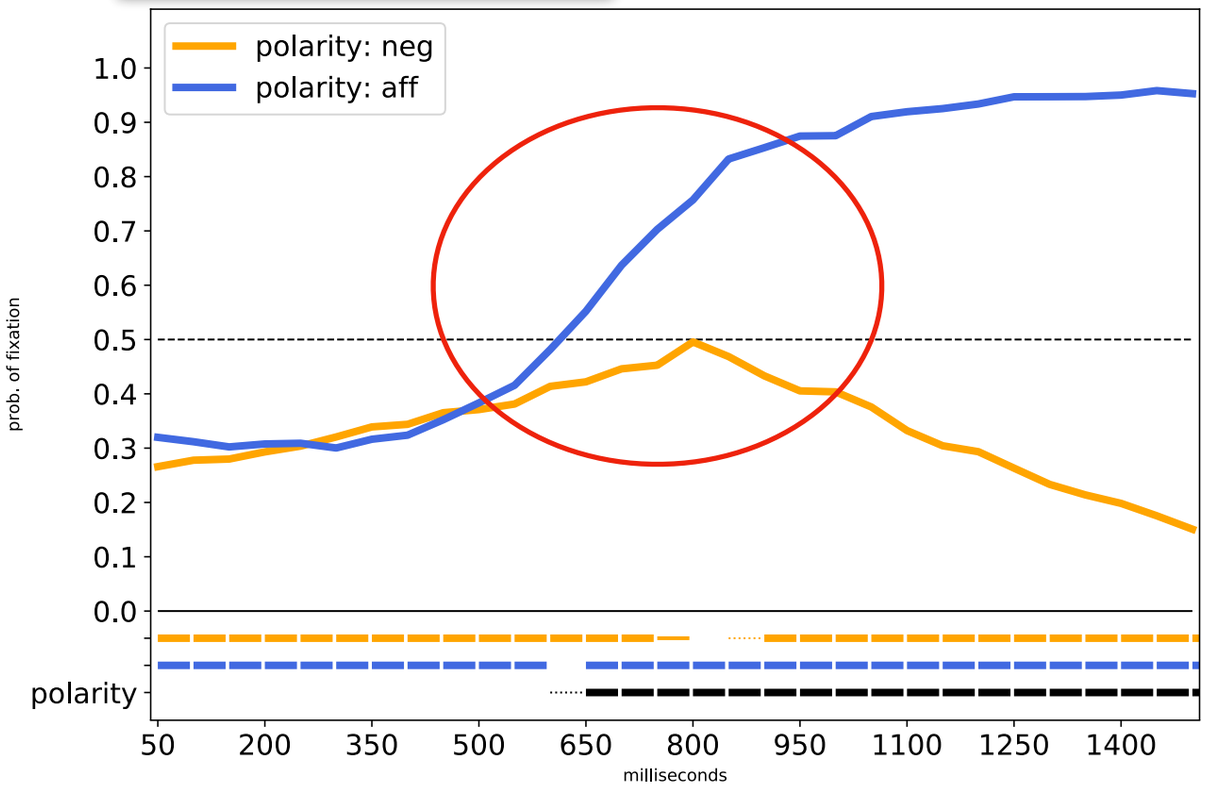
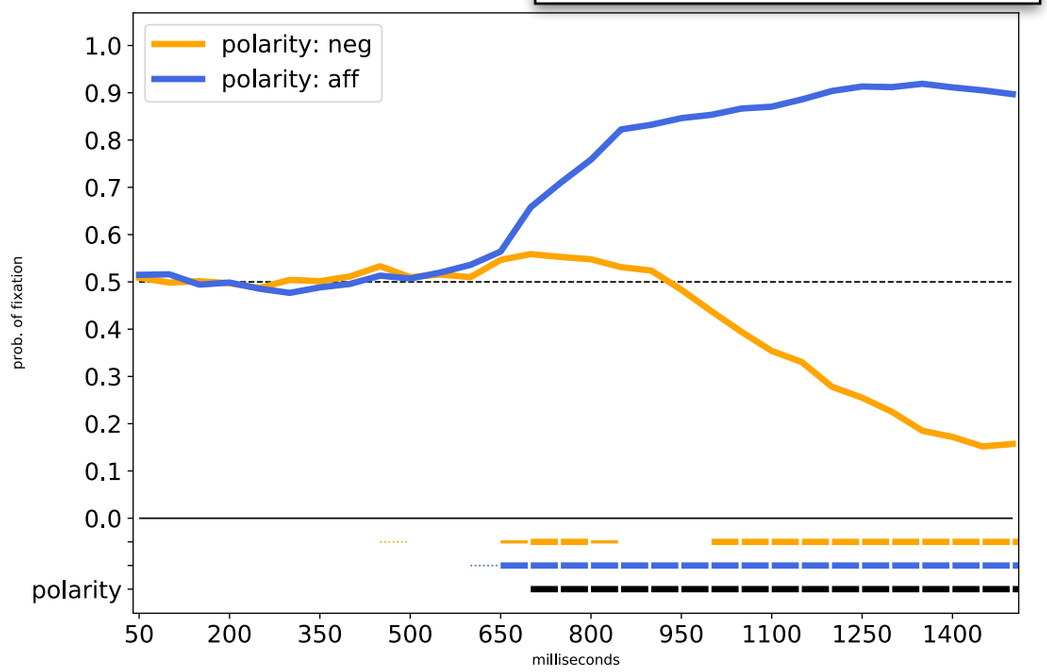
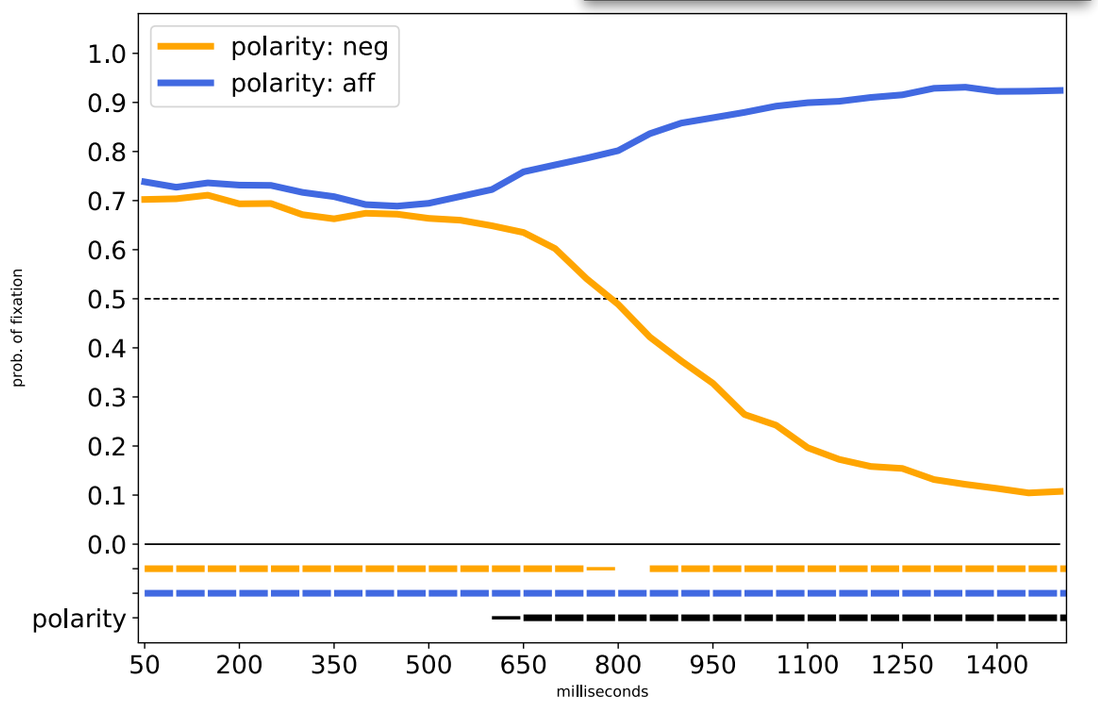


2 Mentioned Argument



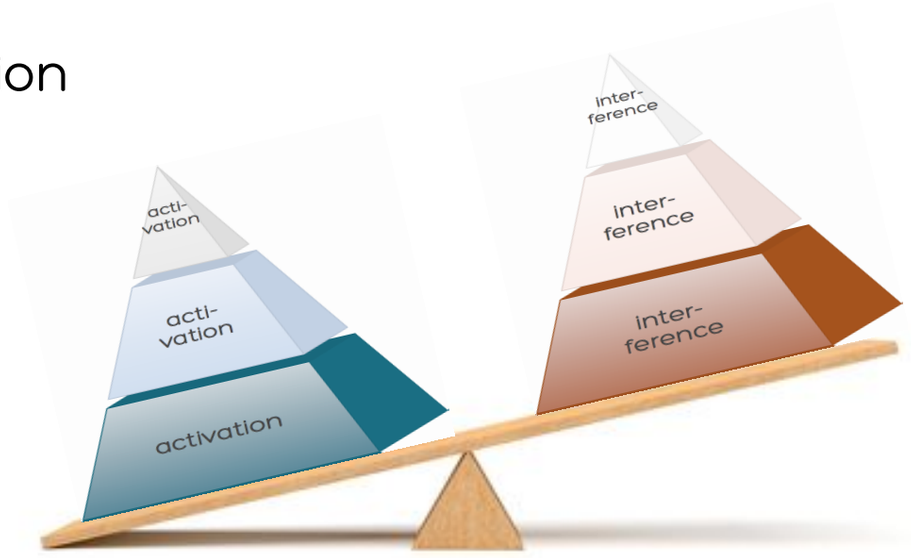
3 Mentioned Argument



summary of results

1) negation displayed a <u>processing penalty</u> in every condition

2) <u>activation</u> of mentioned argument weighs more on the budget than inhibition



- the prominence of the mentioned argument in the visual context reduces the cost of processing negation

- the process for <u>activation</u> (i.e. identification/retrieval of argument of negation), rather than <u>inhibition</u>, is one of the key factors underlying the processing penalty of negation

← prolonged looks to MA in negative sentences with 1 > 2 > 3 targets

3) with colored shapes the effect is smaller and does not reach significance

colors facilitate spatial/MA encoding and target identification

4) with complex scenes (cartoons) the effect is stronger and delayed

they require deeper encoding/comprehension

<u>FLEXIBILITY</u> of the system

conclusions

- overcoming 1 vs. 2 step models debate

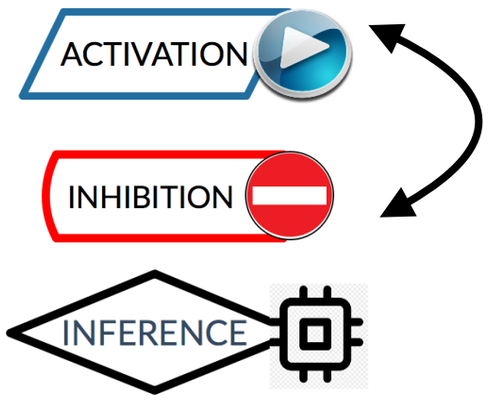
  our results strongly support 2 step models BUT...

  - INCREMENTALITY
  - FLEXIBILITY
  - SENSITIVITY to PROPOSITIONAL content

MULTI-PROCESS model of NEGATION

exclusively based on mental/sensorial simulation

- non-incremental
- non-propositional
- at odds with results from neuroscience



- integrating results from neuroscience & processing

- inhibition in motor/sensory areas
- activation in language areas
  lexical retrieval,
  lexical storage,
  construction of
  propositional content