

Adults are not always faster than children.  
An eye-tracking study on the online comprehension of  
indirect scalar implicatures



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Funding: German Research  
Assoc.  
Project No: 4750059

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THE Nörten-Hardenberg  
school children conspiracy in  
the Neo-Gricean Paradise.



**DFG**

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# IMPLICATURES

direct implicatures

indirect implicatures  
(Chierchia, 2004)

# IMPLICATURES

direct implicatures

the girl ate *some* of the cookies

~~the girl ate *all* of the cookies~~



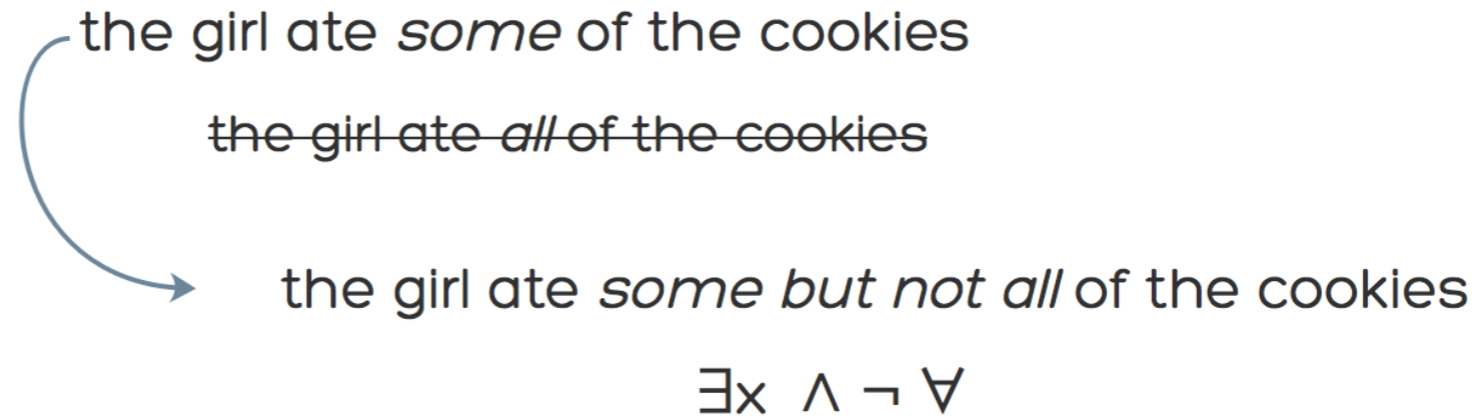
the girl ate *some but not all* of the cookies

$\exists x \wedge \neg \forall$

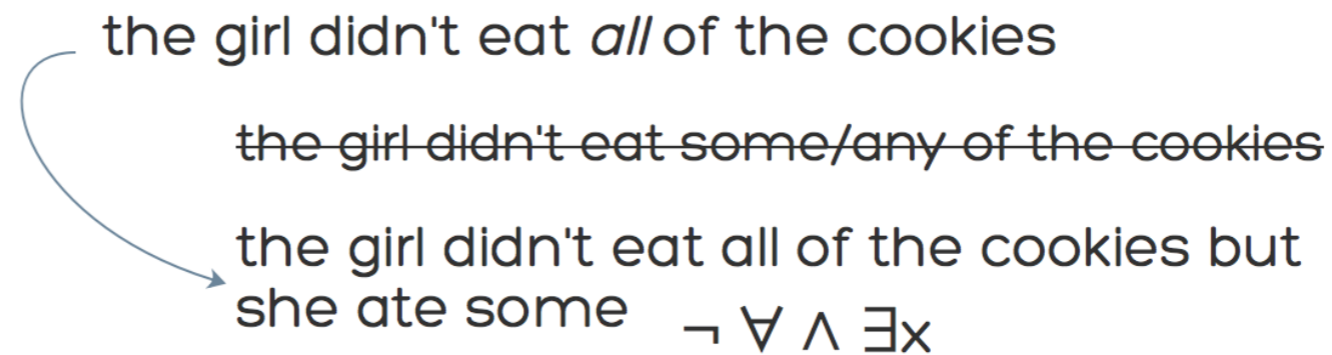
indirect implicatures  
(Chierchia, 2004)

# IMPLICATURES

direct implicatures



indirect implicatures  
(Chierchia, 2004)



## TODAY'S QUESTIONS:

how are indirect implicatures interpreted?



how are indirect implicatures processed?



what is the role of intonation?



## TODAY'S QUESTIONS:

how are indirect implicatures interpreted?



in adults & children

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what is the role of intonation?



# direct s. IMPLICATURES

how are direct implicatures processed?



- 1 sometimes they are very fast (immediate access)
- 2 sometimes they are slow (processing cost)
- 3 unstrengthened interpretations (ALL compatible with SOME) are fast/earlier accessed

neo-Gricean view predicts:

scalar implicatures computed by default

cost for 'canceling' the implicature rather than for calculating it

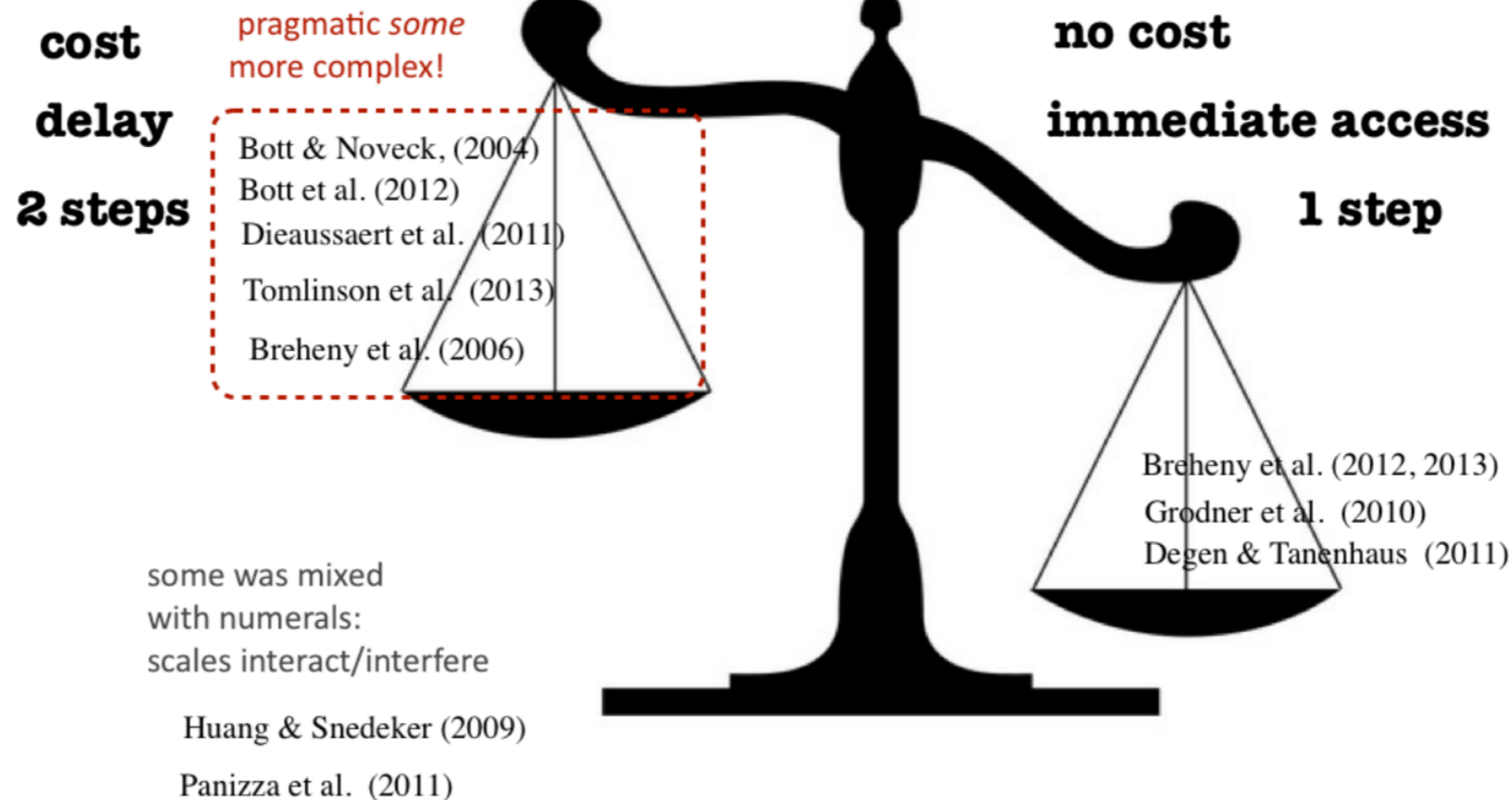


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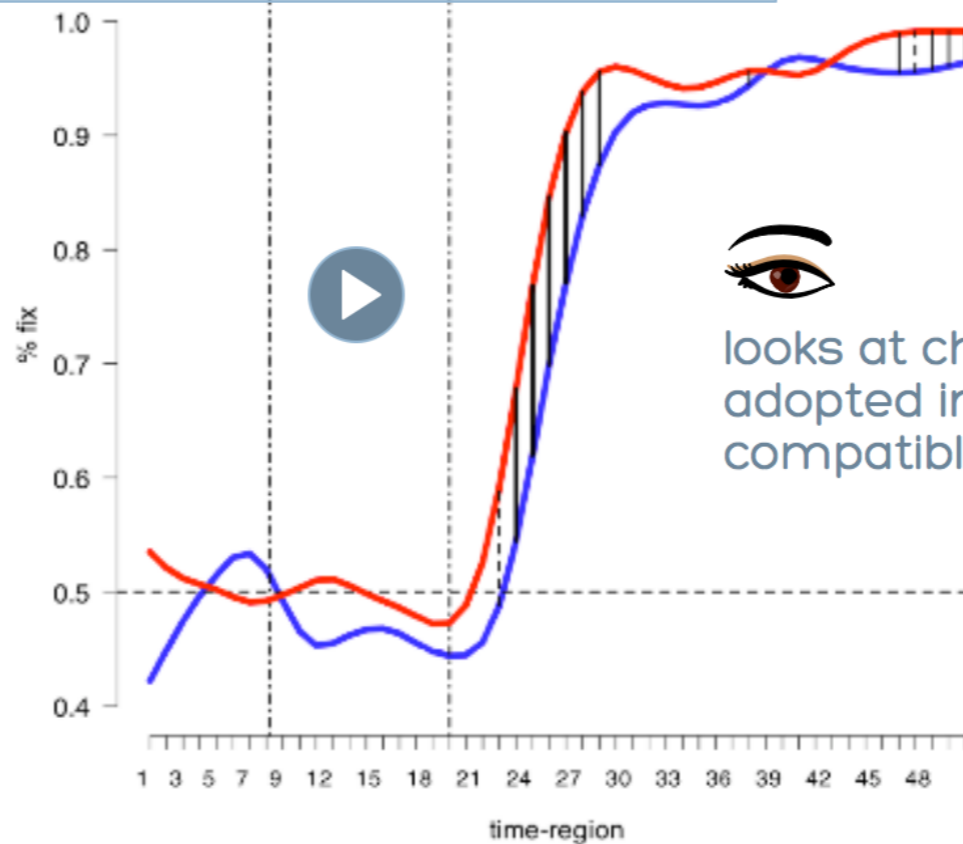
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the boy has *some* of the paper...clips



looks at chance means that the adopted interpretation is compatible with both boys

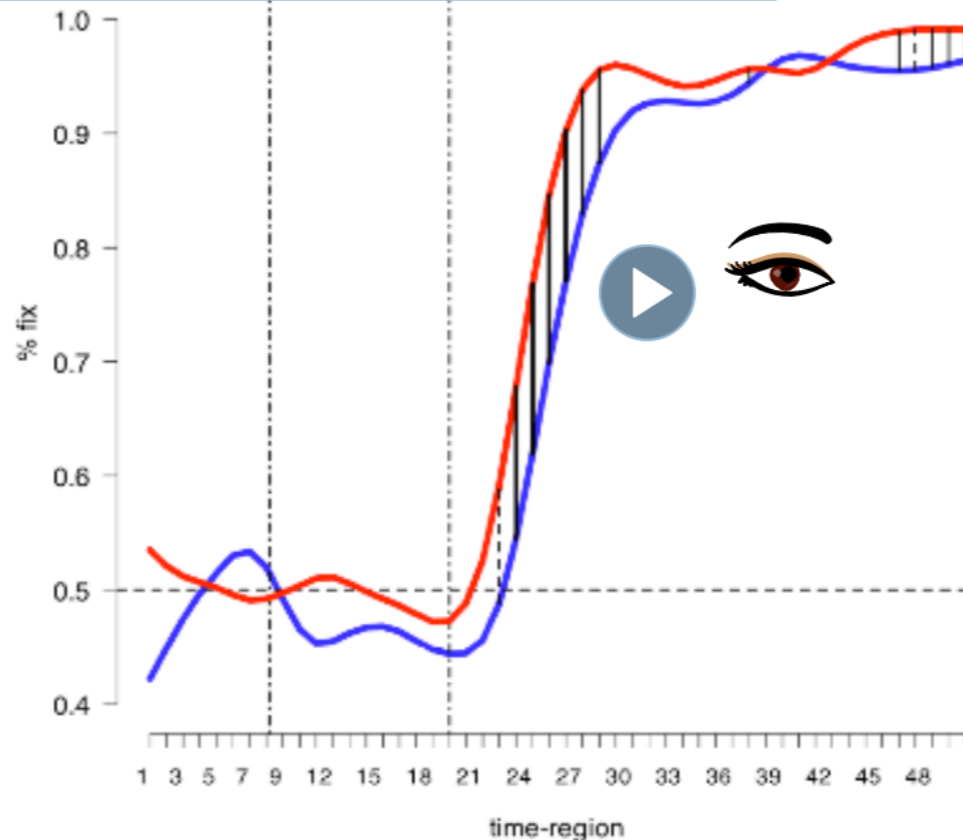
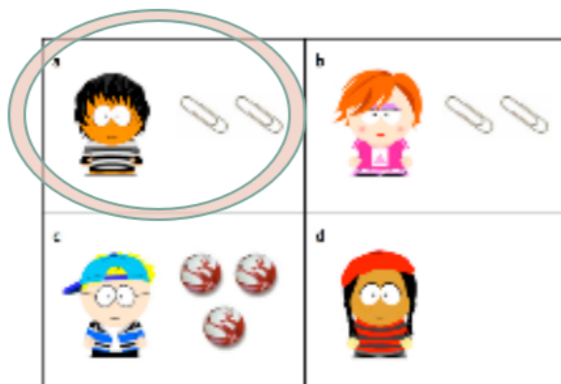
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cost for 'canceling' the implicature rather than for calculating it



we might be groping in the dark with implicatures but...

# direct s. IMPLICATURES



in children

at what age are young learners  
sensitive to implicature violations?  
*very late (from at least 6 years of age)!*

why do children fail at deriving them?  
*lack of pragmatic competence*

*insufficient computational resources*  
*difficulty at retrieving alternatives*

~~derivation/computation  
retrieval/access~~

evaluation  
reaction/reanalysis/repair  
cancelation

# direct s. IMPLICATURES

in children



at what age are young learners sensitive to implicature violations?

why do children fail at deriving them?

Papafragou and Tantalou, 2004  
Papafragou and Musolino, 2003  
Guasti et al., 2005  
Katsos and Bishop, 2011  
Foppolo et al., 2012

improvement in rejecting pragmatic violations from 4 years of age if:

- contextual/pragmatic support
- manipulation of order of trials
- ternary vs. binary judgment

PRAGMATIC TOLERANCE  
Katsos and Bishop, 2011

DIFFICULTY AT CONFLICT MONITORING  
Shetreet et al., 2013

POOR ABILITY AT CHANGING STRATEGY OR SHIFTING PERSPECTIVE  
Foppolo et al., 2012

derivation/computation  
retrieval/access

~~evaluation  
reaction/reanalysis/repair  
cancelation~~

## the curious case of indirect SI

how they should be processed and interpreted?

quite bad:

1. negation always makes things more difficult
2. no lexically defined scale

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in lang. development





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how are indirect implicatures processed?

in lang. development



if SI are not computed by default, ISIs should not be either



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if SIs are costly, ISIs should be more costly

in lang. development



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if SIs are costly, ISIs should be more costly

in lang. development



if children struggle with SIs, they should struggle even more with ISIs

# the curious case of indirect SI

NOT SO BAD...

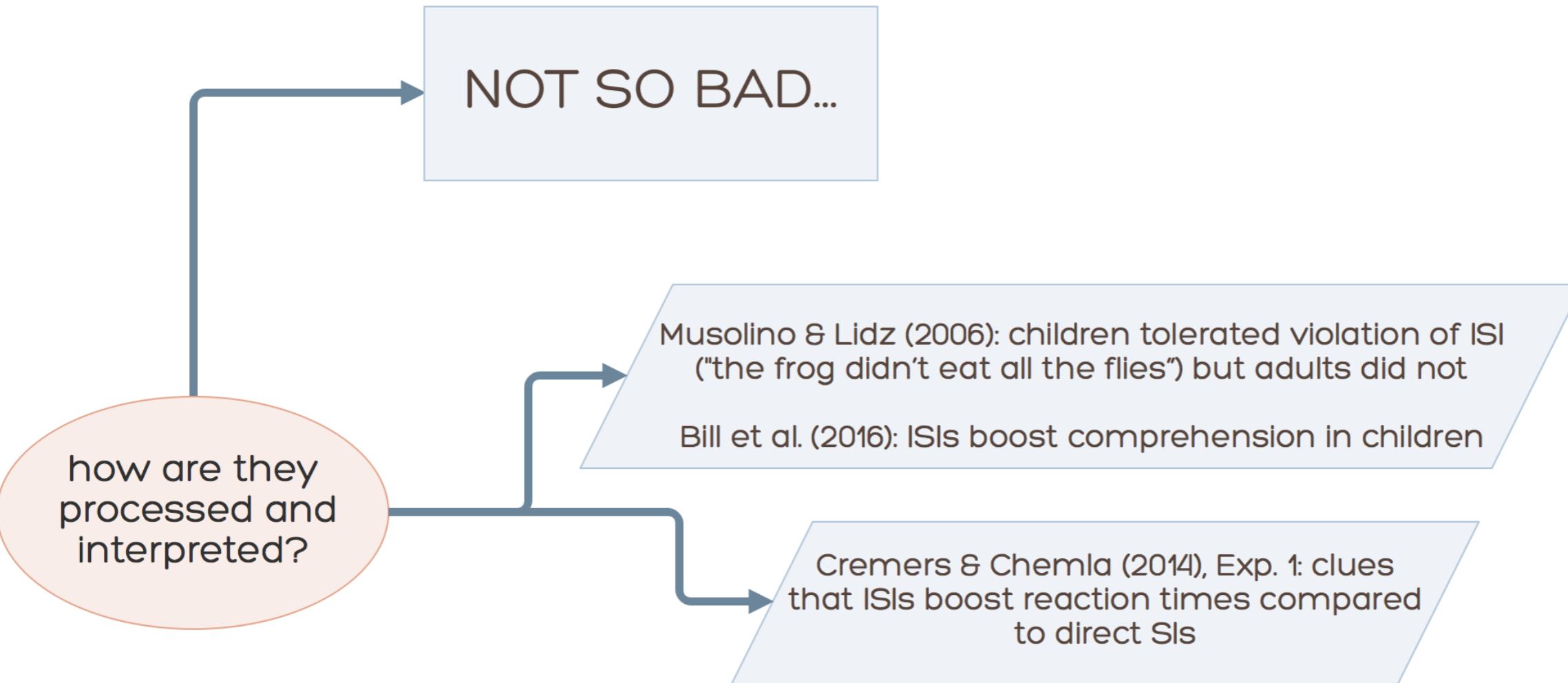
Musolino & Lidz (2006): children tolerated violation of ISI  
("the frog didn't eat all the flies") but adults did not

Bill et al. (2016): ISIs boost comprehension in children

how are they  
processed and  
interpreted?

```
graph LR; A([how are they processed and interpreted?]) --> B[NOT SO BAD...]; A --> C[/Musolino & Lidz (2006): children tolerated violation of ISI ("the frog didn't eat all the flies") but adults did not  
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# the curious case of indirect SI



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Bill et al. (2016): ISIs boost comprehension in children

Cremers & Chemla (2014), Exp. 1: clues that ISIs boost reaction times compared to direct SIs

Lohiniva & Panizza (2016); ISIs facilitate comprehension of scope inversion but slowed down target identification  
→ *pragmatic boost hypothesis*:  
the derivation of a SI, when supported by the context, is able to boost the comprehension

previously on "the Fantastic Island"

Semantic Choice Task (SCT)  
Lohiniva & Panizza (2016); Panizza,  
Lohiniva & Foppolo (submitted)



**alle** Piraten sind **nicht** auf das Schiff zurückgekehrt  
all the pirates did not go back to the ship



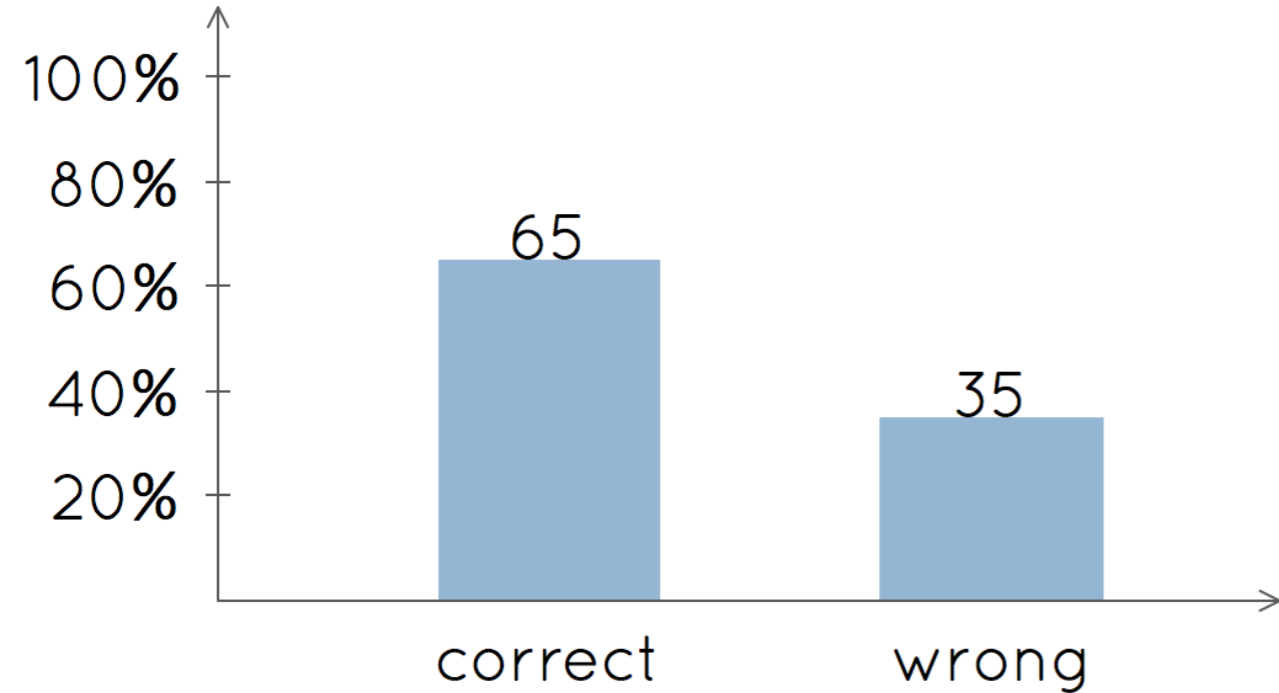
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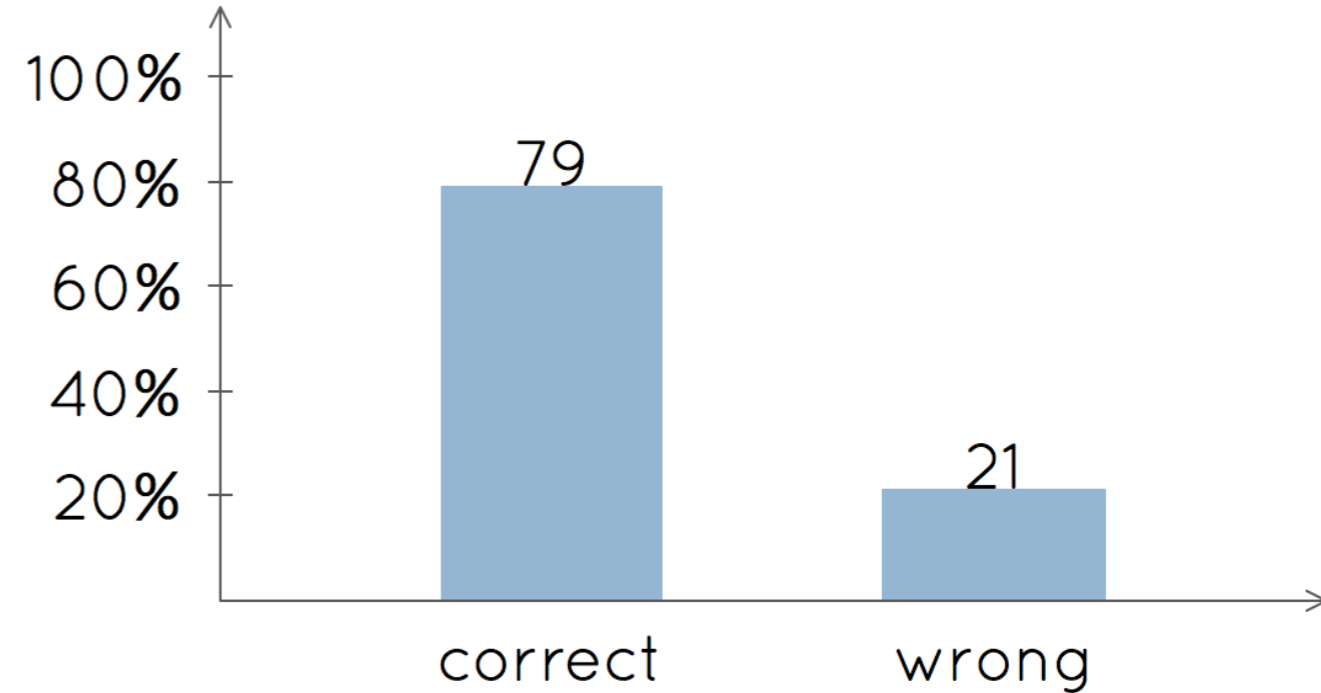
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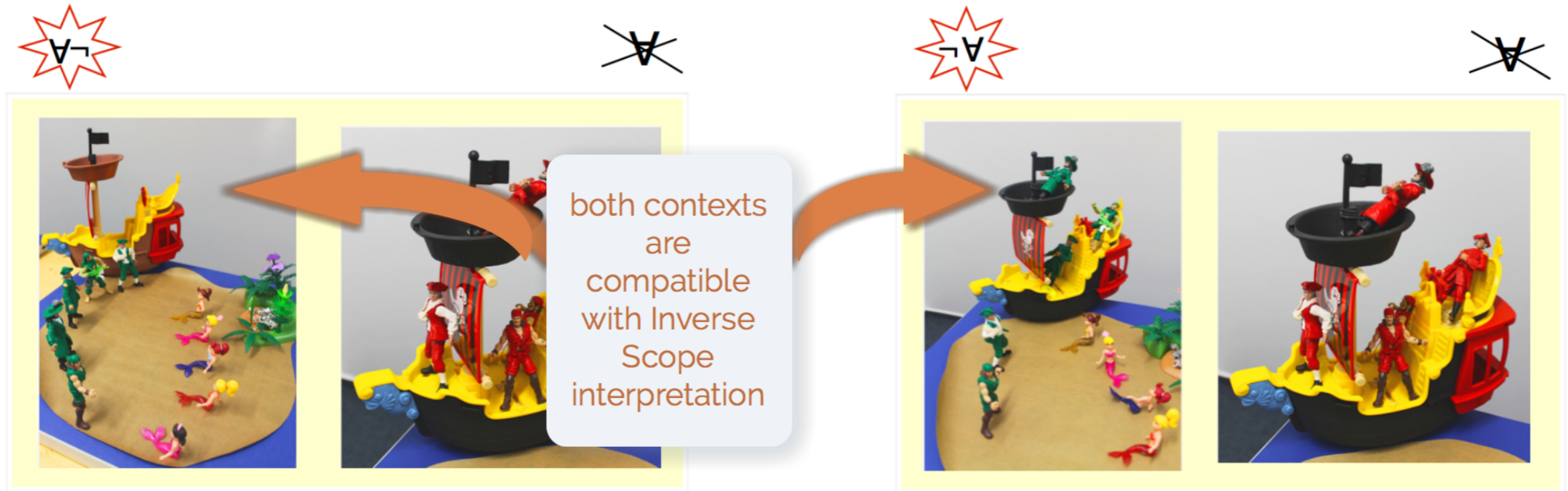
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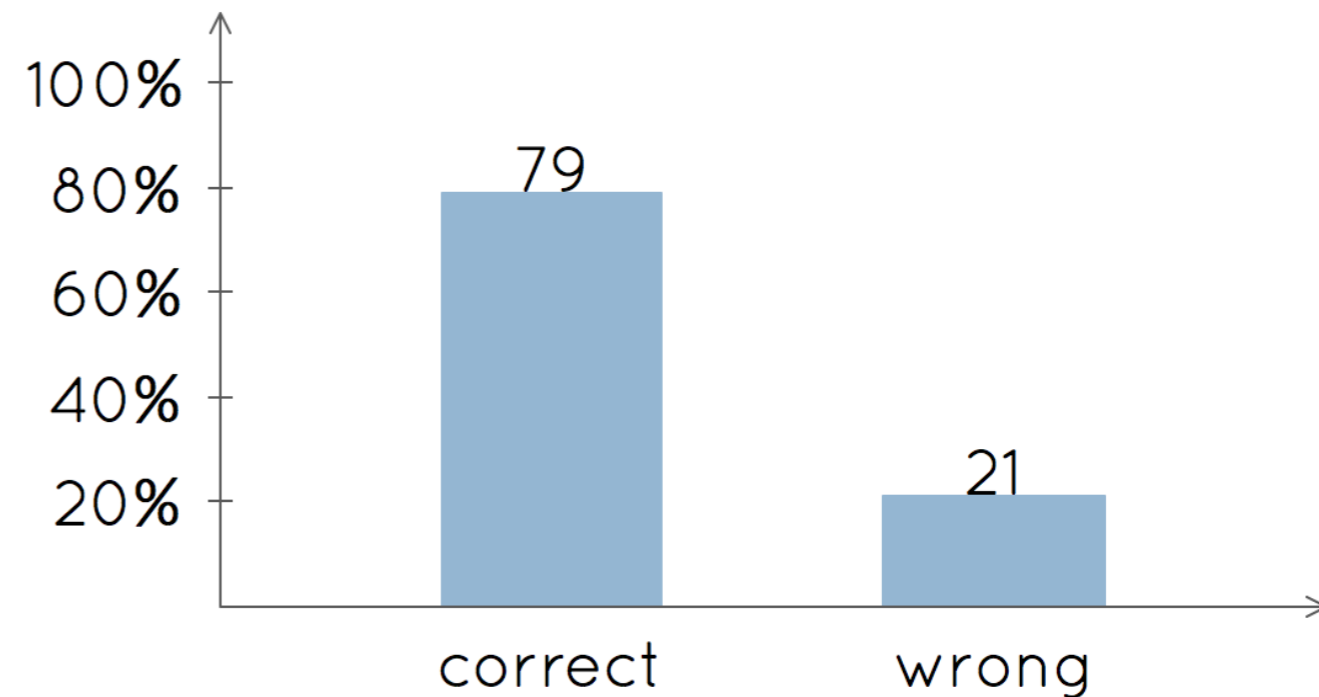
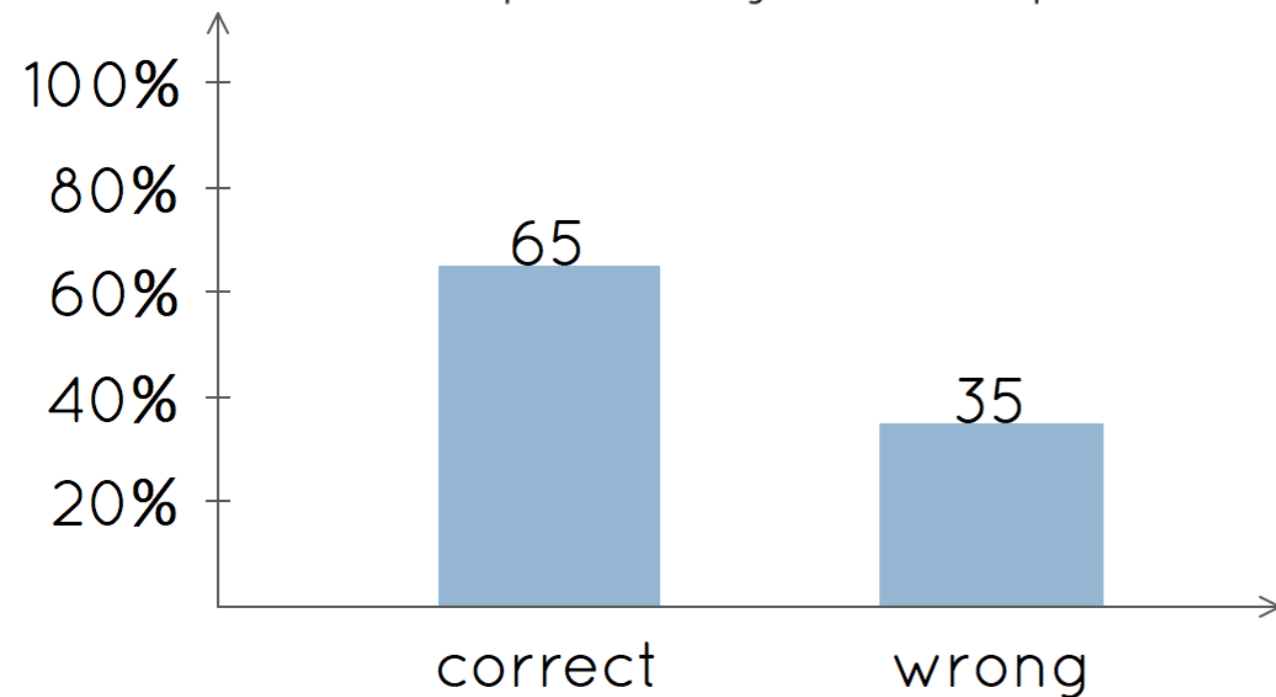
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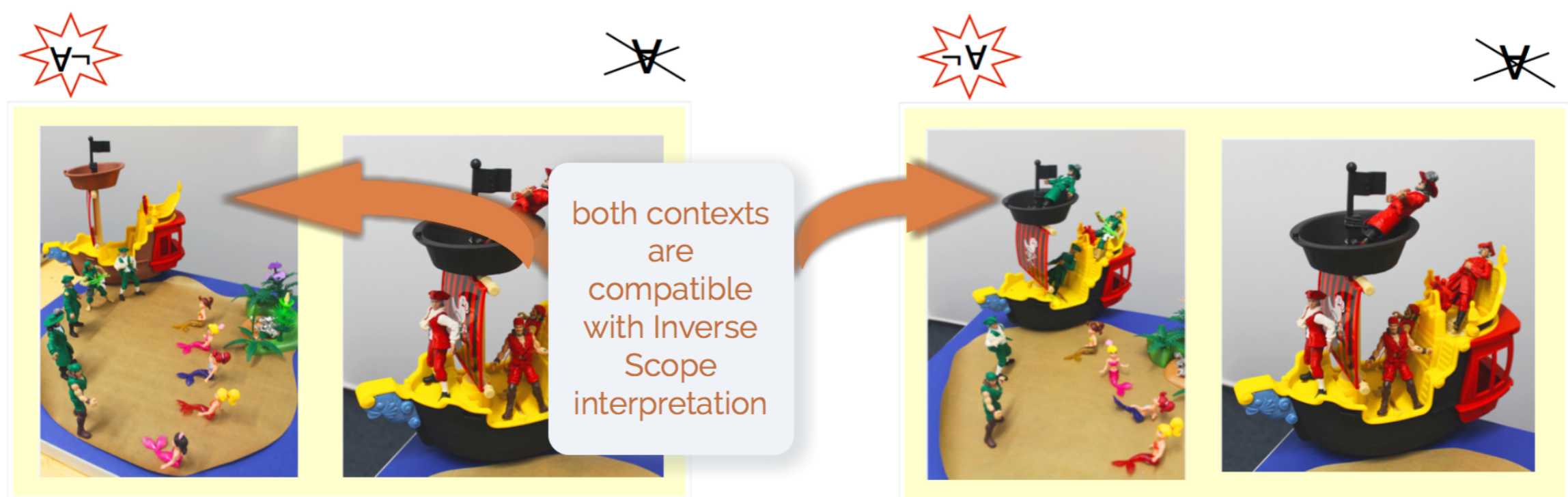
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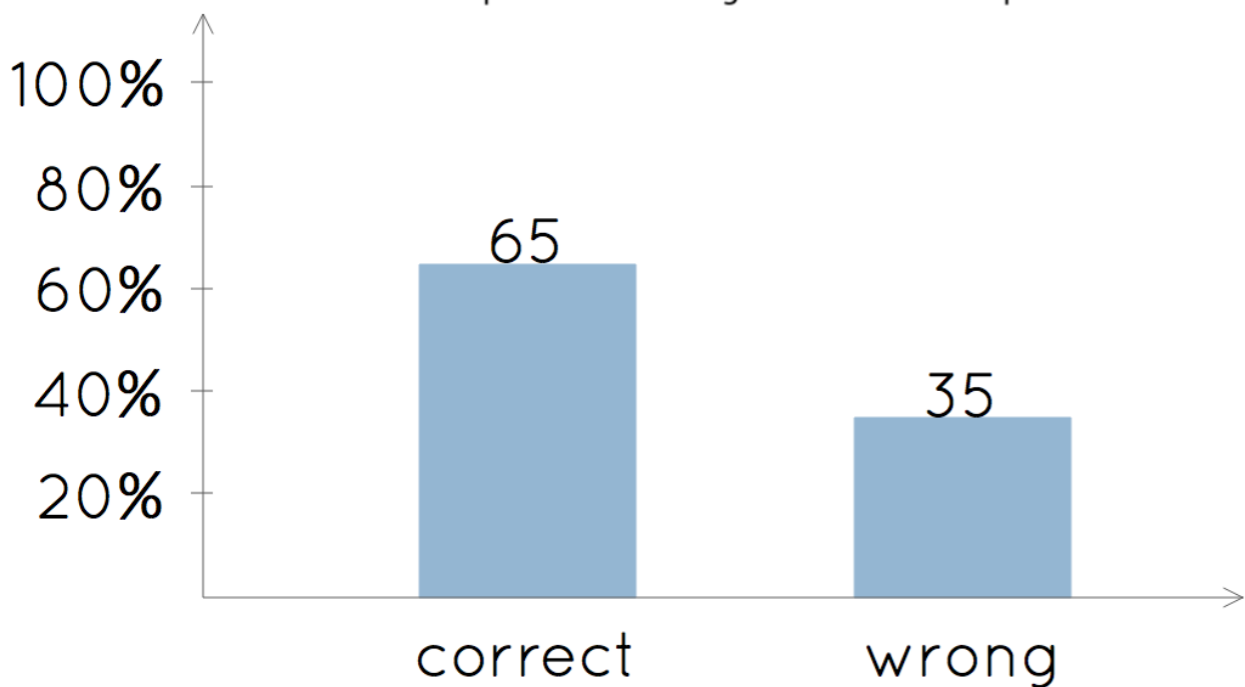


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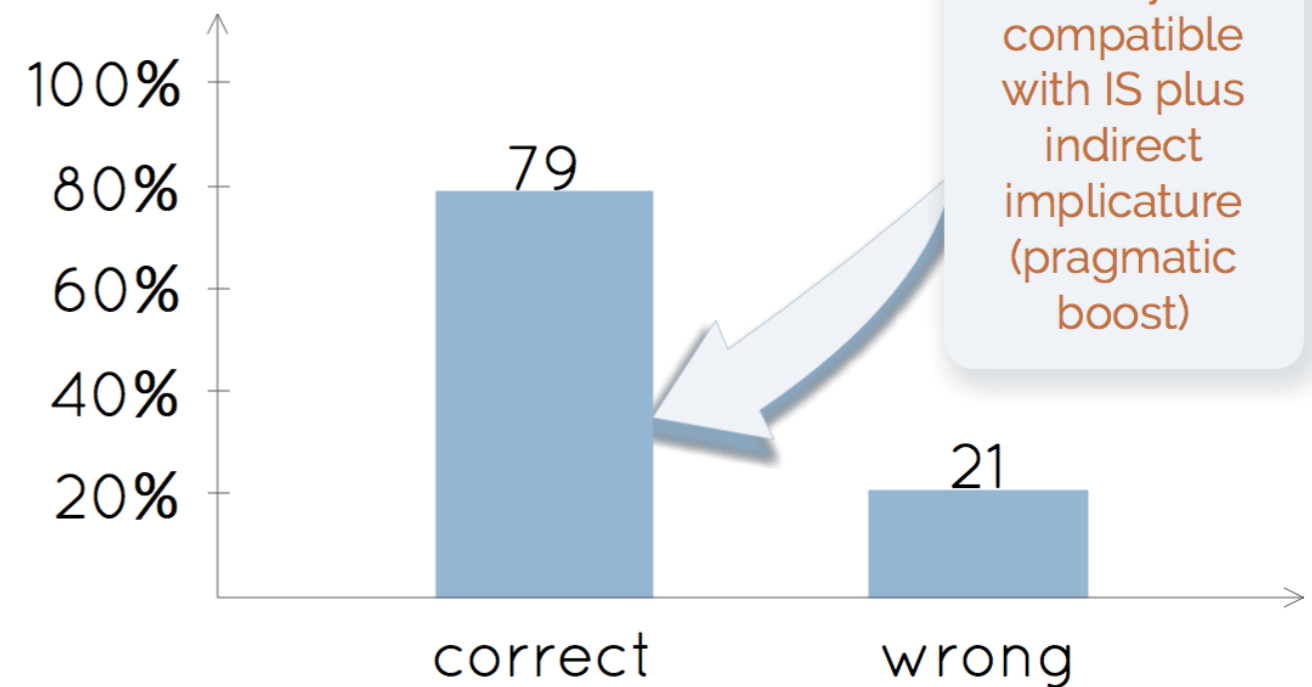
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**alle Piraten sind nicht** auf das Schiff zu  
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so now we have a test

## EXPERIMENT 1

Semantic Choice Task  
Picture Selection Task with  
eye movement recording

so now we have a test

## EXPERIMENT 1

offline  
judgments

ACCESS: to a specific interpretation

PREFERENCE: for a scenario supporting one reading

Semantic Choice Task  
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offline judgments

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online eye-tracking data

WHEN: disambiguation takes place

HOW: different readings are processed

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offline judgments

ACCESS: to a specific interpretation

PREFERENCE: for a scenario supporting one reading

online eye-tracking data

WHEN: disambiguation takes place

HOW: different readings are processed

Semantic Choice Task  
Picture Selection Task with  
eye movement recording

allows control  
of intonation

unbiased intonation: no stress on negation or quantifier

(2) Der Kapitän hat nicht mit allen Meerjungfrauen getanzt.

The captain has  $\neg$  with  $\forall$  mermaids danced

*The captain did not dance with all the mermaids.*

# EXPERIMENT 1

Semantic Choice Task  
4 trials

ACCESS to ISI violation



FALSE



NONE: not all (and possibly none)



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Semantic Choice Task  
4 trials

ACCESS to ISI



FALSE



NALL: not all but some



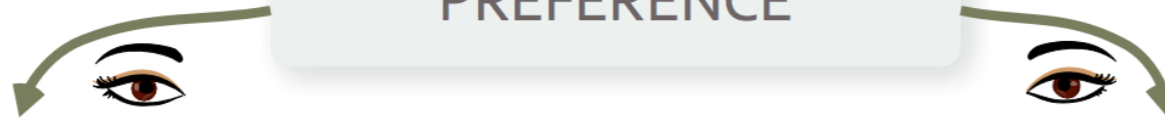
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Semantic Choice Task  
4 trials

PREFERENCE



NONE: not all (and possibly none)

NALL: not all but some



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# EXPERIMENT 1

## Semantic Choice Task

### design

16 stories involving pirates and fantastic creatures

4 trials: ACCESS to NONE

4 trials: ACCESS to NALL

4 trials: PREFERENCE NALL vs. NONE

4 trials: CONTROL w/o negation

### participants

30-40 min average length

48 German speakers per group  
(adults vs. 6-10yo from 1st to 3rd grade)

### task

choose the group of pirates that performs better

# EXPERIMENT 1

## Semantic Choice Task

### PREDICTIONS

how are indirect implicatures interpreted?



if ISIs boost comprehension:  
NALL contexts more accurate  
than NONE contexts

how are indirect implicatures processed?



in lang.  
development



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if ISIs are costly, later disambiguation  
comparable pace otherwise

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development



if children struggle with ISIs,  
comprehension increases  
with AGE



if ISIs facilitate  
comprehension in children:  
boost effect of NALL context

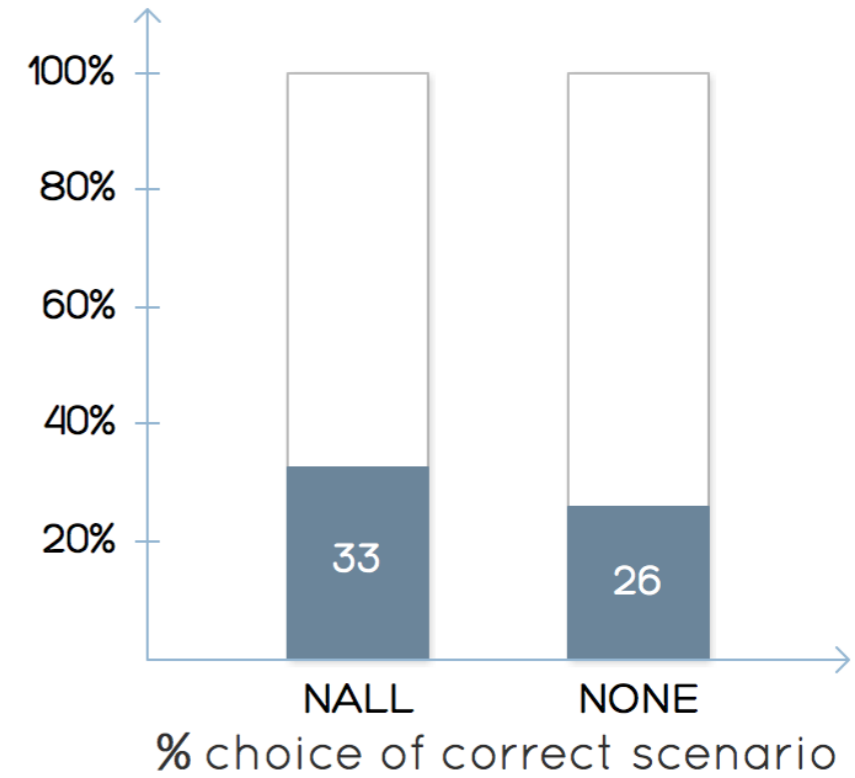
# EXPERIMENT 1: offline results



## Semantic Choice Task

4- to 5-year-old

failed to comprehend experimental sentences: they ignore negation, despite always repeating the sentence correctly



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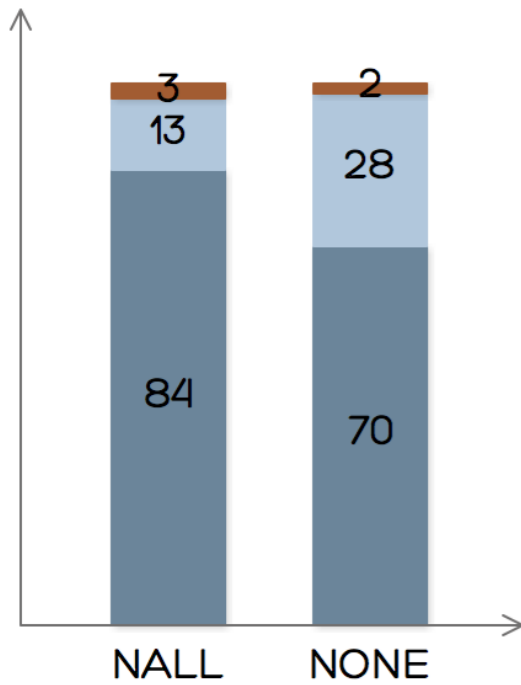


## Semantic Choice Task

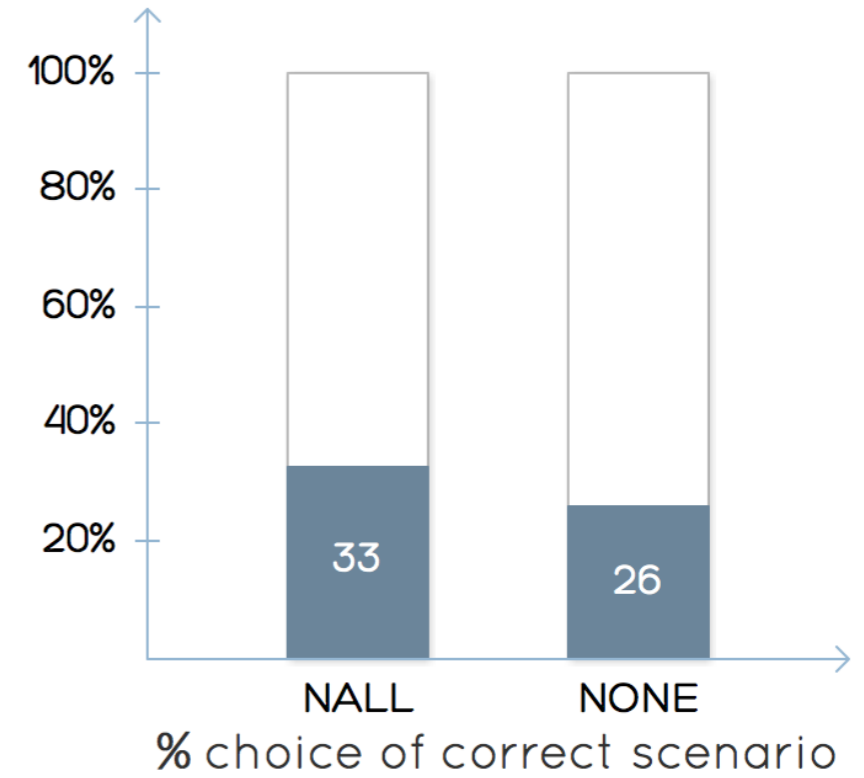
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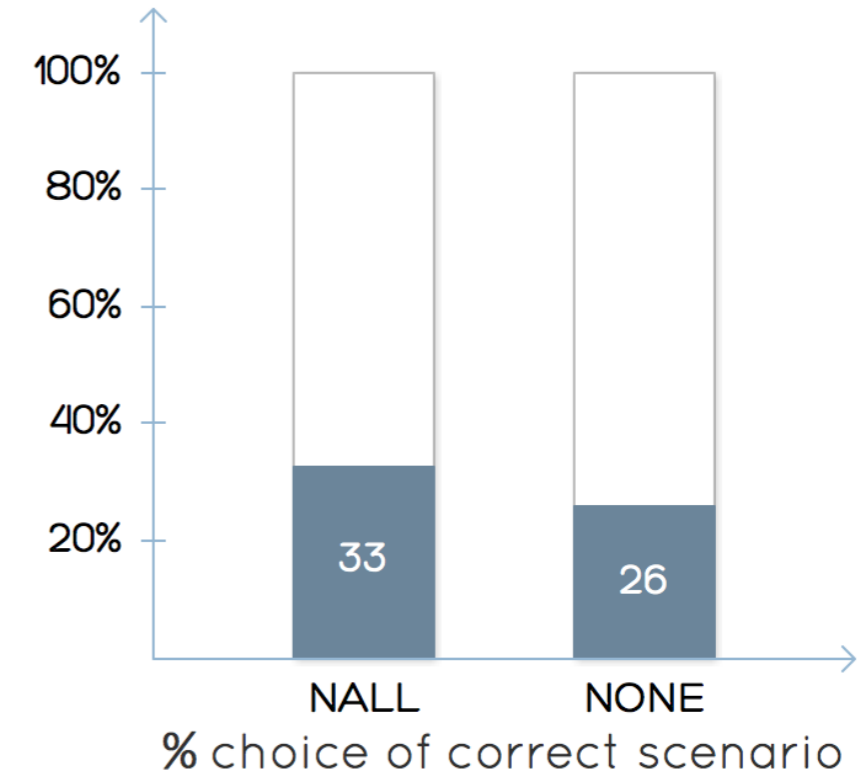
correct reject wrong



# EXPERIMENT 1: offline results



## Semantic Choice Task

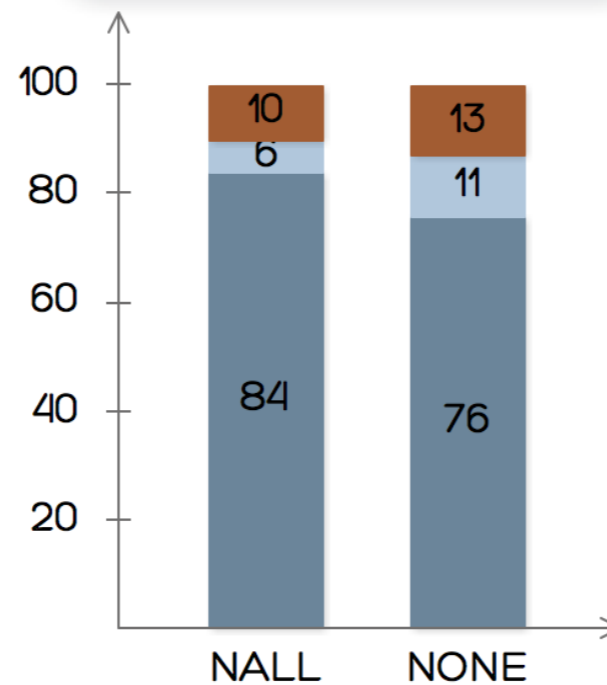
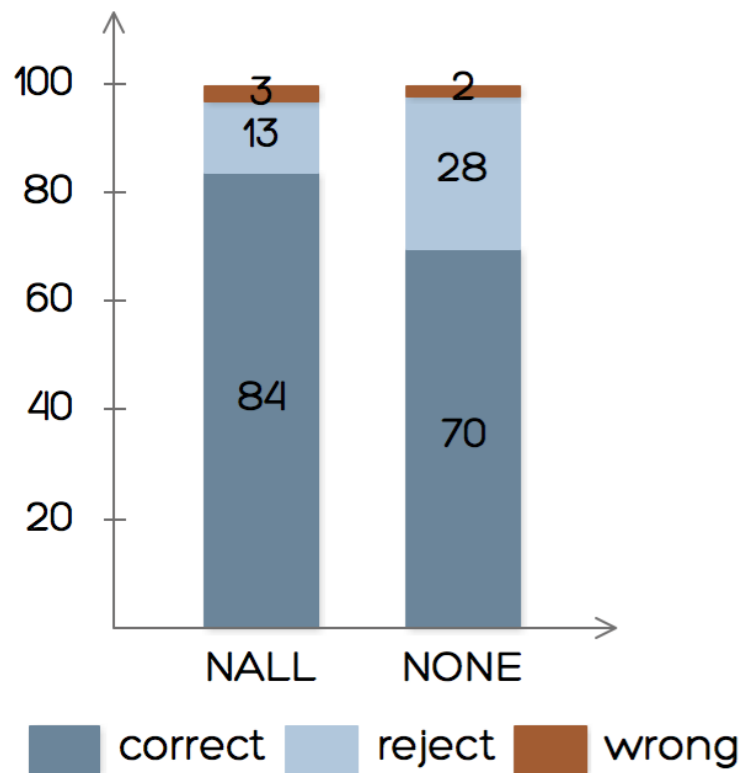


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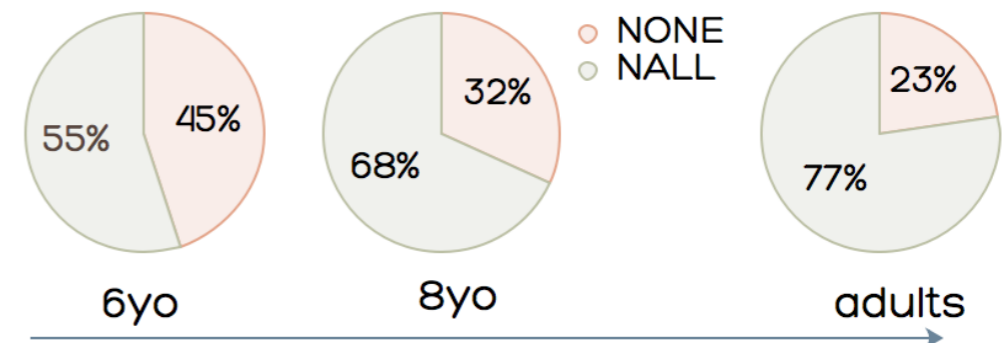
6- to 10-year-old



high accuracy in both conditions

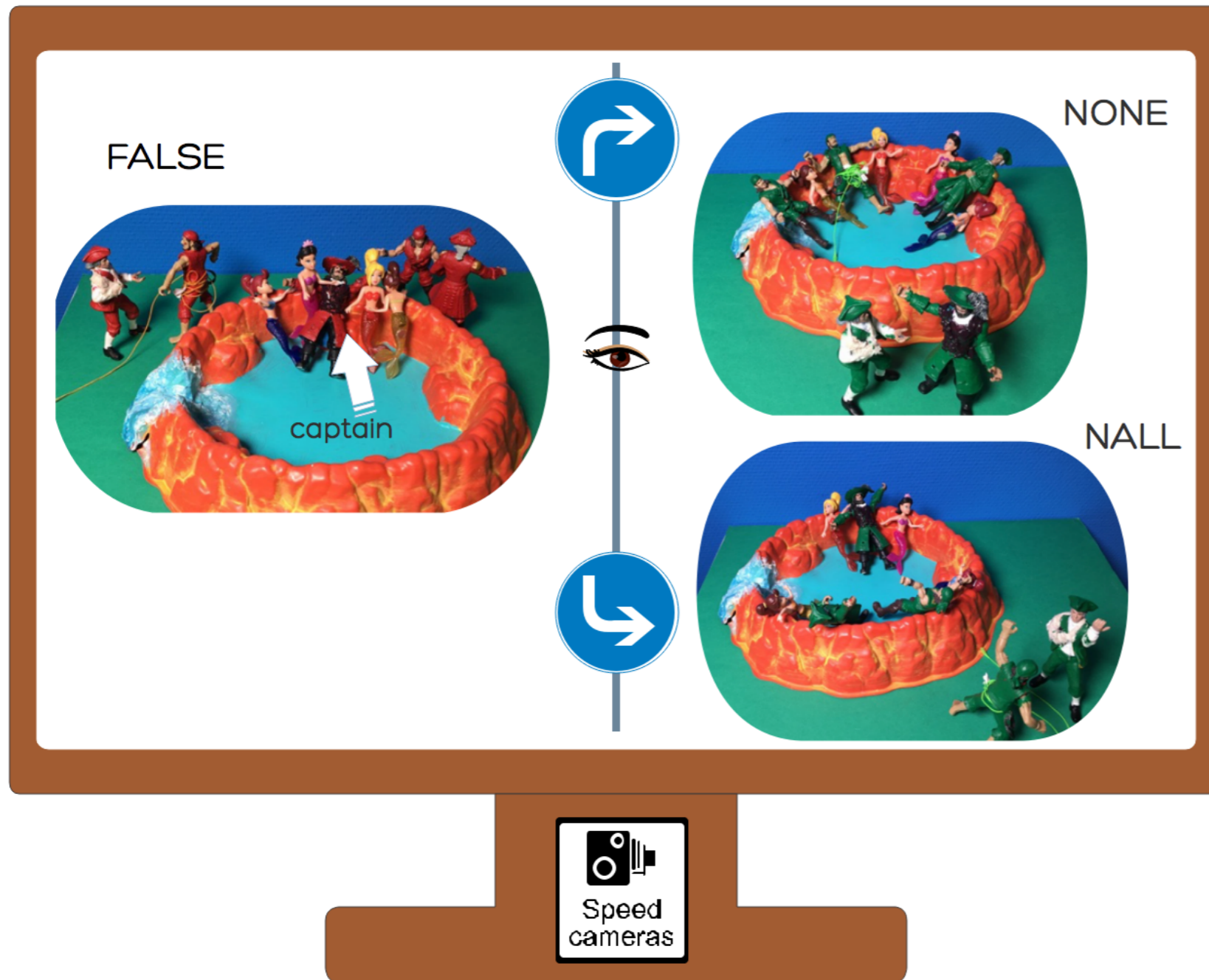
more accuracy and less rejections in NALL condition than in NONE

preference for NALL increases with age (TOLERANCE of ISI violation)

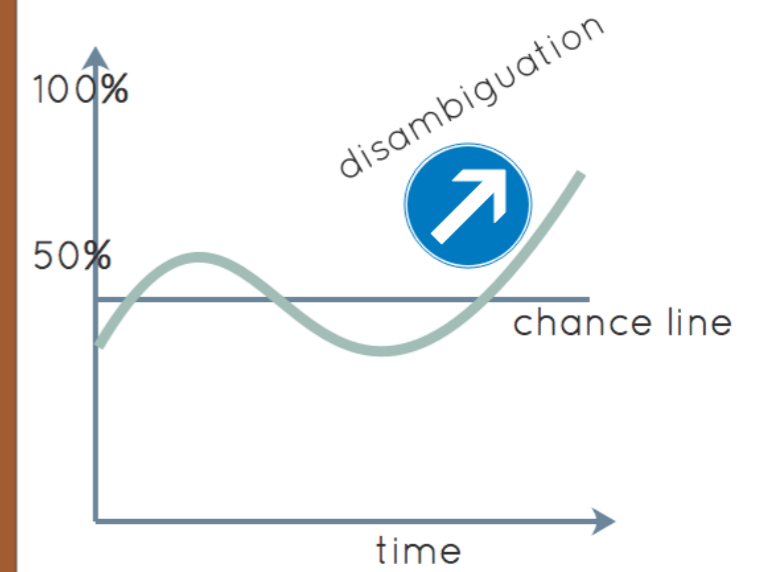




# EXPERIMENT 1: online results



target preference



# EXPERIMENT 1: online results



Semantic Choice Task

target preference

onset of nicht

6- to 10-year-old

chance line

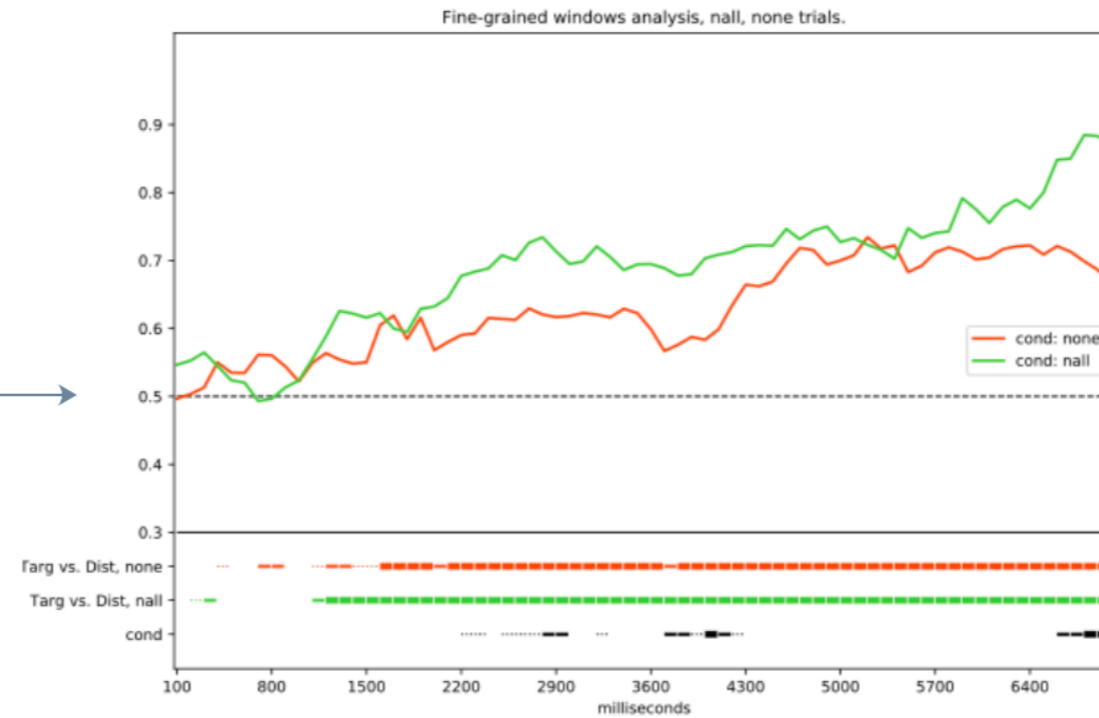


Fig. 1: Prop. of looks to target scenario: **children**, onset of *nicht*

# EXPERIMENT 1: online results



## Semantic Choice Task

target preference

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Fig. 1: Prop. of looks to target scenario: **children**, onset of *nicht*

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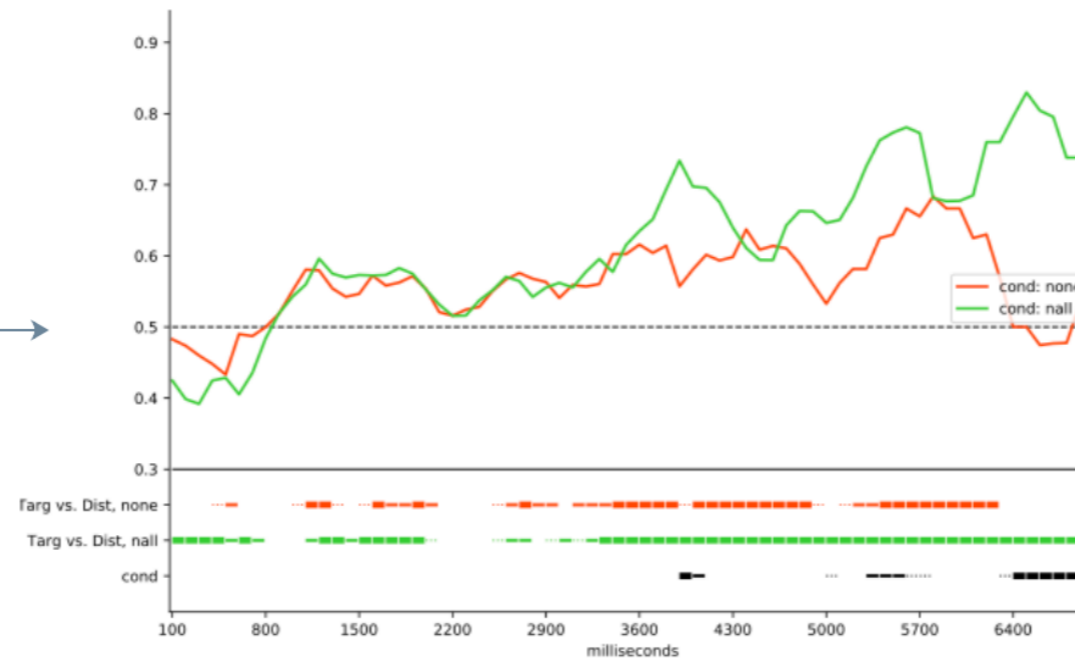


Fig. 2: Prop. of looks to target scenario: **adults**; onset of *nicht*

# EXPERIMENT 1: online results



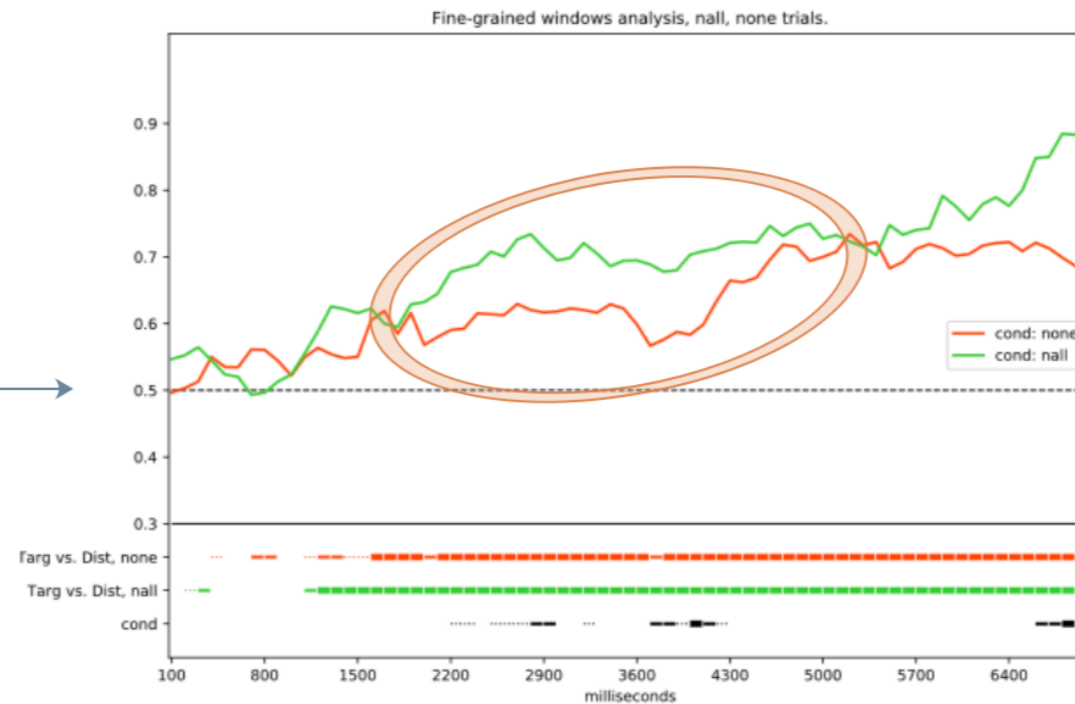
## Semantic Choice Task

target preference

6- to 10-year-old

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faster disambiguation for **NALL** in both children and adults (in both eye movements and reaction times)

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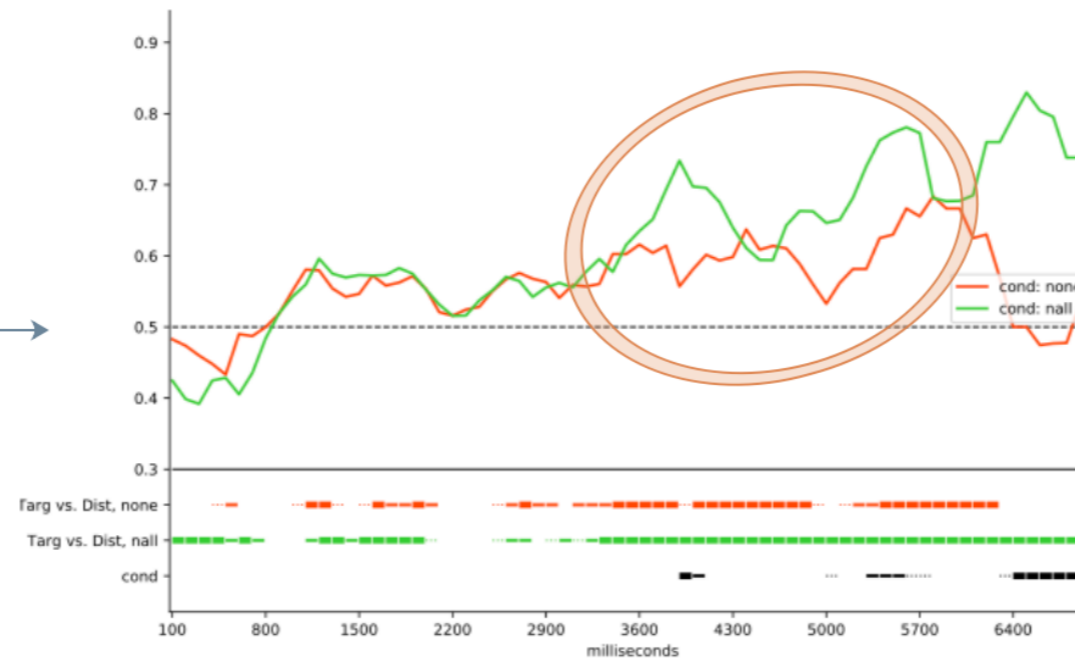


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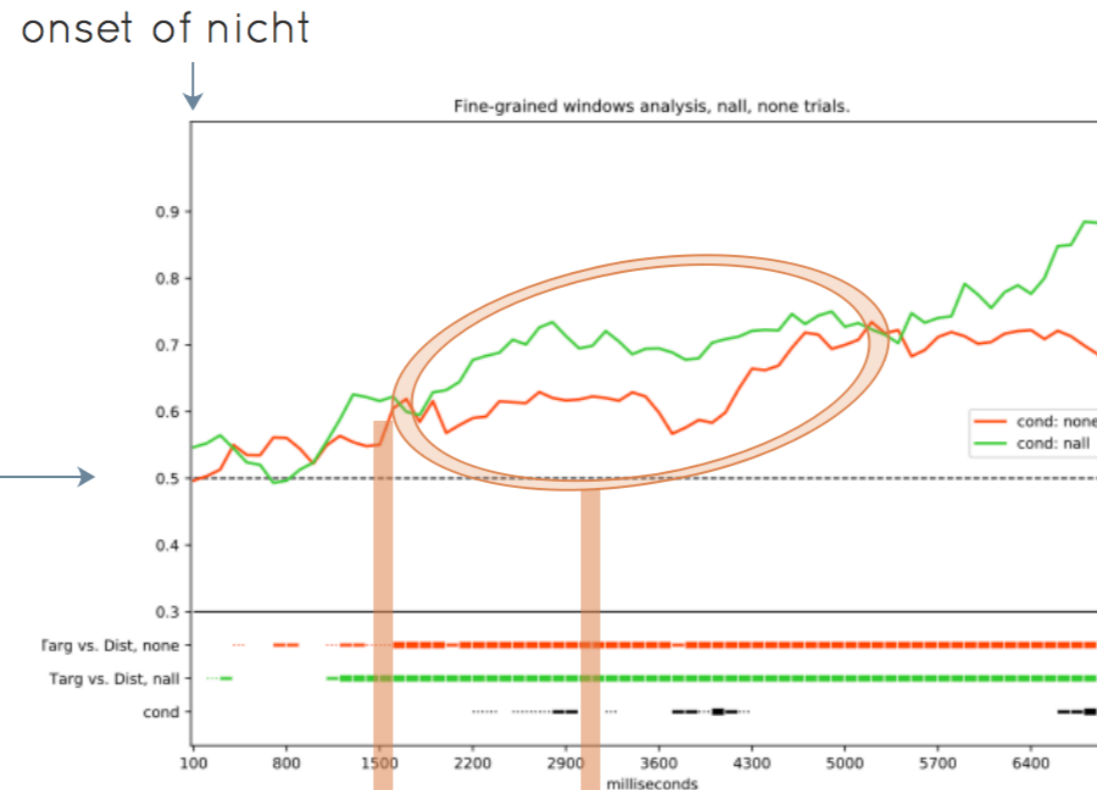


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target preference

6- to 10-year-old

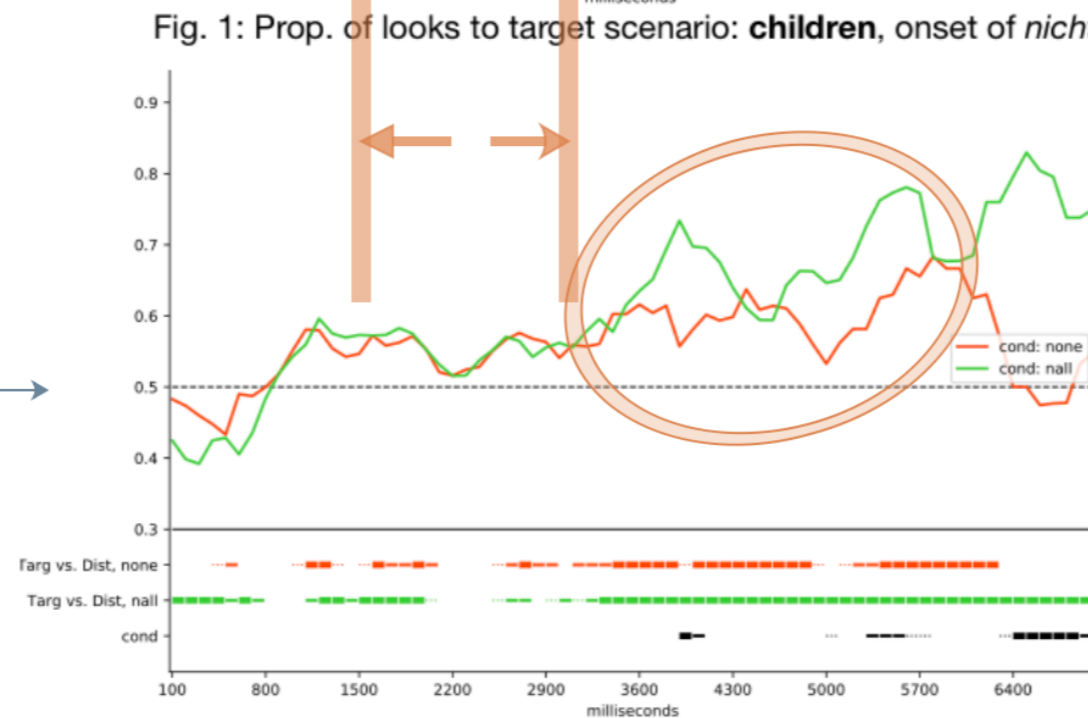
chance line



faster disambiguation for **NALL** in both children and adults (in both eye movements and reaction times)

adults

chance line



earlier disambiguation in children than in adults!

Fig. 1: Prop. of looks to target scenario: **children**, onset of *nicht*

Fig. 2: Prop. of looks to target scenario: **adults**; onset of *nicht*

# EXPERIMENT 1: online results



## Semantic Choice Task

6- to 10-year-old vs. adults NALL condition

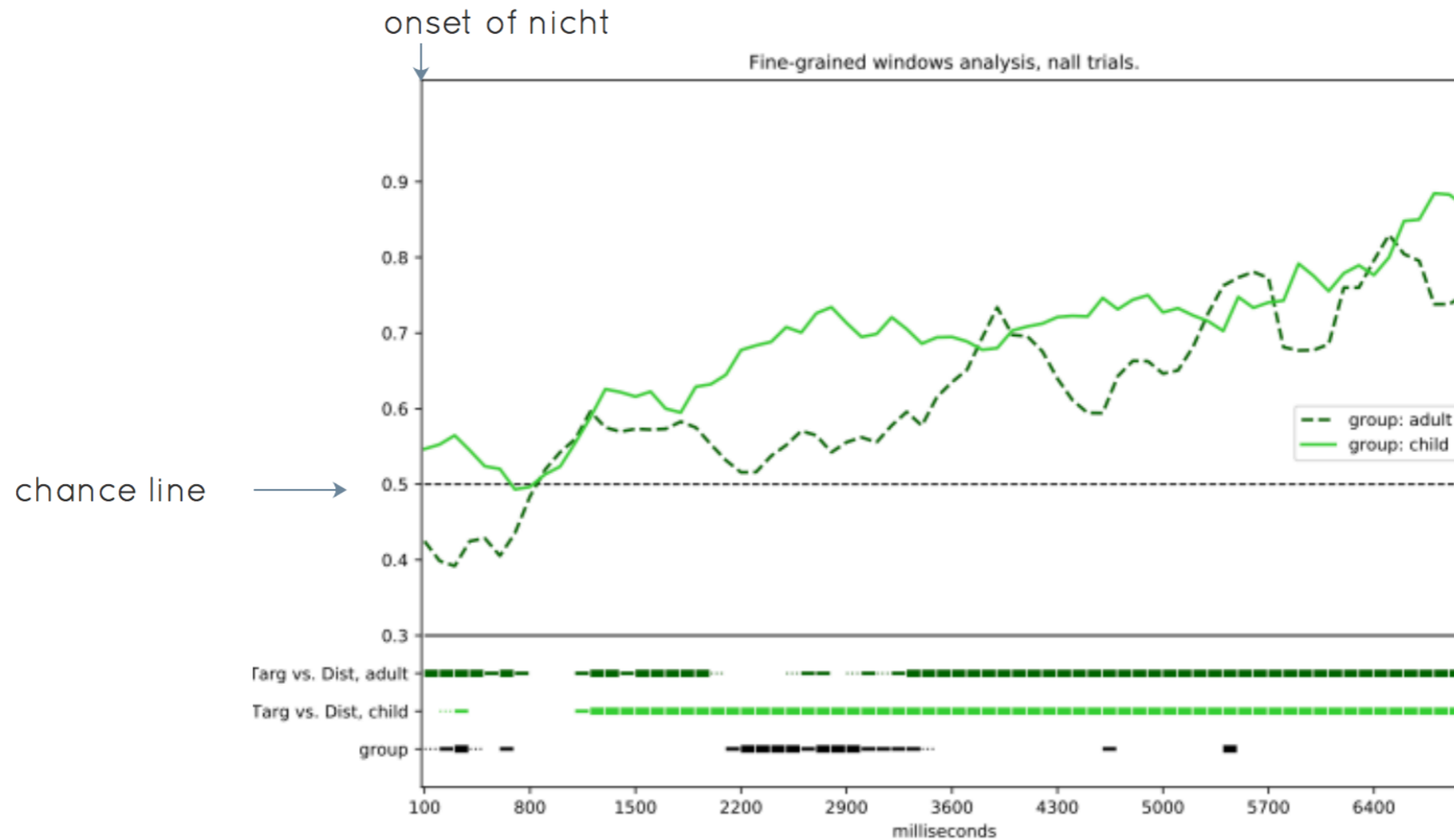


Fig. 3: prop. of looks to target in **NALL** condition, adults vs children

# EXPERIMENT 1: online results



## Semantic Choice Task

6- to 10-year-old vs. adults NALL condition

earlier disambiguation in children than in adults!

chance line

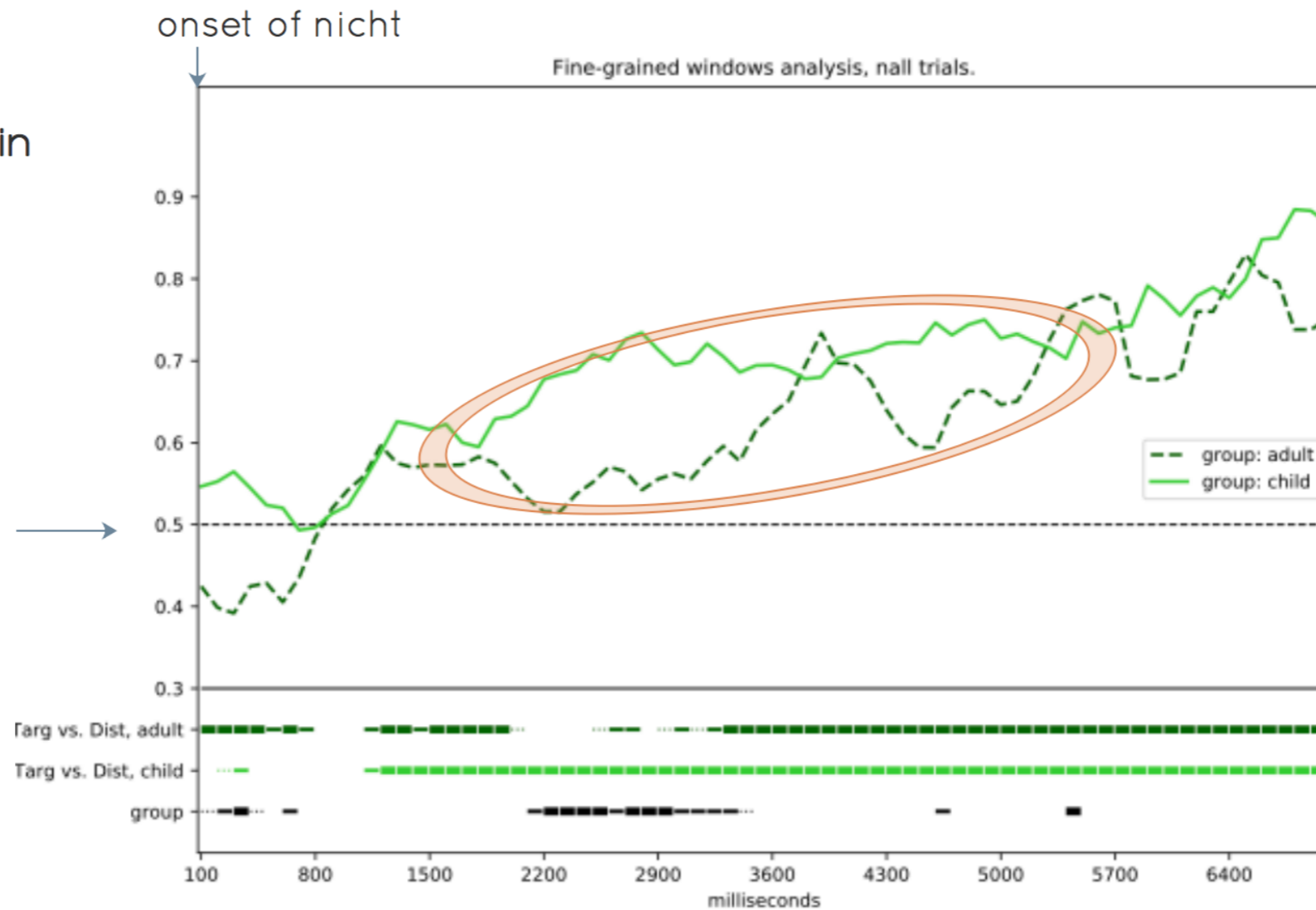


Fig. 3: prop. of looks to target in **NALL** condition, adults vs children

# EXPERIMENT 1: discussion



Semantic Choice Task

## RESULTS

how are indirect implicatures interpreted?



how are indirect implicatures processed?



in lang. development





# EXPERIMENT 1: discussion



## Semantic Choice Task

### RESULTS

how are indirect implicatures interpreted?



high accuracy in 6-10yo and adults  
less tolerance to violation in adults

how are indirect implicatures processed?



in lang.  
development



# EXPERIMENT 1: discussion



## Semantic Choice Task

### RESULTS

how are indirect implicatures interpreted?



high accuracy in 6-10yo and adults  
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processing advantage for  
context supporting ISI (NALL)  
than violating ISI (NONE)

in lang.  
development



# EXPERIMENT 1: discussion



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4-5yo fail to understand negation (?!?)  
more rapid target  
identification in 6-10yo than  
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# EXPERIMENT 1: discussion



## Semantic Choice Task

The neo-Gricean paradise

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The neo-Gricean  
paradise

THE Nörten-  
Hardenberg school  
children conspiracy





WHY ARE CHILDREN  
FASTER THAN ADULTS?



## WHY ARE CHILDREN FASTER THAN ADULTS?

what is the role of  
intonation?



## EXPERIMENT 2

### CHANGES in EXP2

natural intonation  
(stress on quantifier)

final part of the sentence  
destressed

recorded with  
more natural  
(faster) pace

from 5-6s to 3-4s

exactly the same  
experiment to adults  
and children

computerized version  
with stop-motion  
videos for every story



# EXPERIMENT 2

## CHANGES in EXP2

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from 5-6s to 3-4s

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ADULTS should be as fast  
as children, if not faster

AFAWK, adults have better  
working memory, higher  
linguistic/pragmatic skills

stronger preference for ISI,  
less tolerance to violations

intonation should reinforce  
ISI interpretation

## PREDICTIONS

## EXPERIMENT 2: offline results



Semantic Choice Task

EXP 1

vs.

EXP 2

# EXPERIMENT 2: offline results

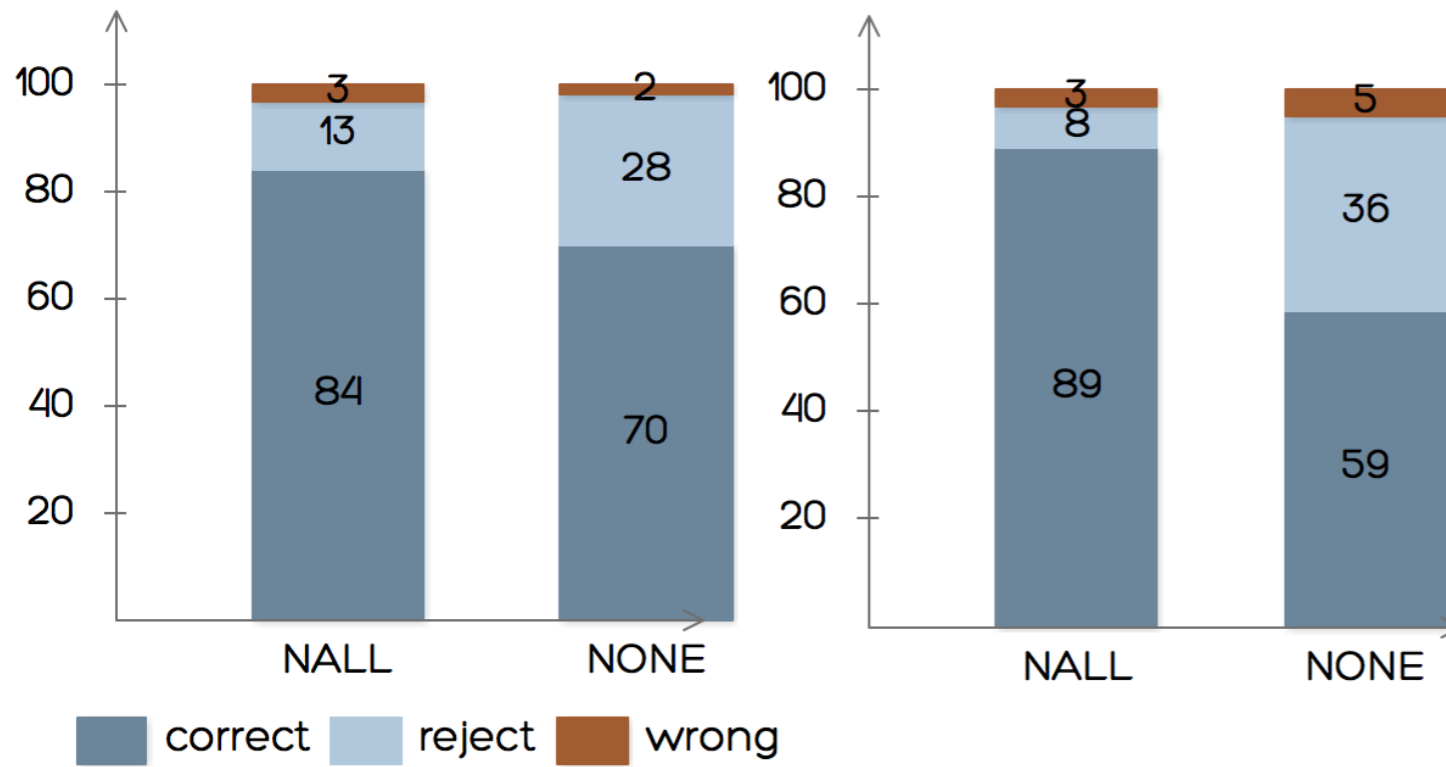


## Semantic Choice Task

EXP 1

vs.

EXP 2



← less tolerance to violation  
+8% rejection  
-11% acceptance

# EXPERIMENT 2: offline results

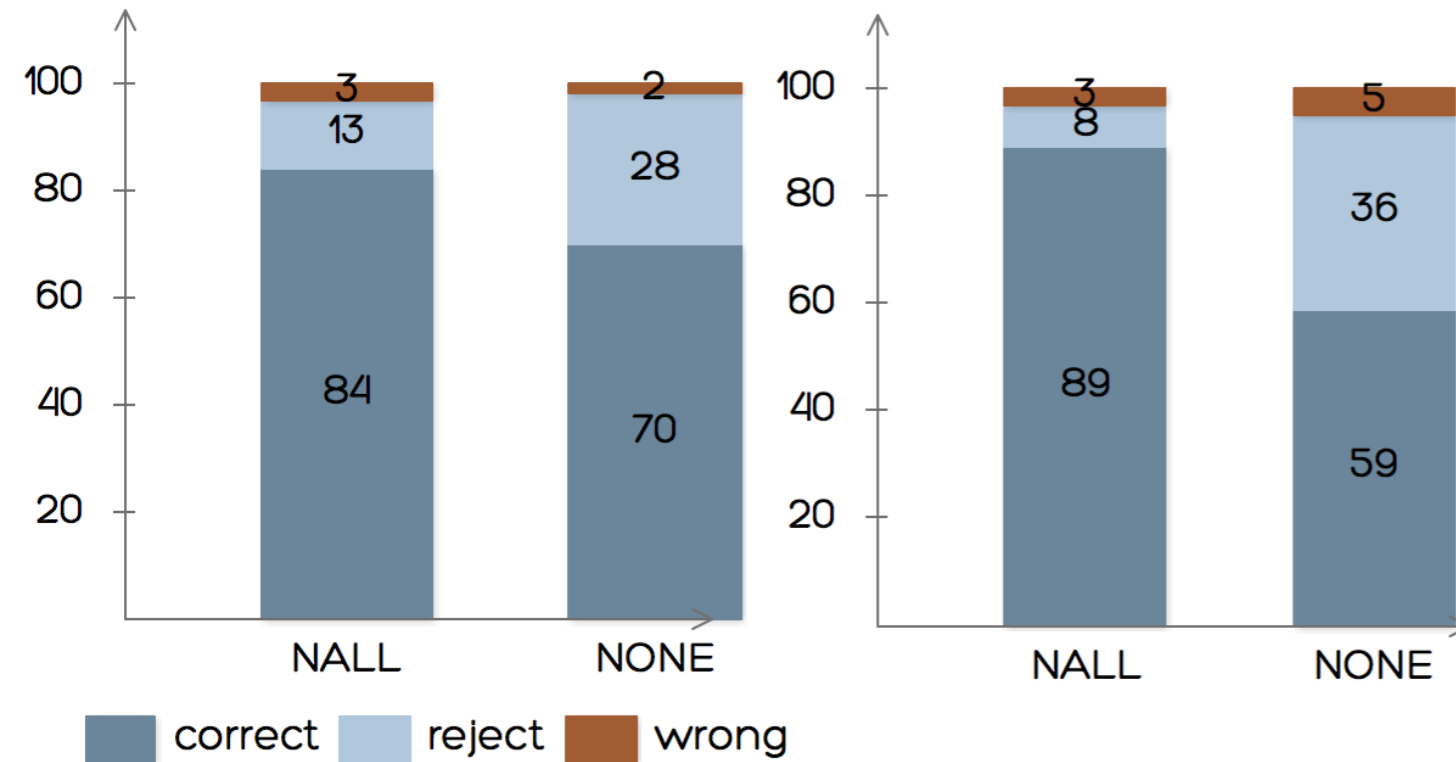


## Semantic Choice Task

EXP 1

vs.

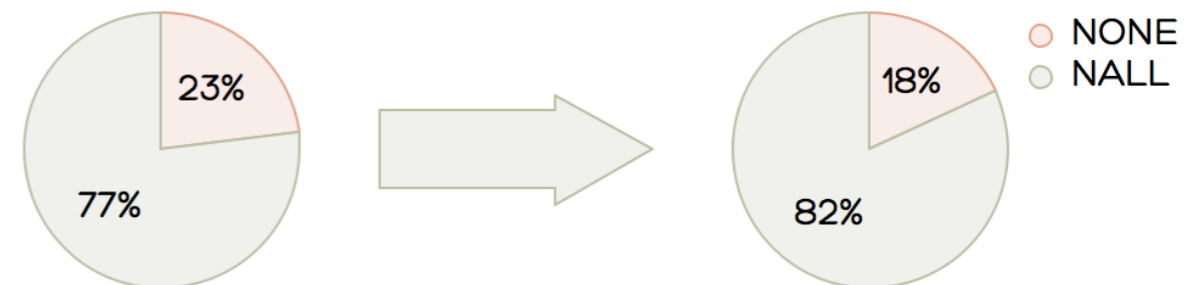
EXP 2



less tolerance to violation  
+8% rejection  
-11% acceptance

slight increase in preference (+5%)

manipulation of intonation works, but relatively small difference in offline results



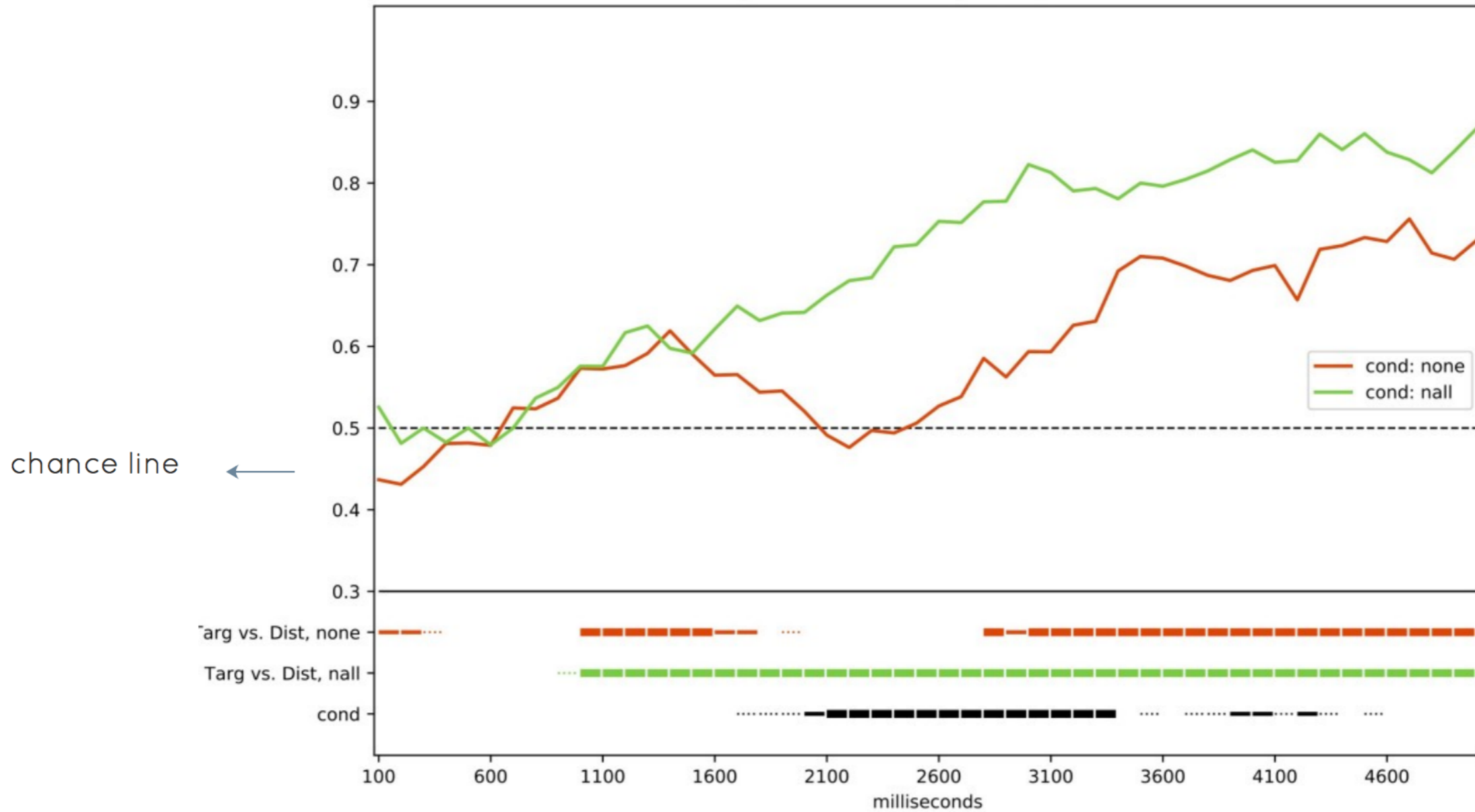
# EXPERIMENT 2: online results



## Semantic Choice Task

adults

Fine-grained windows analysis, nall, none trials.



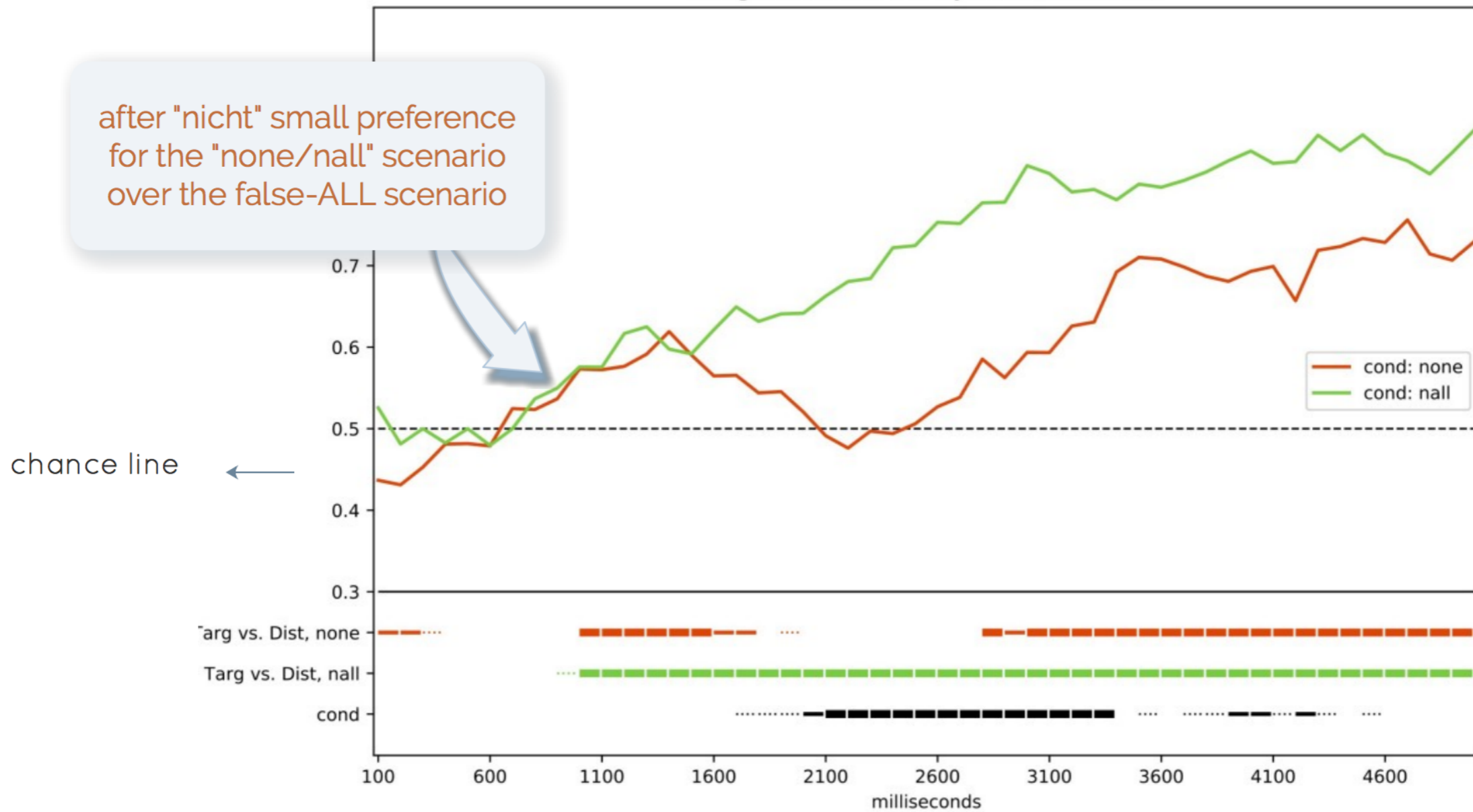
# EXPERIMENT 2: online results



## Semantic Choice Task

adults

Fine-grained windows analysis, nall, none trials.



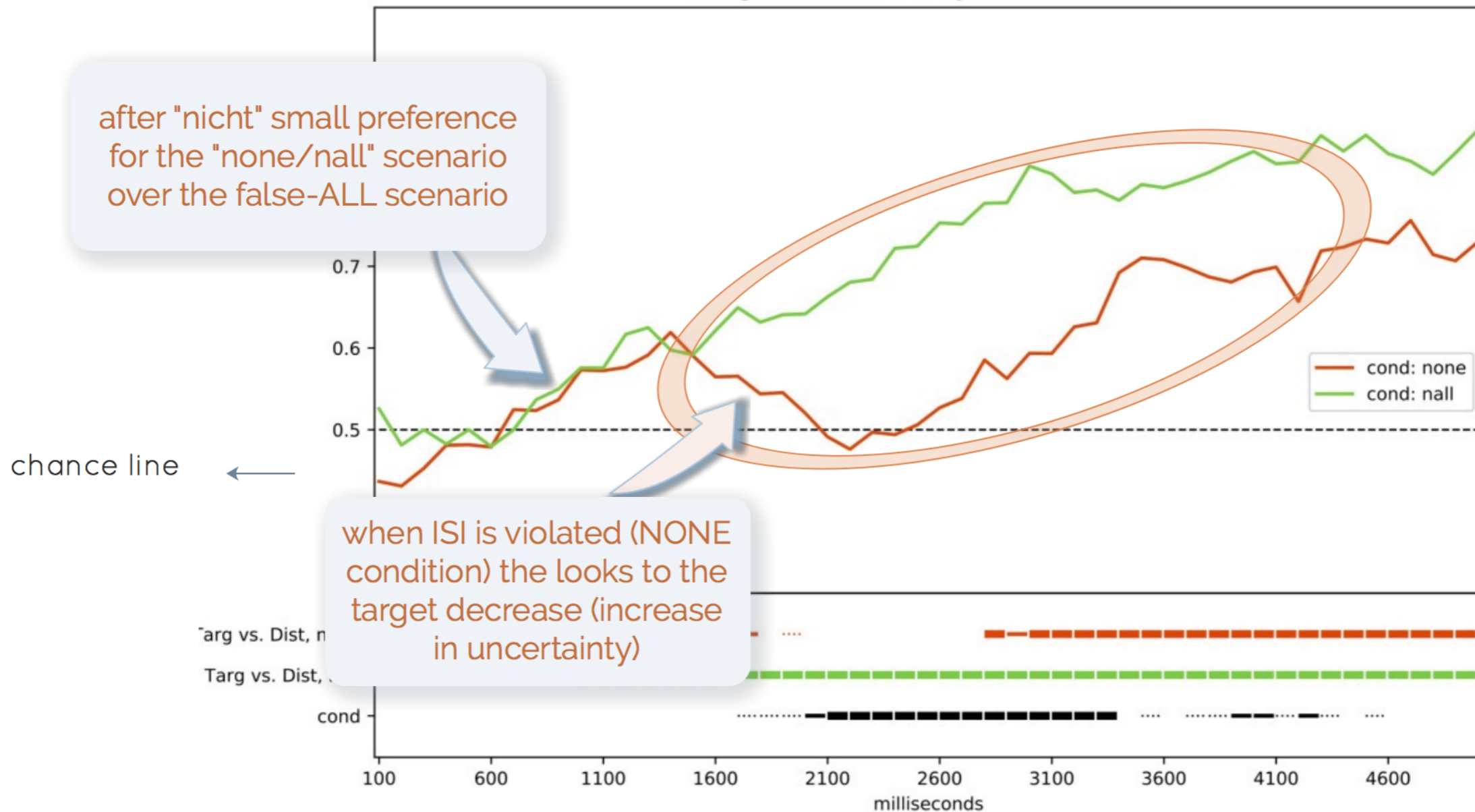
# EXPERIMENT 2: online results



## Semantic Choice Task

adults

Fine-grained windows analysis, nall, none trials.

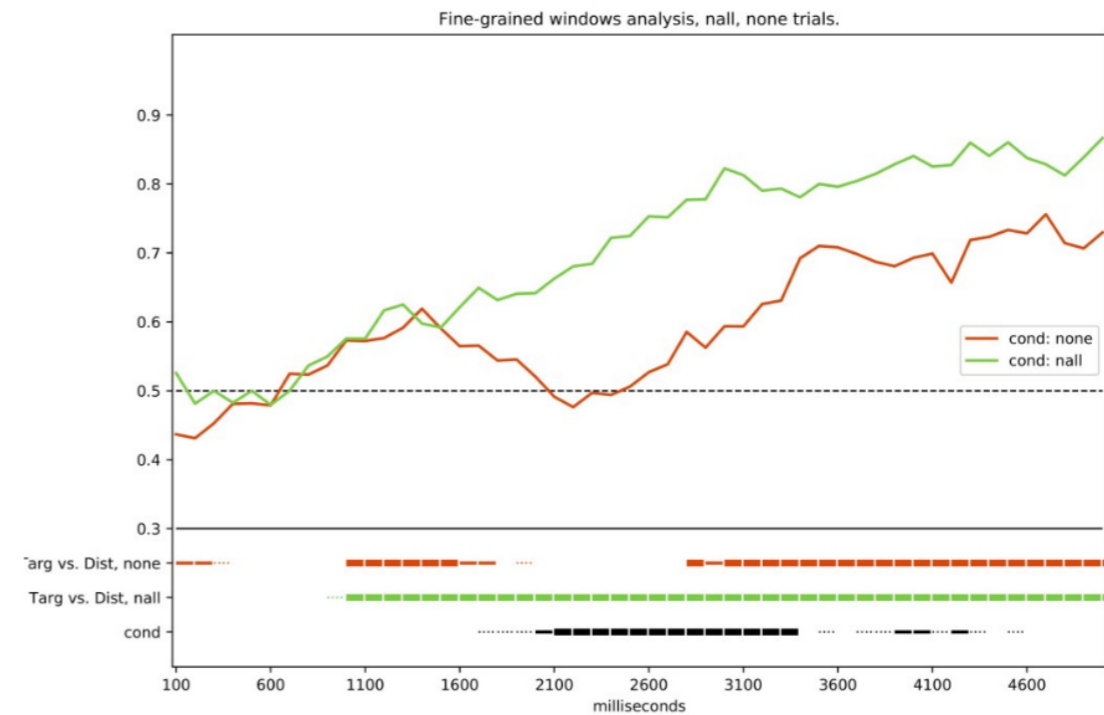
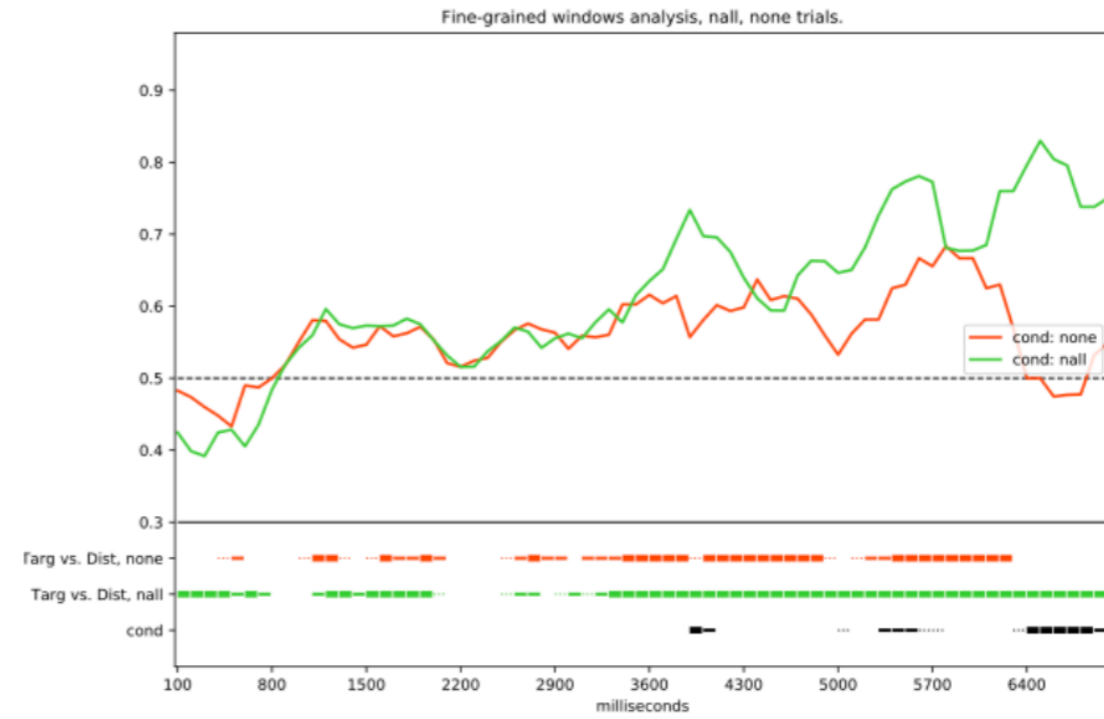


# EXPERIMENT 2: online results



## Semantic Choice Task

adults comparison EXP1 & Exp2





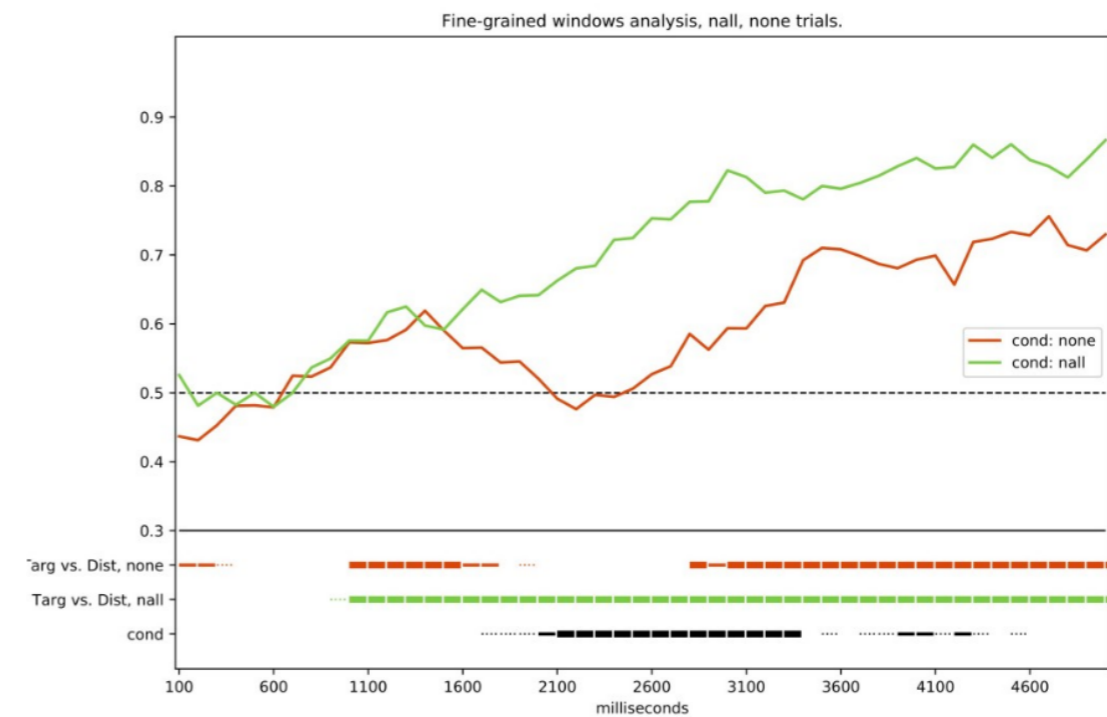
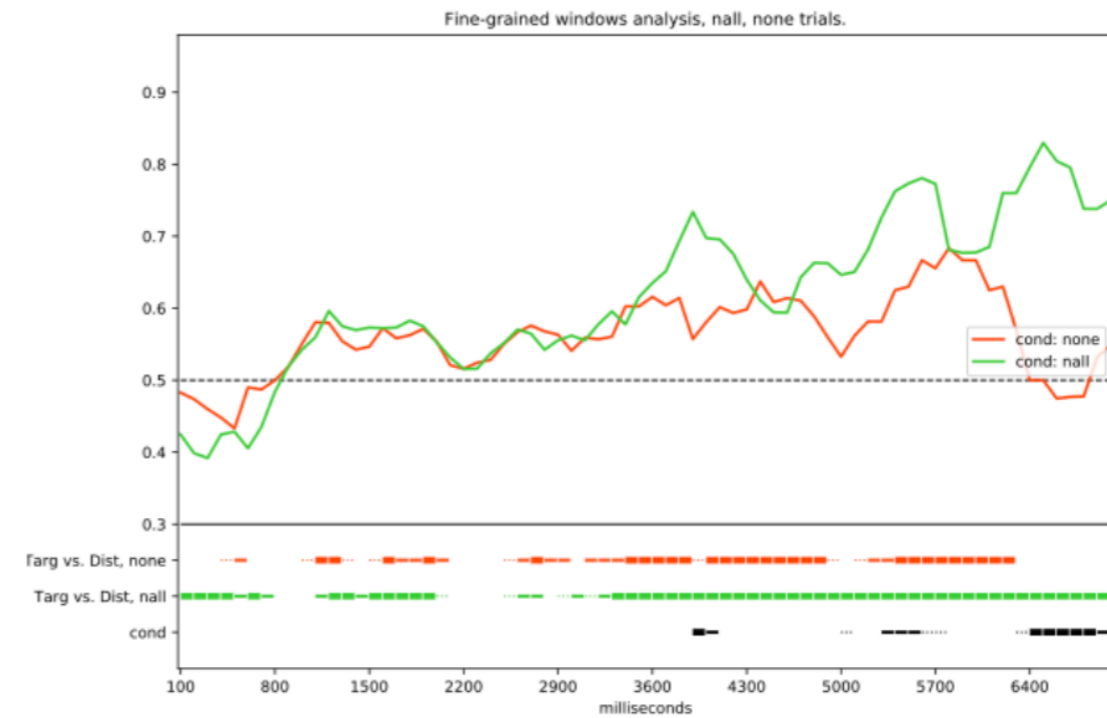
# EXPERIMENT 2: online results



## Semantic Choice Task

adults comparison EXP1 & Exp2

➔ more difference between NALL and NONE



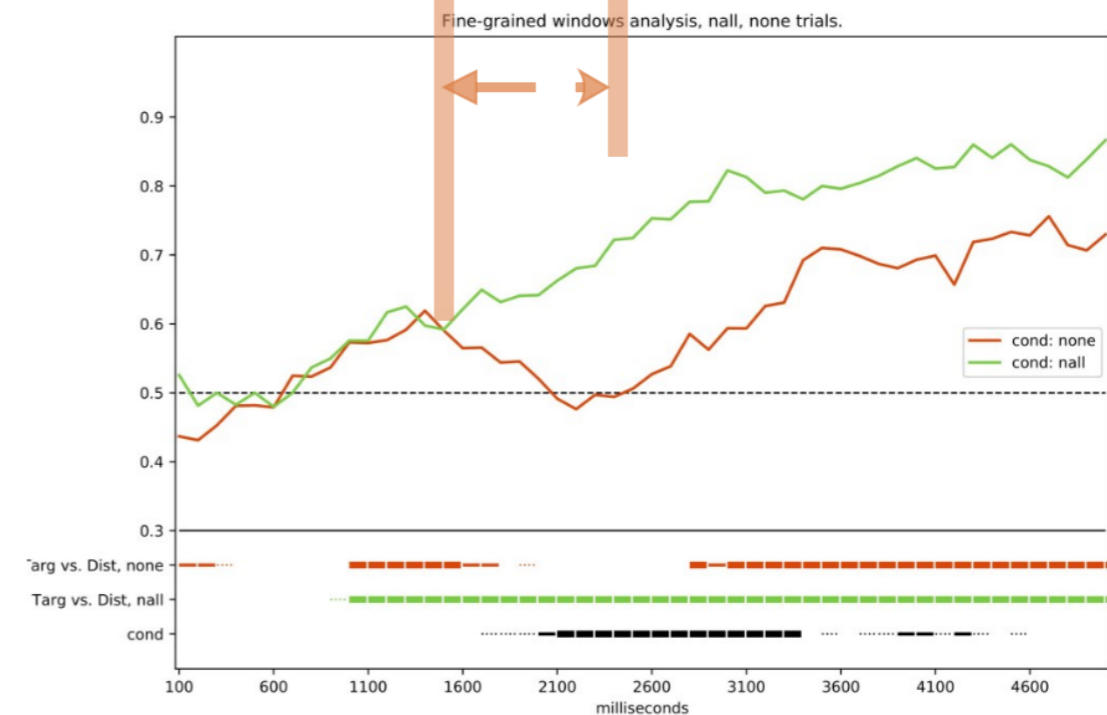
# EXPERIMENT 2: online results



## Semantic Choice Task

adults comparison EXP1 & Exp2

- more difference between NALL and NONE
- earlier disambiguation (but sentences were shorter)

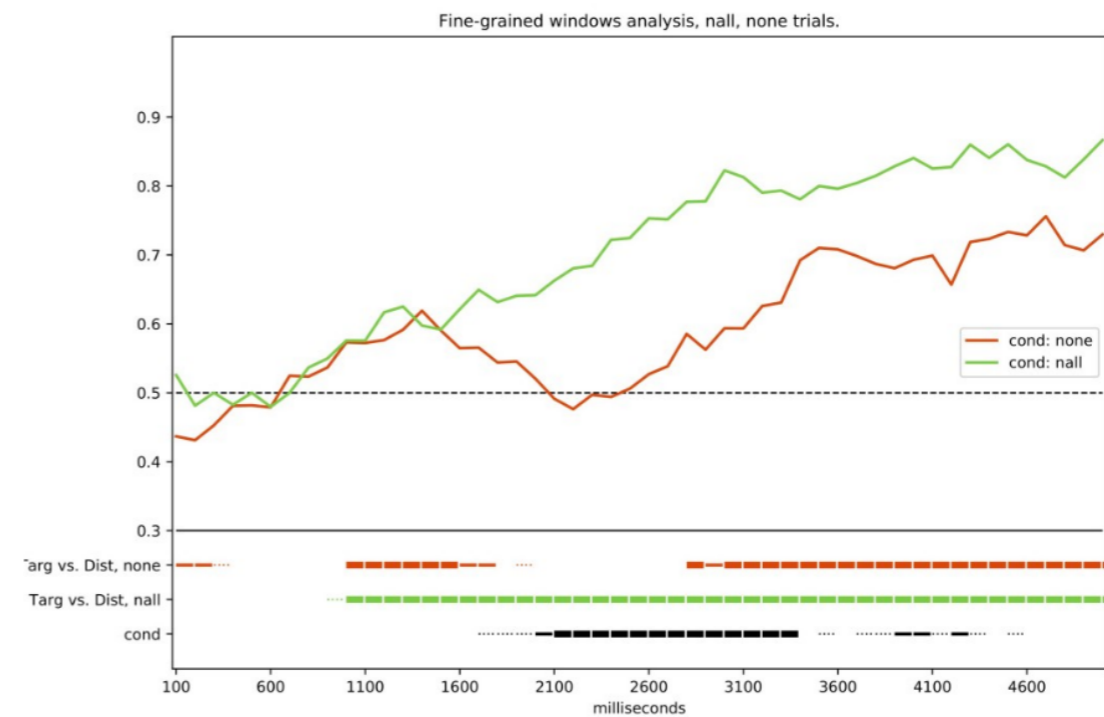
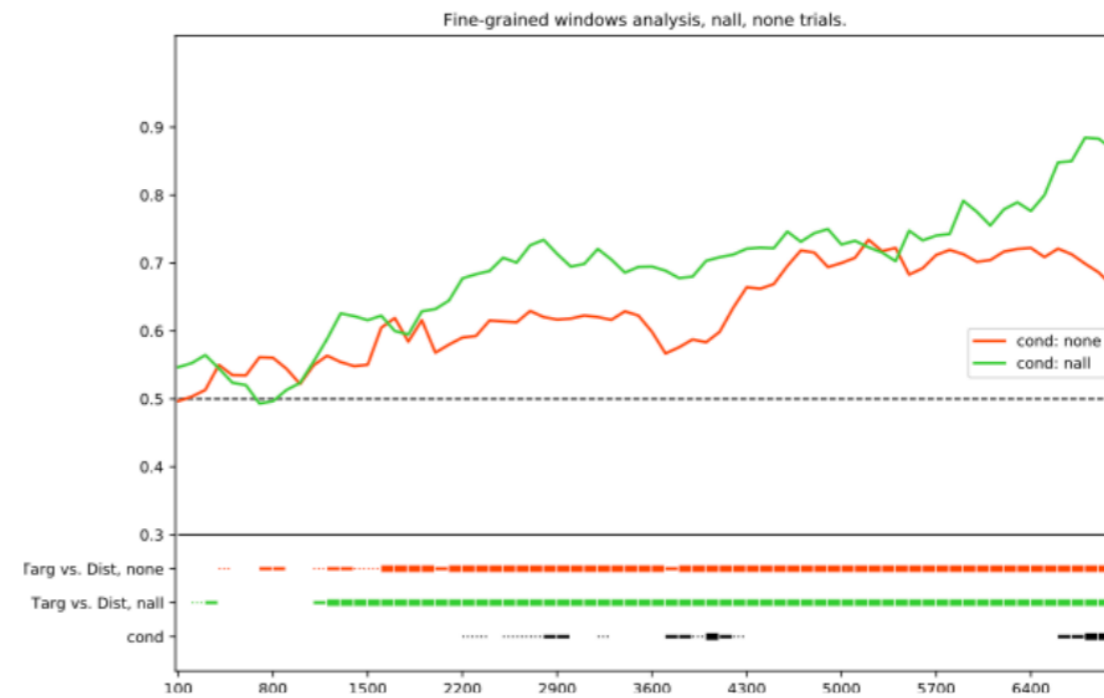


# EXPERIMENT 2: online results



## Semantic Choice Task

adults Exp2 vs. children Exp1



# EXPERIMENT 2: online results

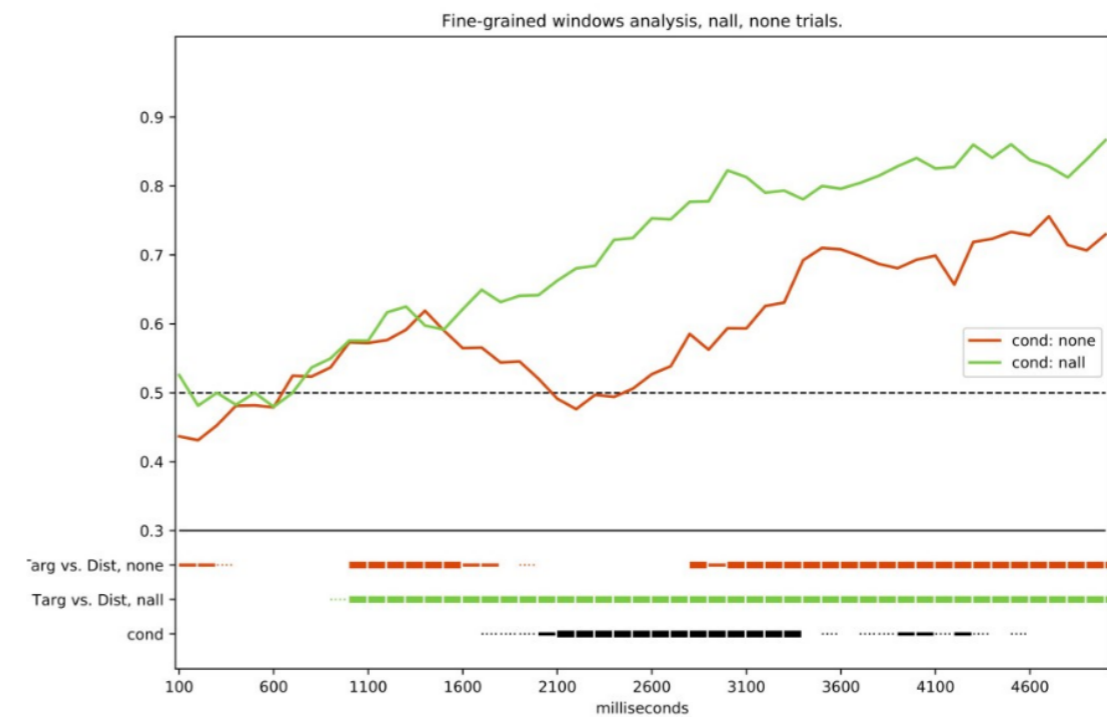
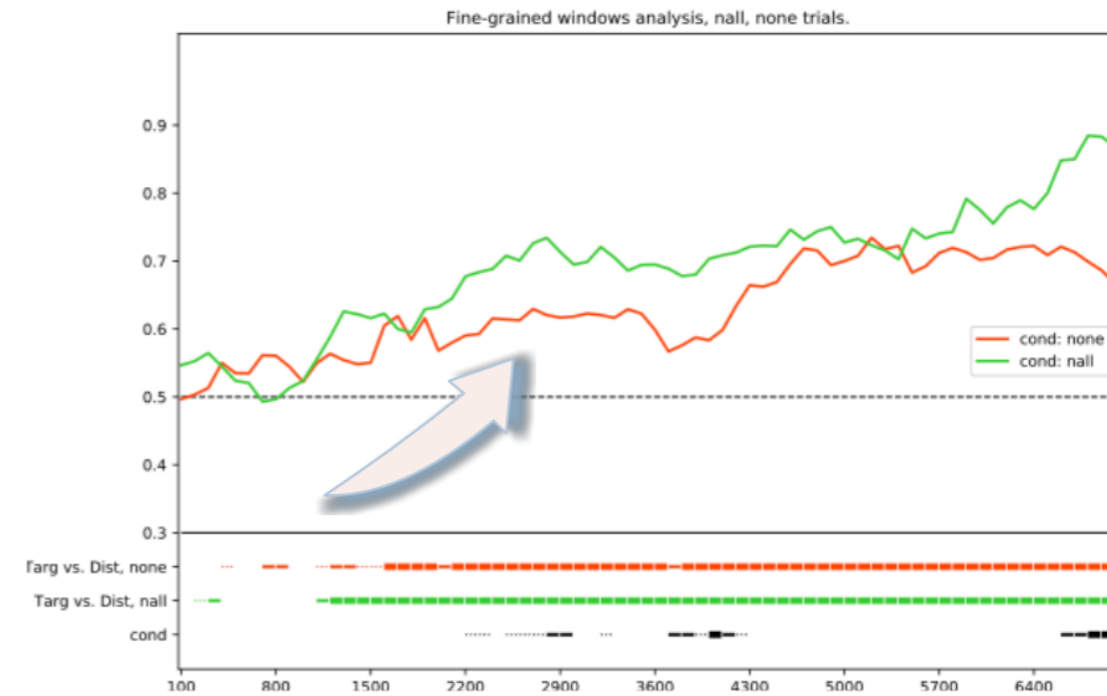


## Semantic Choice Task

adults Exp2 vs. children Exp1



adults more children-like



# EXPERIMENT 2: online results

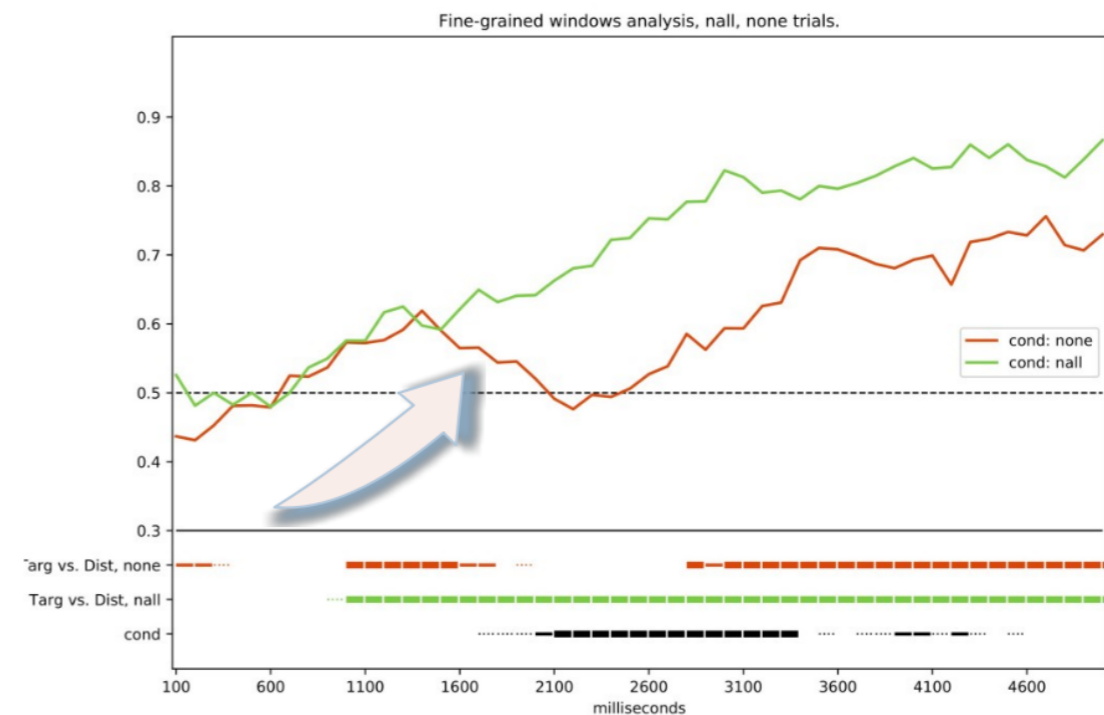
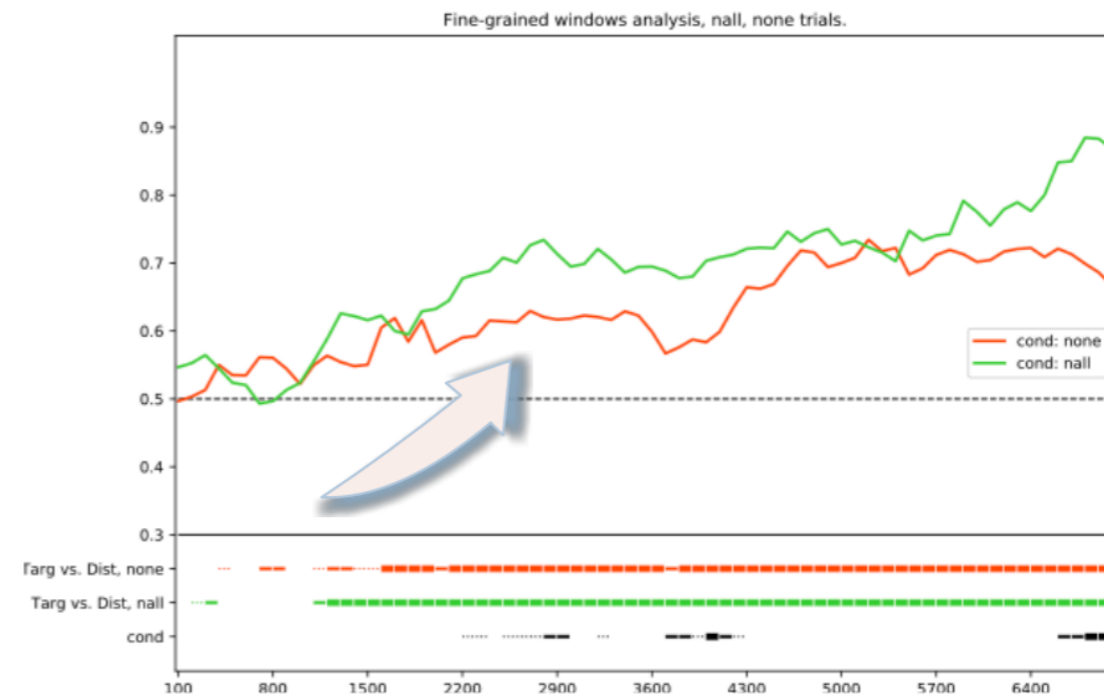


## Semantic Choice Task

adults Exp2 vs. children Exp1

adults more children-like

more pronounced going-back to chance in NONE condition (implicature cancelation?)



# EXPERIMENT 2: online results



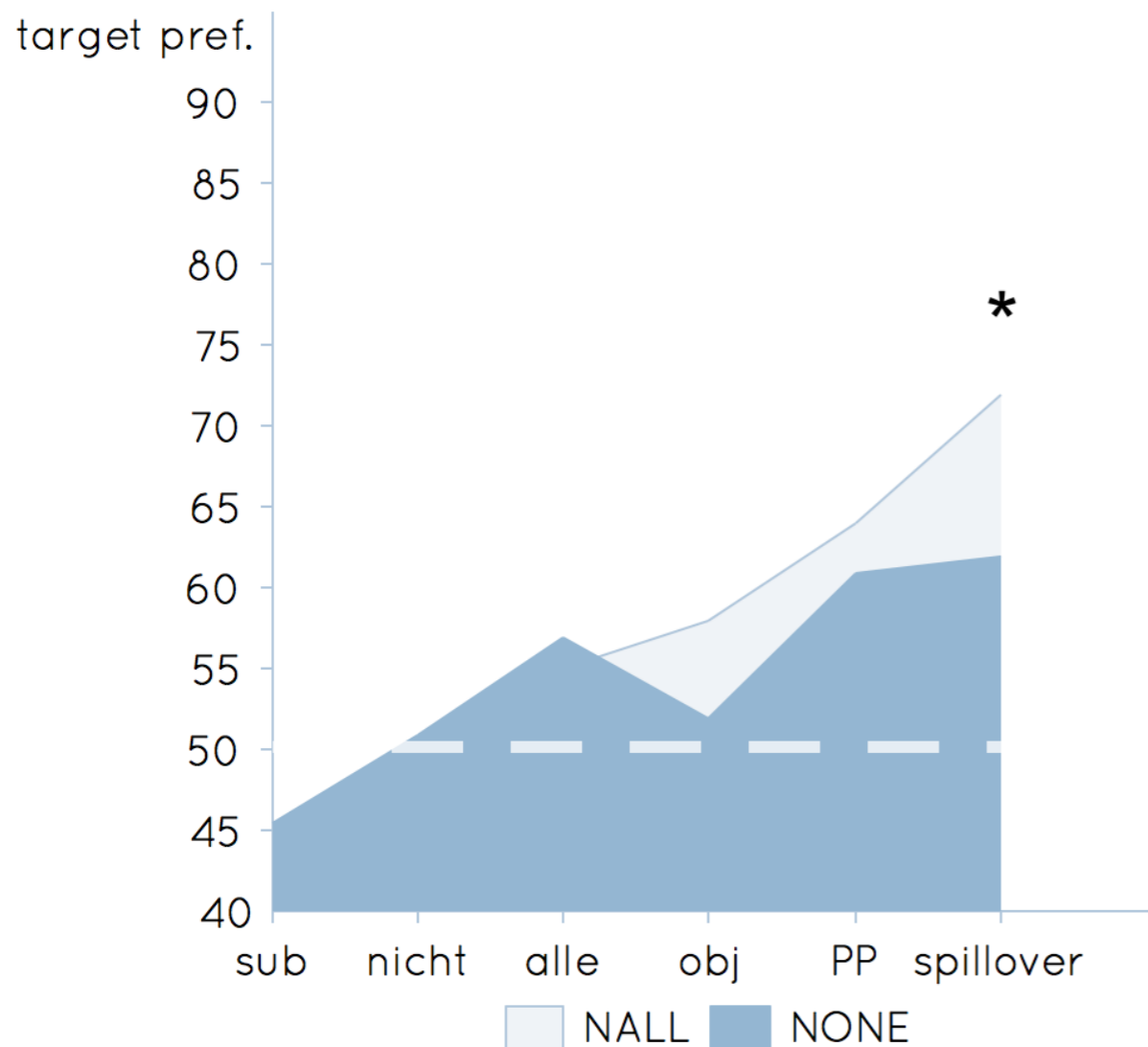
## Semantic Choice Task

broad time-windows analysis adults

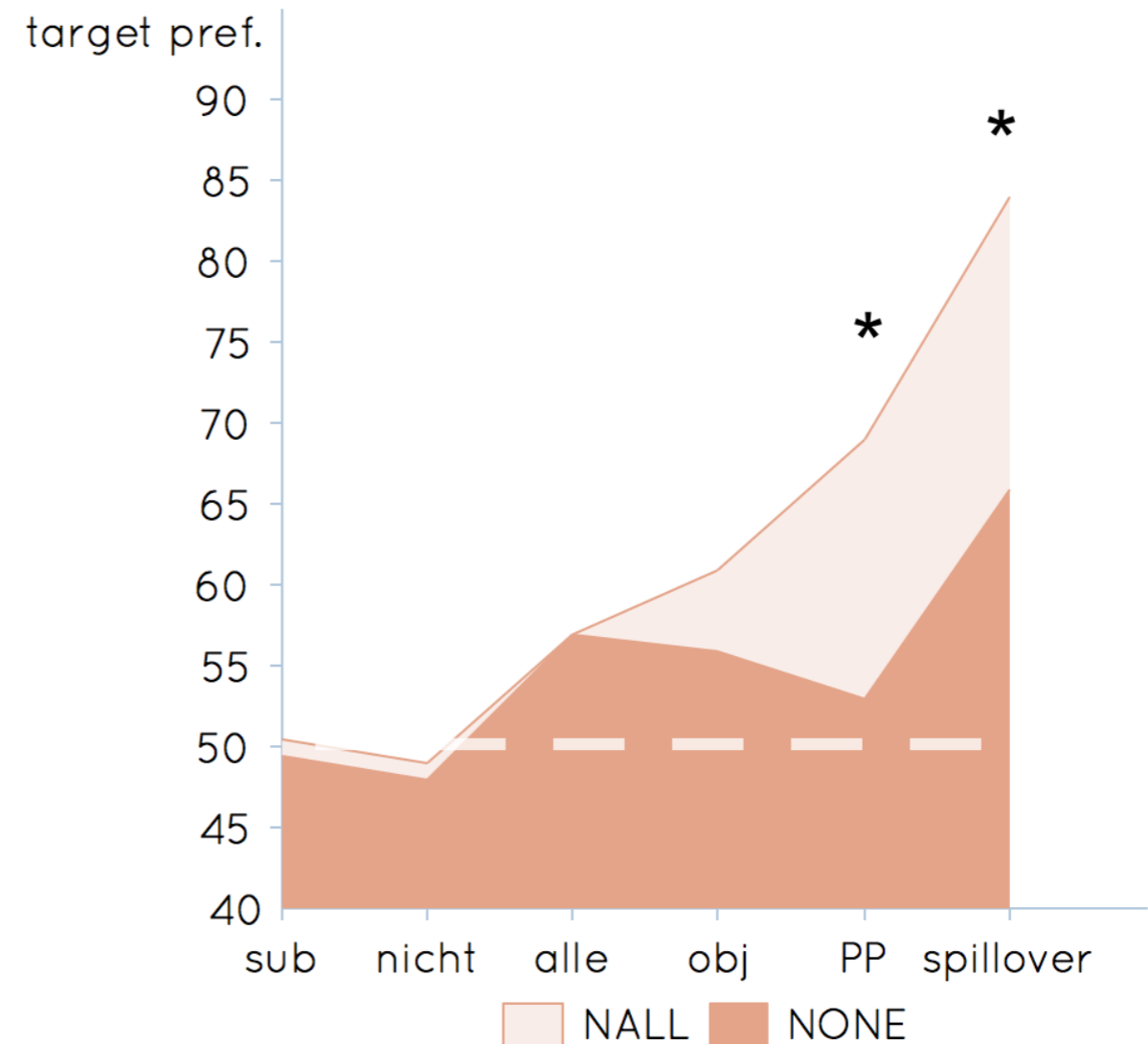


greater difference between conditions in EXP 2, significant in earlier time-window

NALL vs. NONE EXP1



NALL vs. NONE EXP2



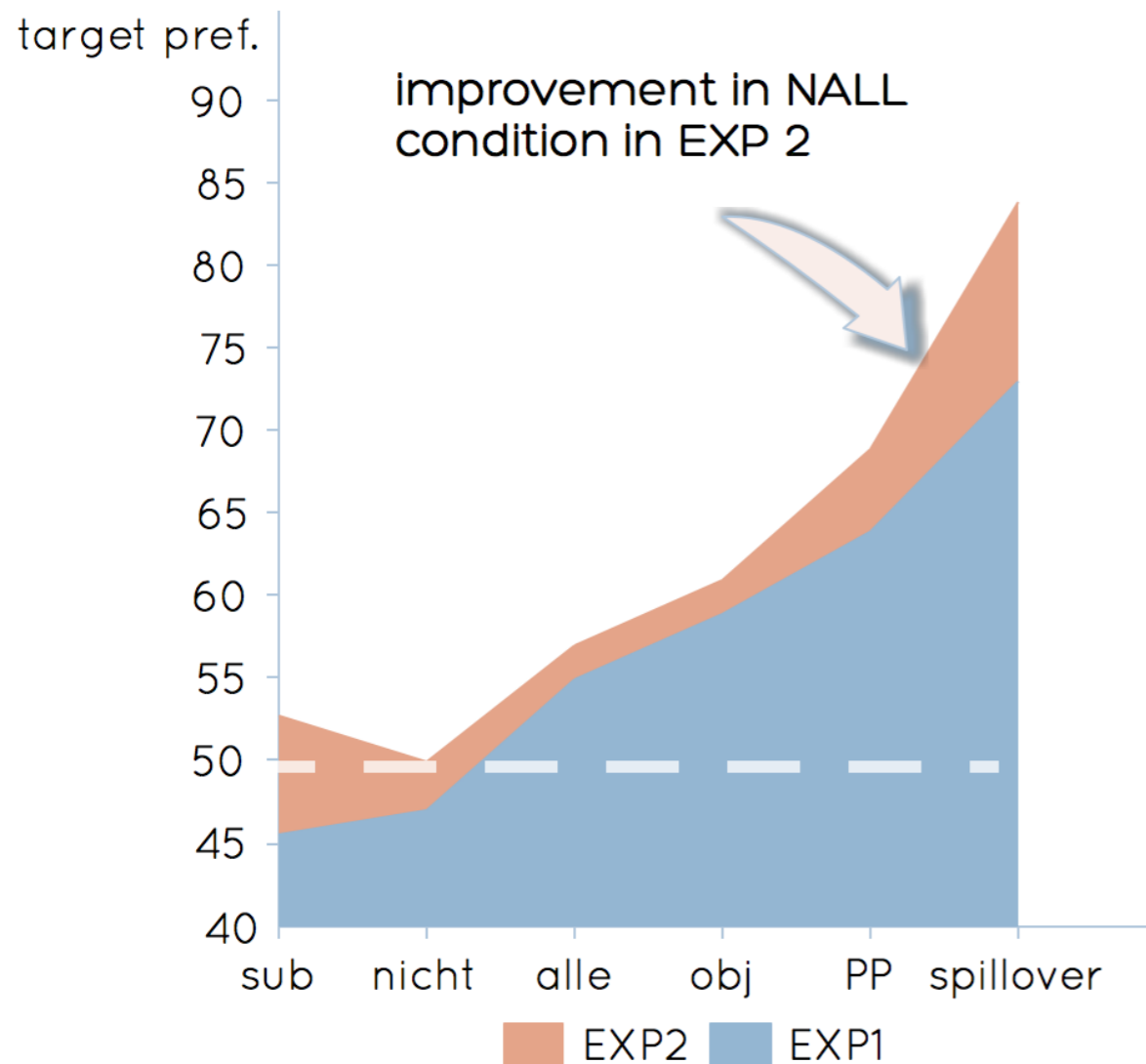
# EXPERIMENT 2: online results



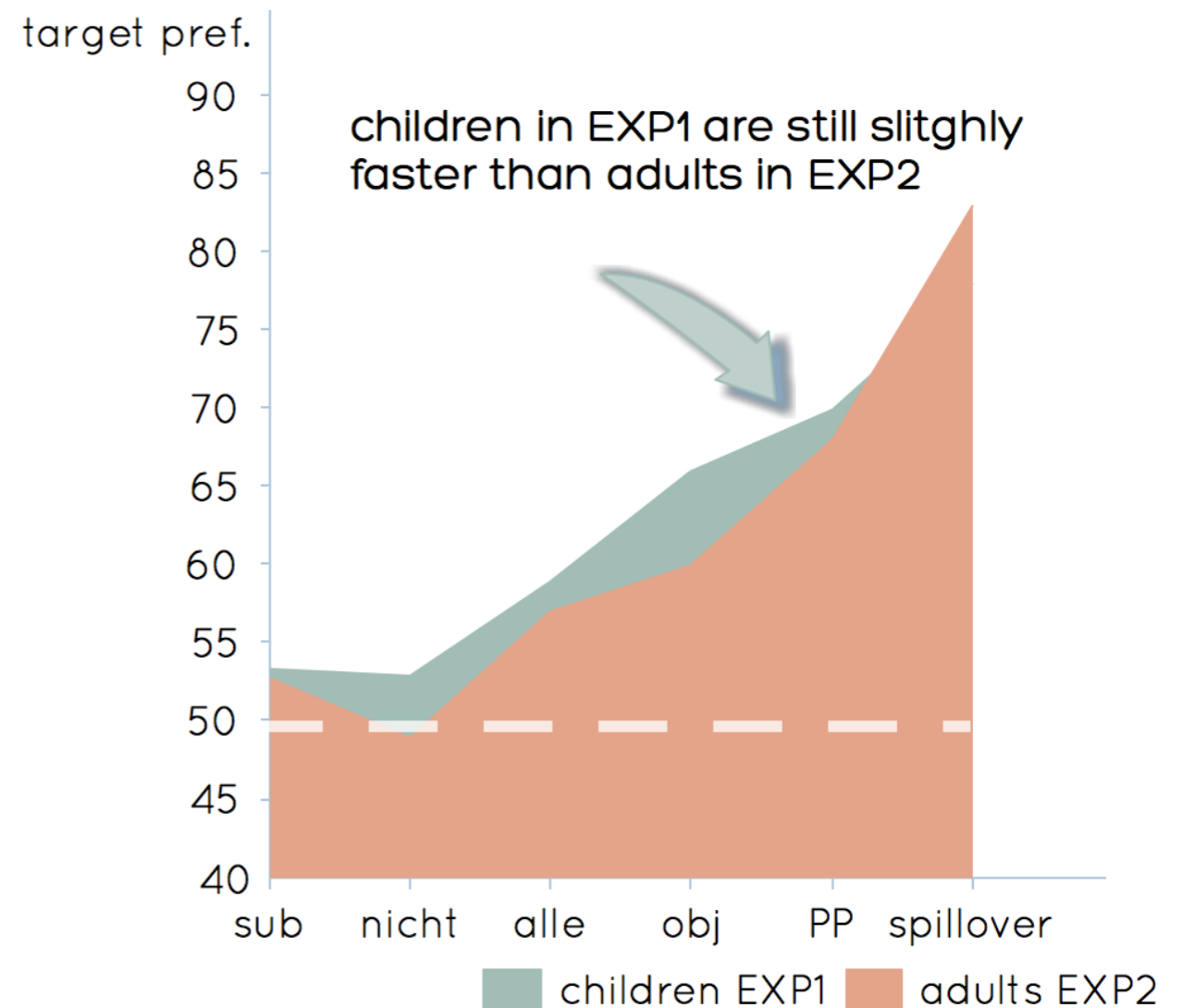
## Semantic Choice Task

broad time-windows analysis

NALL condition: ADULTS,  
EXP1 vs EXP2



NALL condition:  
ADULTS, EXP2 vs CHILDREN EXP1



## EXPERIMENT 2

role of intonation

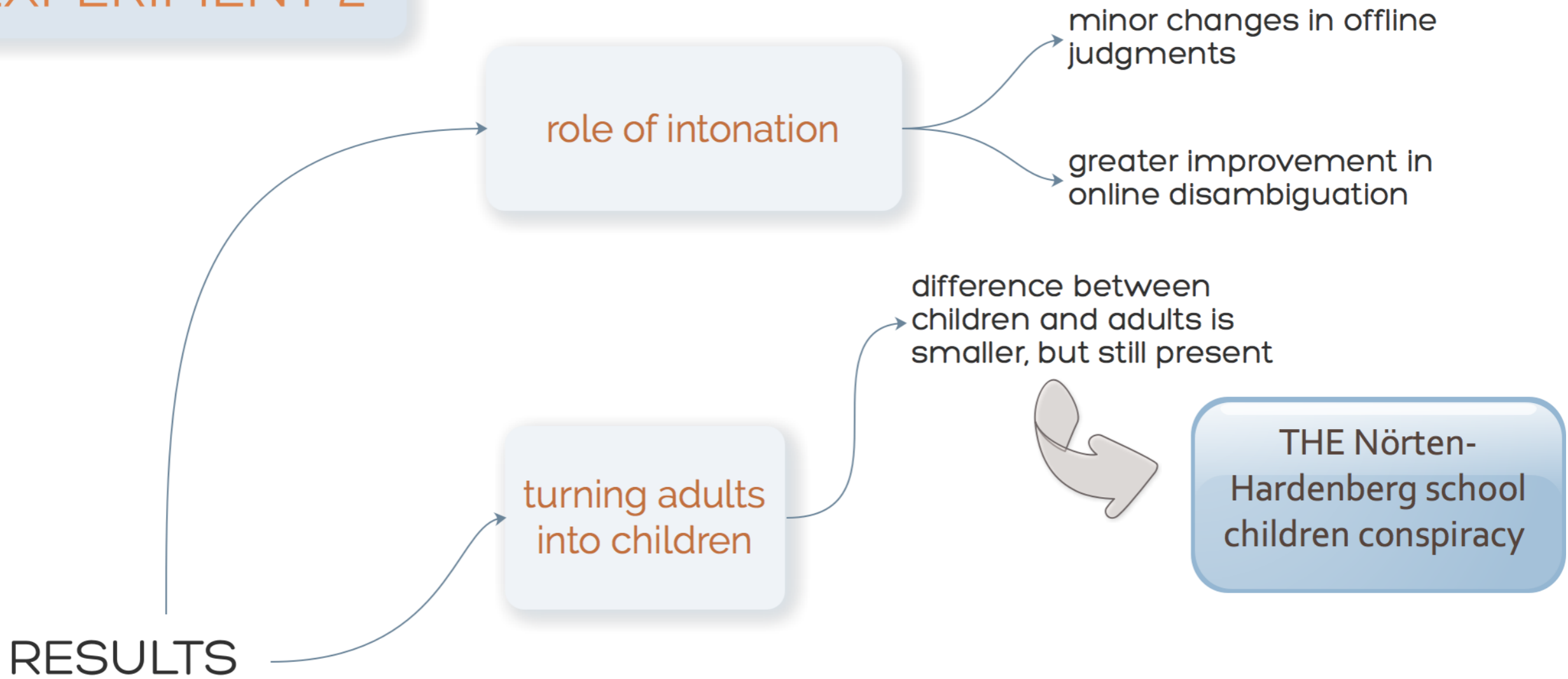
minor changes in offline judgments

greater improvement in online disambiguation

RESULTS



# EXPERIMENT 2



# EXPERIMENT 2

## RESULTS

role of intonation

minor changes in offline judgments

greater improvement in online disambiguation

turning adults into children

difference between children and adults is smaller, but still present

THE Nörten-Hardenberg school children conspiracy

large difference between context supporting ISI (NALL) vs. context violating ISI (NONE)

it seems that "not all but some" is the first available representation of the sentence as soon as "all" is combined with negation

The neo-Gricean paradise



THE Nörten-  
Hardenberg school  
children conspiracy

WHY do ADULTS require  
supporting intonation?



THE Nörten-  
Hardenberg school  
children conspiracy

pay more attention  
to intonation than  
children

ISIs under negation are very often  
associated with special  
phonological contour

intonation automatically  
triggers operations at the  
syntax-semantics/  
discourse interface  
(implicatures, scope shift,  
topicalization/focus, etc.)

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parallel activation of  
multiple meanings

natural intonation might enhance  
one interpretation (ISI) over other  
competing ones (inverse scope?  
topic? unstrengthened?)

it would explain while the children  
conspiracy effects still persists in  
comparison: EXP2 vs. EXP1



THE Nörten-Hardenberg school children conspiracy

WHY do ADULTS require supporting intonation?

pay more attention to intonation than children

ISIs under negation are very often associated with special phonological contour

intonation automatically triggers operations at the syntax-semantics/discourse interface (implicatures, scope shift, topicalization/focus, etc.)

interference



ambiguity



parallel activation of multiple meanings

natural intonation might enhance one interpretation (ISI) over other competing ones (inverse scope? topic? unstrengthened?)

it would explain while the children conspiracy effects still persists in comparison: EXP2 vs. EXP1



The neo-Gricean  
paradise

WHY are ISIs > SIs  
& computed by default?



The neo-Gricean  
paradise

*direct implicatures*

the girl ate *some* of  
the cookies

the girl ate *some but not all*  
of the cookies

WHY are ISIs > SIs  
& computed by default?

*indirect implicatures*

the girl didn't eat *all* of  
the cookies

the girl didn't eat all of the cookies but  
she ate *some*





The neo-Gricean paradise

*direct implicatures*

the girl ate *some* of the cookies

the girl ate *some but not all* of the cookies

SI alternatives

$\exists$

$\forall$

ISI alternatives

$\neg \forall$

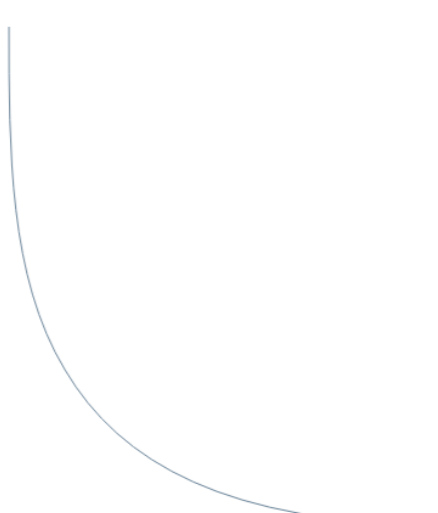
$\forall \neg$

*indirect implicatures*

the girl didn't eat *all* of the cookies

the girl didn't eat all of the cookies but she ate some

WHY are ISIs > SIs & computed by default?





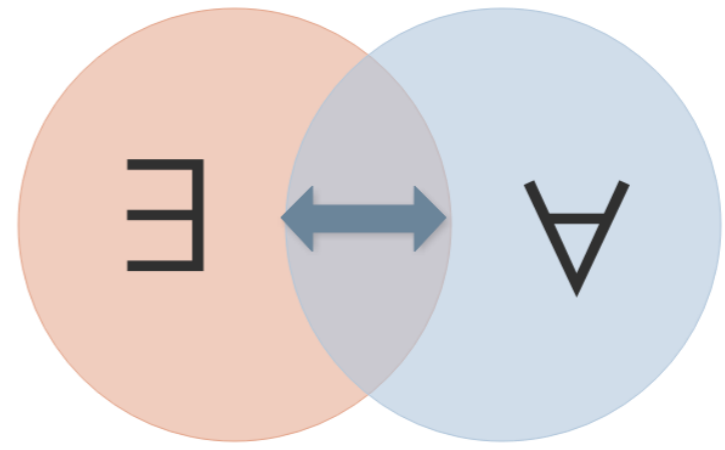
The neo-Gricean paradise

*direct implicatures*

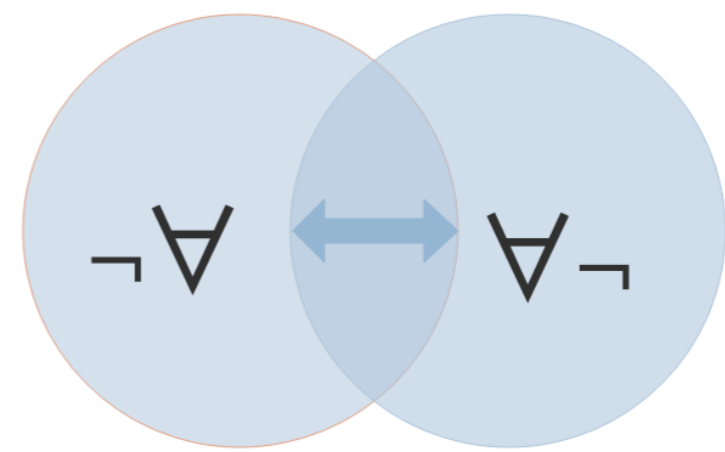
the girl ate *some* of the cookies

the girl ate *some but not all* of the cookies

SI alternatives



ISI alternatives



*indirect implicatures*

the girl didn't eat *all* of the cookies

the girl didn't eat all of the cookies but she ate *some*

WHY are ISIs > SIs & computed by default?





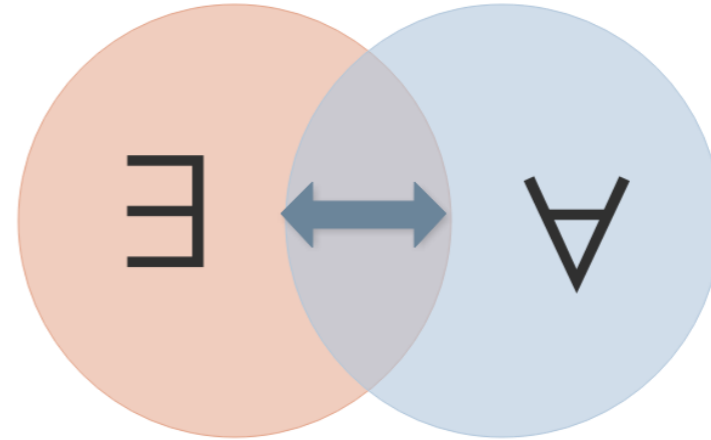
The neo-Gricean paradise

*direct implicatures*

the girl ate *some* of the cookies

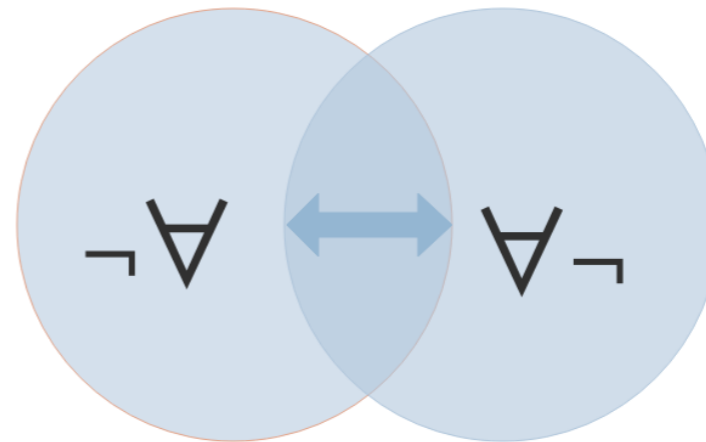
the girl ate *some but not all* of the cookies

SI alternatives



maybe alternatives to ISIs are always active because they are part of the Logic Form of the asserter proposition

ISI alternatives

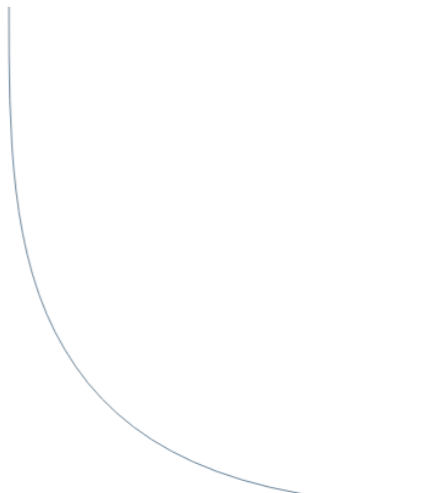


*indirect implicatures*

the girl didn't eat *all* of the cookies

the girl didn't eat all of the cookies but she ate *some*

WHY are ISIs > SIs & computed by default?



thanks to: MAIK, CARINA, NICO, WIEBKE, CATARINA



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THE Nörten-Hardenberg  
school & children



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thank you!

