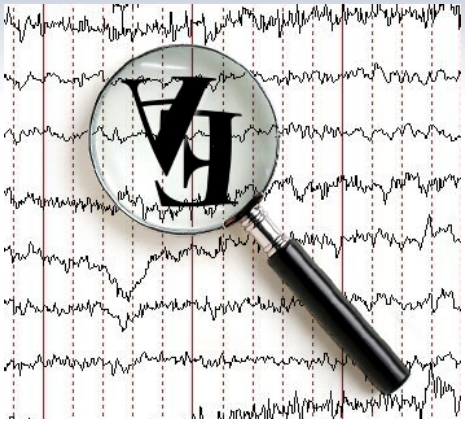

Pragmatic effects on the processing of quantifiers

Maria Spychalska
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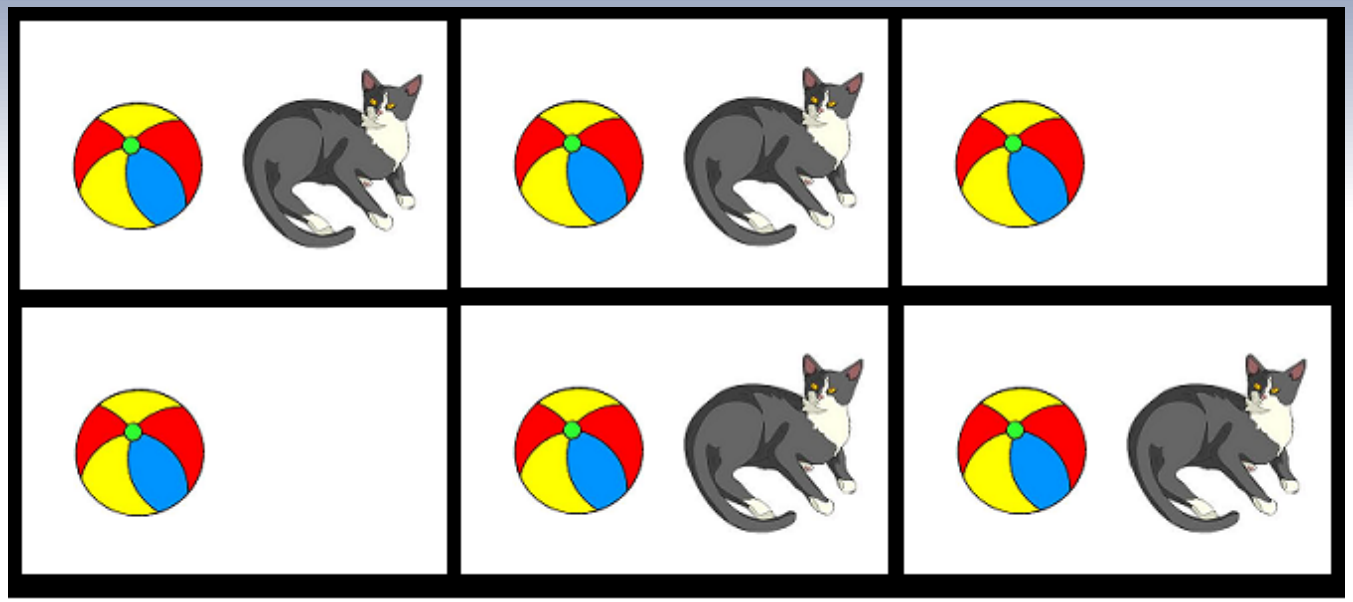
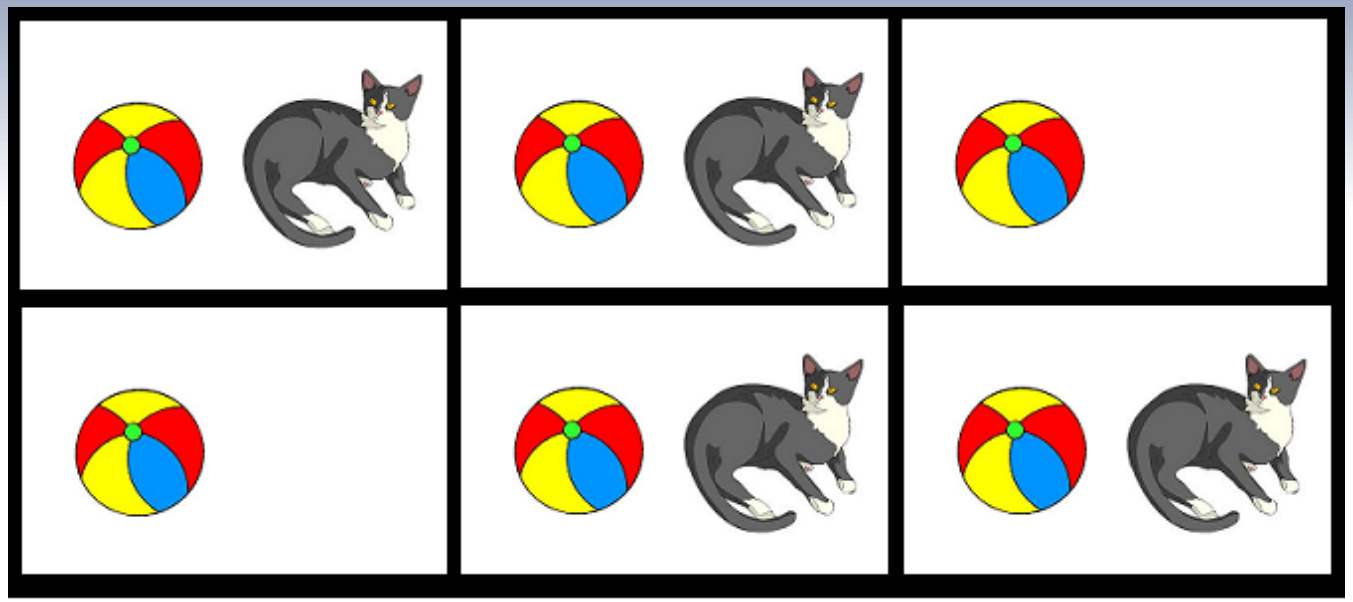
Amsterdam, 29th September 2017

Introduction

Semantics vs. pragmatics

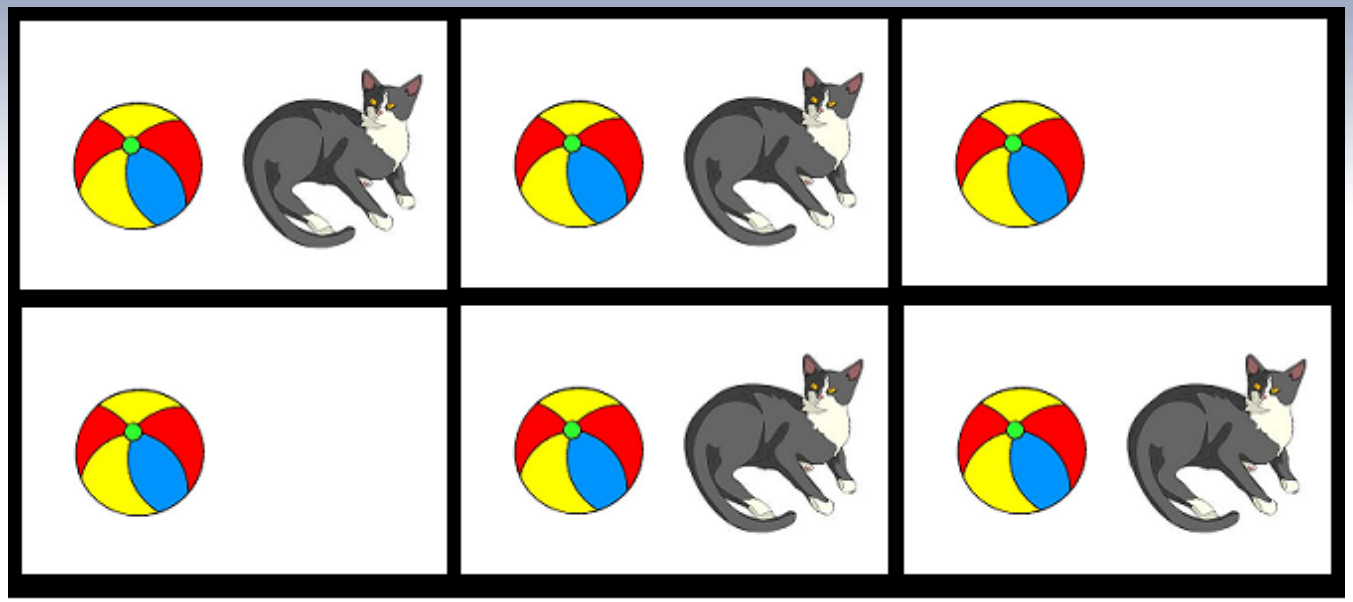


Semantics vs. pragmatics



All pictures contain balls.

Semantics vs. pragmatics



All pictures contain balls.
No picture contains dogs.

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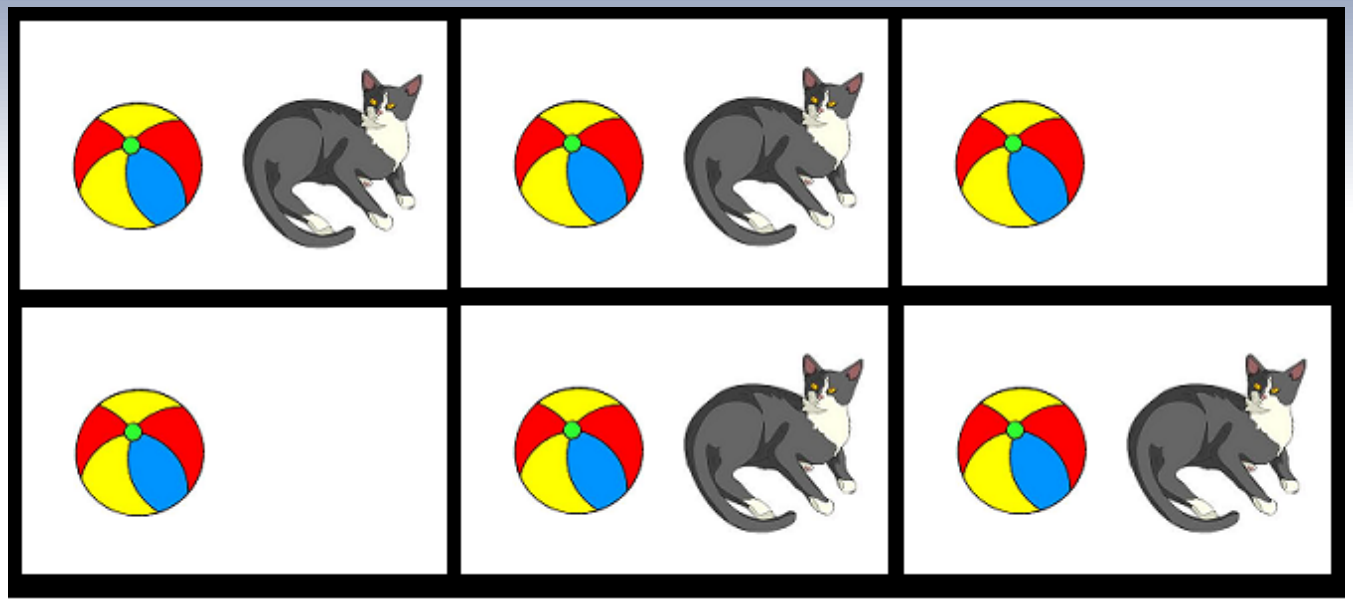
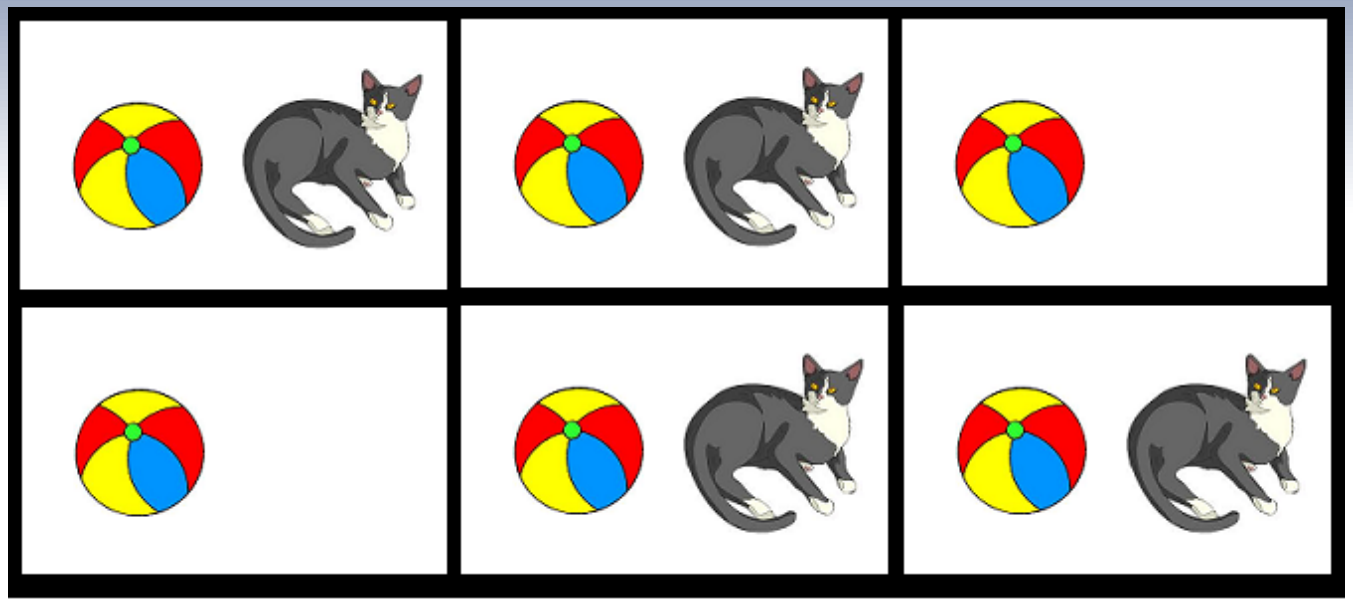


All pictures contain balls.
No picture contains dogs.
More than two pictures contain balls.

Semantics vs. pragmatics



All pictures contain balls.
No picture contains dogs.
More than two pictures contain balls.
Some / Four pictures contain (cats/balls).

Scalar Implicature

Quantity: If the speaker knew that **all**, she should have said so. (**Give a more informative statement, if available!**)

Gricean Mechanism

- The speaker said **some...**
- The speaker is obeying the Maxim of Quantity
- Thus, if the speaker believed or knew that **all...** is true, she should have said so.
- The speaker doesn't believe (or know) that **all...**: $\neg B_S$ (all...)

Scalar Implicature

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- Thus, if the speaker believed or knew that **all...** is true, she should have said so.
- The speaker doesn't believe (or know) that **all...**: $\neg B_S$ (all...)
- **Competence Assumption** $\mapsto$ the speaker is informed or at least has an opinion regarding the stronger alternative: B_s (all...) or $\neg B_s$ (all...)
- **Epistemic Step** $\mapsto$ the speaker believes that the stronger alternative is false: $B_S \neg(all\ldots)$

Weak and strong implicature

Some As are B

$\rightsquigarrow \neg B_s$ **(all As are B)**

$\rightsquigarrow B_s \neg$ **(all As are B)** (by assuming the competence)

Controversies

- Main controversy: **default vs. context-based controversy**.

  How implicatures are generated? By default, i.e. more or less automatically or as results of complex reasoning processes based on context?

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- local vs. global character of SIs: can they be embedded under the scope of other operators?

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  How implicatures are generated? By default, i.e. more or less automatically or as results of complex reasoning processes based on context?

- local vs. global character of SIs: can they be embedded under the scope of other operators?

- **Truth-conditional role?** Do SIs contribute to the sentence truth-conditional content? Minimal semantics [Cappelen and Lepore, 2005, Borg, 2012] vs. truth-conditional pragmatics [Recanati, 2010].

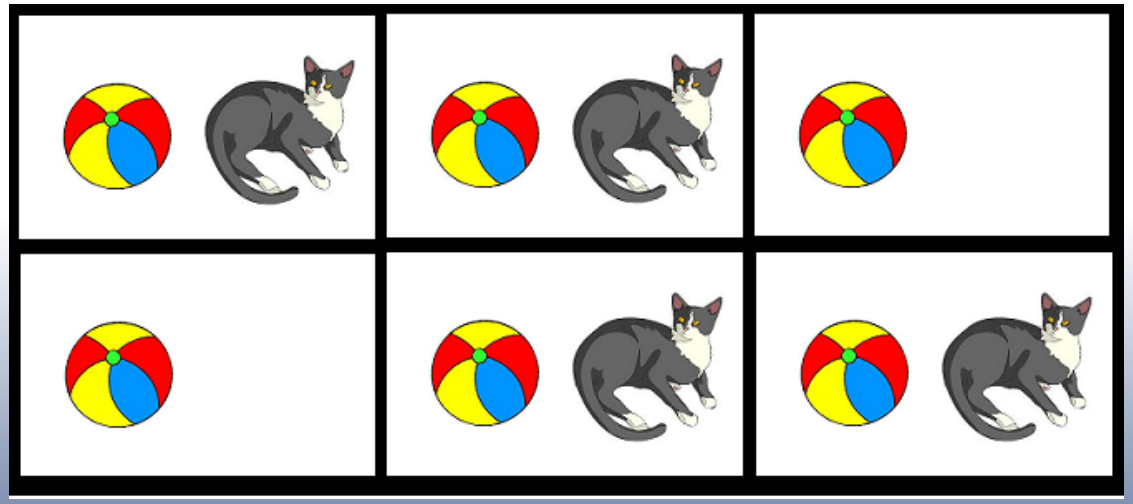
Not a polar controversy

	Context-independent		Context-dependent	
	TC	**not TC**	**TC**	**not TC**
local	?[Levinson, 2000]	[Chierchia, 2004]	—	—
global	—	[Sauerland, 2004]	[Sperber and Wilson, 1986] [Carston, 1988, Carston, 1998]	[King and Stanley, 2005]
both			?[Chierchia et al., 2012]	?[Chierchia et al., 2012]

Example

Most psycholinguistic literature focuses on the default vs. context-based controversy. → The cognitive costs of processing SIs taken as a proxy of their default vs. non-default character.
& Most experiments explore full information contexts.

- World-knowledge: *Some elephants are mammals.*
- Sentence-picture verification task



Some / Four pictures contain (cats/balls).

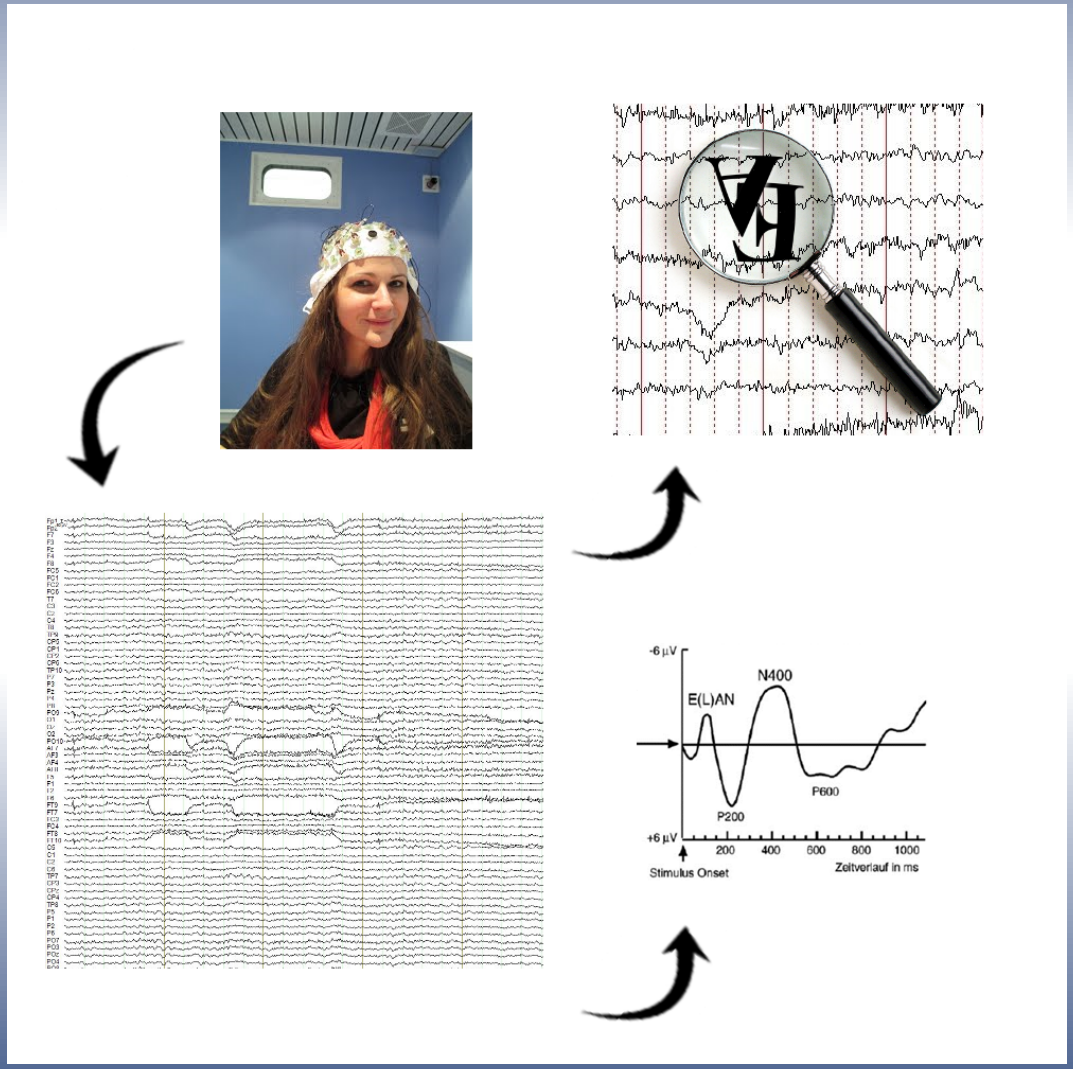
Empirical evidence: basics

- Divergent truth-value intuitions regarding so-called underinformative sentences, e.g. **Some elephants are mammals** [Bott and Noveck, 2004].
  - "true" $\mapsto$ logical response
  - "false" $\mapsto$ pragmatic response
- Pragmatic interpretation is usually slower (reaction time, eye-tracking) [Bott and Noveck, 2004, Huang and Snedeker, 2009, Tomlinson et al., 2013]
- But: seems to be computed as the utterance unfolds and prior to phrasal completion (eye-tracking [Huang and Snedeker, 2009]).
- Whether SIs are computed as slow and effortful or rapid and default depends on context, for instance, the presence of other scalar alternatives available (e.g. numerals) [Degen and Tanenhaus, 2015, Degen and Tanenhaus, 2015].

Processing

- Are implicatures incrementally processed? $\dashrightarrow$ Do they modulate predictability for upcoming words during the online sentence comprehension?
- What is the role of the truth-conditional judgement in the processing of SIs?
- What role does perspective taking play in the implicature processing?

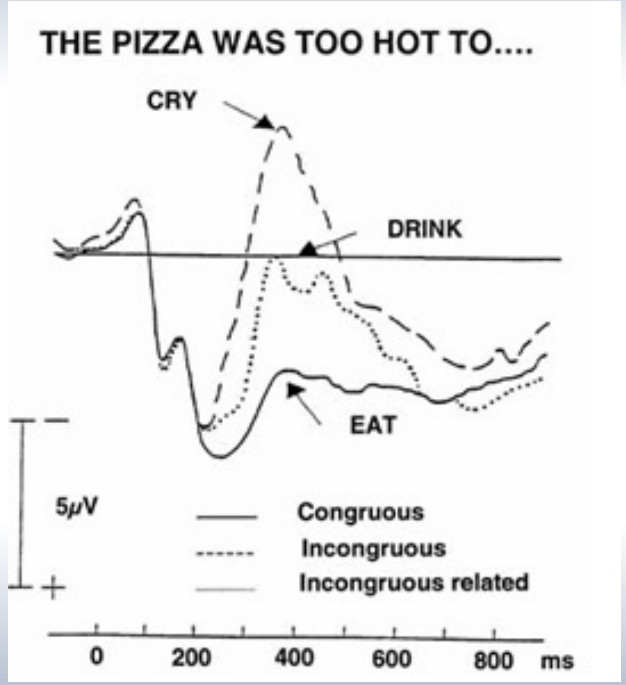
ERPs and language processing



- Event-related potentials (ERPs) are direct brain responses time-locked to specific events, e.g. a visual or auditory stimuli.
- An ERP component is a scalp-recorded voltage change that is considered to reflect a specific neural process
- The N400, P600, and P300

The N400

[Kutas and Van Petten, 1988]



- Negative deflection, latency between 200 and 600 ms post-stimulus onset (usually lasts ca. 300 ms and reaches maximum amplitude between 380 and 440 ms, delayed in elderly persons or aphasia)
- Maximal over centro-parietal scalp sites
- Observed for all meaningful stimuli: single words, words in sentences, pictures
- Its amplitude varies as function of semantic expectancy of this stimulus.

N400 modulation

Larger N400 for:

- semantic violations, words semantically less appropriate or less expected in the context/ based on world-knowledge /propositional truth-value (modulo other factors, e.g. negation)
- words are semantically or lexically less related to the preceding context

Smaller N400 for: more frequent words, words primed, high cloze probability words, etc.

Semantic & pragmatic factors!

Theories

N400 as signature of semantic expectancy (two mainstream views):

- reflects the level of facilitation of the lexical retrieval from memory [Kutas et al., 2006]
- reflects the level of the difficulty of semantic integration into the discourse context [Hagoort, 2007, Van Petten and Luka, 2012]

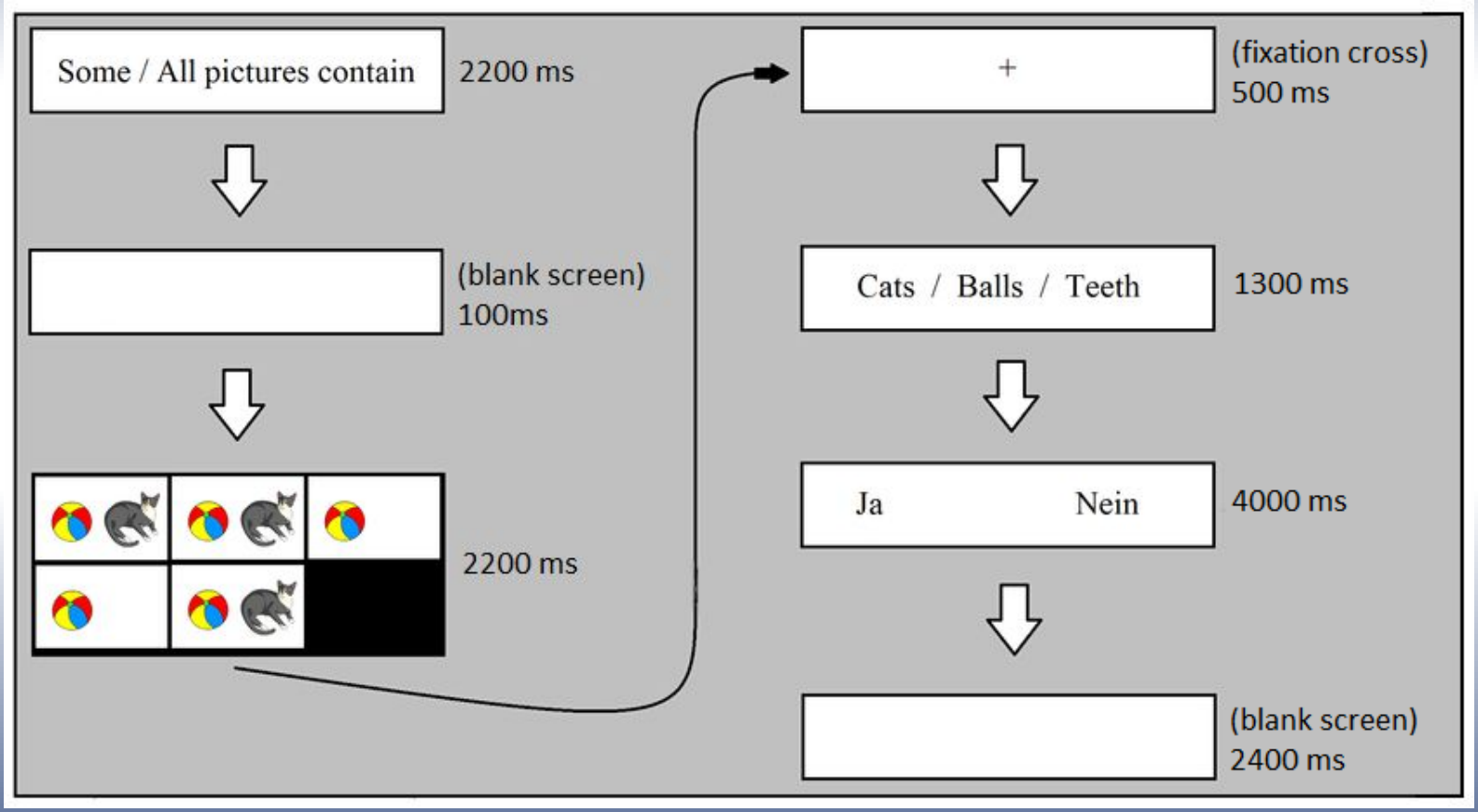
⇢ N400 is related to semantic expectancy/ “prediction” (in probabilistic sense)
[Van Petten and Luka, 2012, Lau et al., 2013, Kuperberg and Jaeger, 2015]
(debate what “prediction” means in this context and whether or not N400 reflects prediction)

Implicature processing: Evidence from ERPs

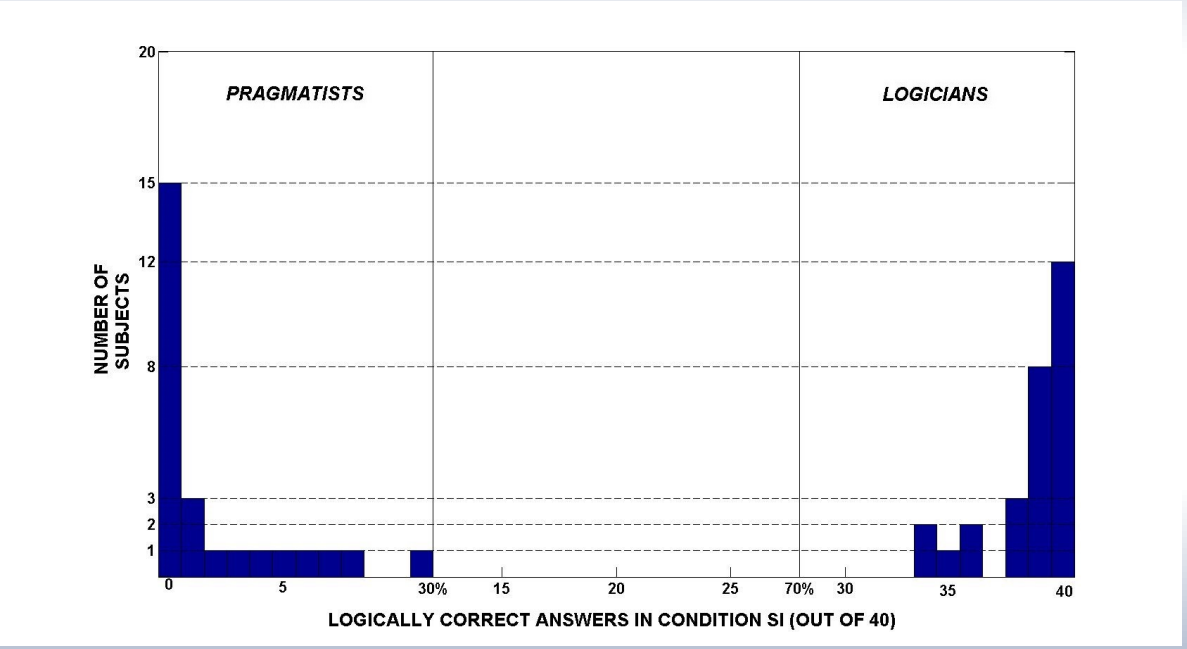
- N400 results: quantifiers are interpreted incrementally though pragmatic aspects may impact the speed and depth of the quantifier interpretation [Nieuwland, 2016, Urbach and Kutas, 2010, Urbach et al., 2015]
- Is the scalar implicature incrementally integrated into sentence meaning/does it modulate the N400 for words downstream the quantifier phrase if the prediction of these words depends on the scalar implicature?
  - world-knowledge-related: **some people have lungs** / **some people have pets**
  - interference with lexical-semantic relationship within the sentence
  - mixed results: [Noveck and Posada, 2003, Nieuwland et al., 2010, Politzer-Ahles et al., 2012, Hunt et al., 2013]
  - [Nieuwland et al., 2010] suggested that subjects' individual difference in their communicative abilities may affect the depth of the scalar implicature processing.

Experiment on scalar implicatures

Spychalska, M., Kontinen, J. and Werning, M., 2016, Investigating scalar implicatures in a truth-value judgment task: Evidence form event-related brain potentials. Language, Cognition and Neuroscience.



Response pattern: two groups

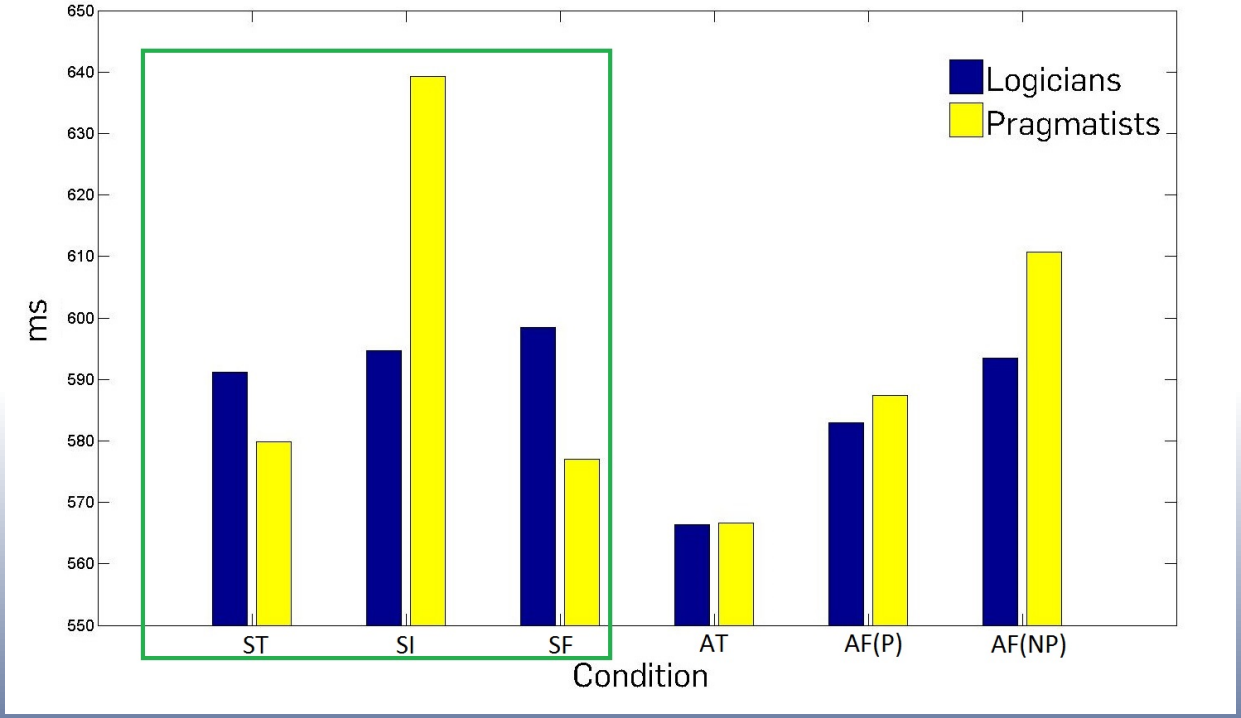


(a)

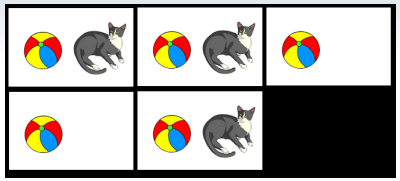
- **"Logicians"** (N=28): at least 70% of logical responses
- **"Pragmatists"** (N=26): at least 70% of pragmatic responses
- High accuracy in all control conditions.
- No significant differences between the two groups in any of the measured cognitive values (AQ, digit span, vocabulary, matrix reasoning).

Mean reaction time for each quantifier, truth-condition and group

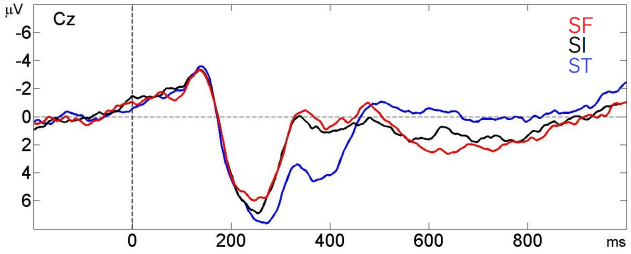
Delay for the pragmatic response in the **Some-infelicitous** condition: similar to [Bott and Noveck, 2004].



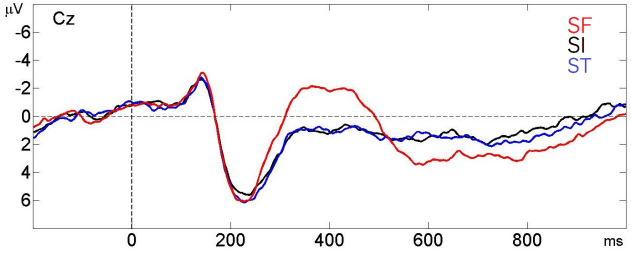
Differential ERP effects for “pragmatists” and “logicians”; biphasic pattern: N400 and P600



Einige Bilder enthalten...
...Katzen (ST: Some-true)
...Bälle (SI: Some-Infelicitous)
...Zähne (SF: Some-false)



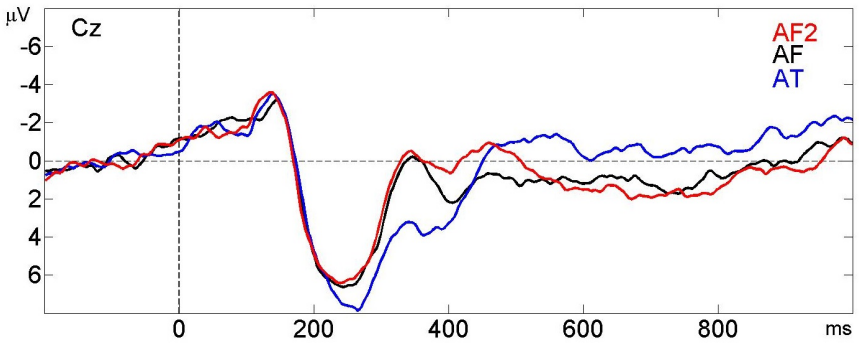
(b) Pragmatists



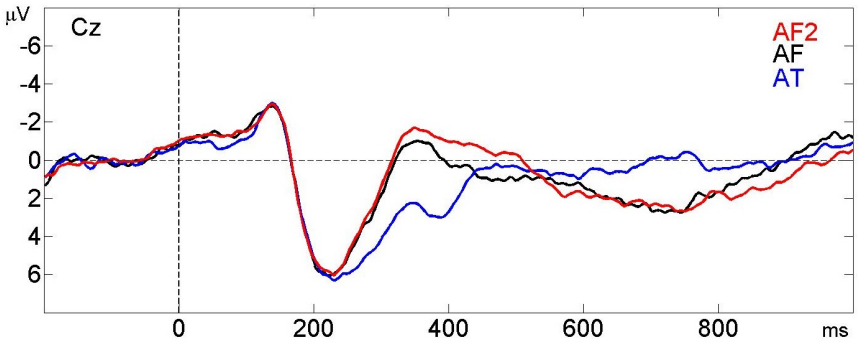
(c) Logicians

Incremental processing: **Only** those responders who applied the strengthened reading had an ERP signature of “semantic violation” (N400), for the condition violating this reading relative to the unambiguously true case.
Non default implicature: No ERP effect for “logicians” in the critical comparison **SI vs ST**

GA for “all” for the for pragmatists and logicians



(d) Pragmatists

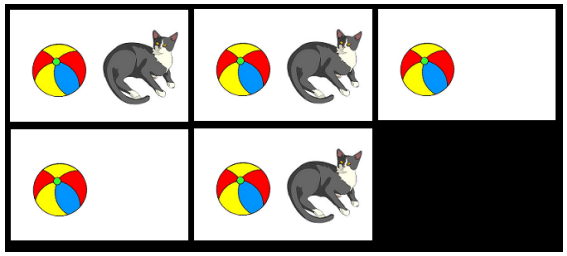


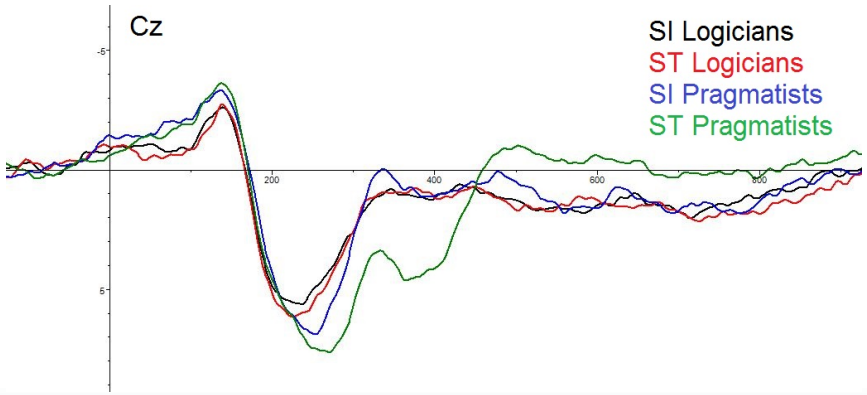
(e) Logicians

No sig. between-group differences;
Biophasic effect: N400 and P600 for **All-true** v.s **All-false** conditions

Priming effect. N400 for **All-false-Nonprimed** vs. **All-false-primed**.

Modulation of the N400 by the number of true sentence completions in the scenario





Einige Bilder enthalten...
...Katzen (ST: Some-true)
...Bälle (SI: Some-Infelicitous)

...Zähne (SF: Some-false)

$ST_{Log}N400 > ST_{Pragm}N400$
$SI_{Log}N400 > ST_{Pragm}N400$
$ST_{Log}N400 \neq SI_{Pragm}N400$
$SI_{Log}N400 \neq SI_{Pragm}N400$

The N400 for the sentence final noun was modulated by:

- The quantifier interpretation, i.e. larger N400 for nouns that, based on the quantifier interpretation, completed false sentences.
- Priming (visually unprimed nouns elicited larger N400).
- The number of “truth-makers” in the scenario: for scenarios with multiple alternative “truth-makers”, the N400 elicited by sentence-final nouns was larger than for scenarios that allowed unique predictions for true sentence completions.

The N400 for the sentence final noun was NOT modulated by:

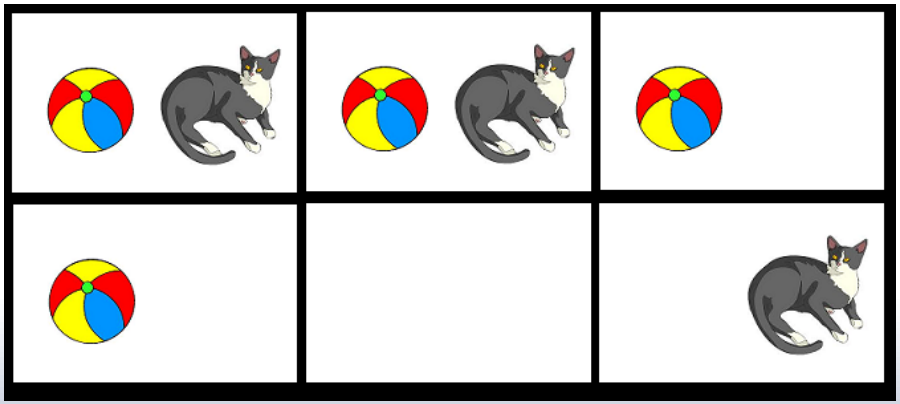
- The Autism Spectrum Quotient of the tested individuals,
- Any other personality or cognitive traits that were measured (e.g. working memory)

Experiment 2: Does it generalize to other scalar triggers?

“Exactly” and “at least” readings of bare numerals

(paper in revision for **Journal of Experimental Psychology**)

Three pictures contain...



cats/balls

- **Standard: neogricean $\mapsto$ the “exactly” reading is a result of exhaustification by means of scalar implicature**
- Exactly semantics: the “exactly” reading is the literal meaning and the “at least” reading results from a pragmatic weakening mechanism
- Lexical ambiguity accounts

Factors

- Factor1: Evaluation
  1. True under **at least** reading
  2. True under **exactly** reading
  3. **False** (under both readings)
- Factor2: Context (evaluation of the sentence if the CW had refereed to the second displayed object): **exactly**, **at least**, **false**
- Three combinations with 2 possibilities for CW = 6 conditions

  Comb1: At least vs. exactly

  Comb2: At least vs. false

  Comb3: Exactly vs. false

Conditions

Figure: Six conditions as combinations of the numeral, scenario types and critical words.

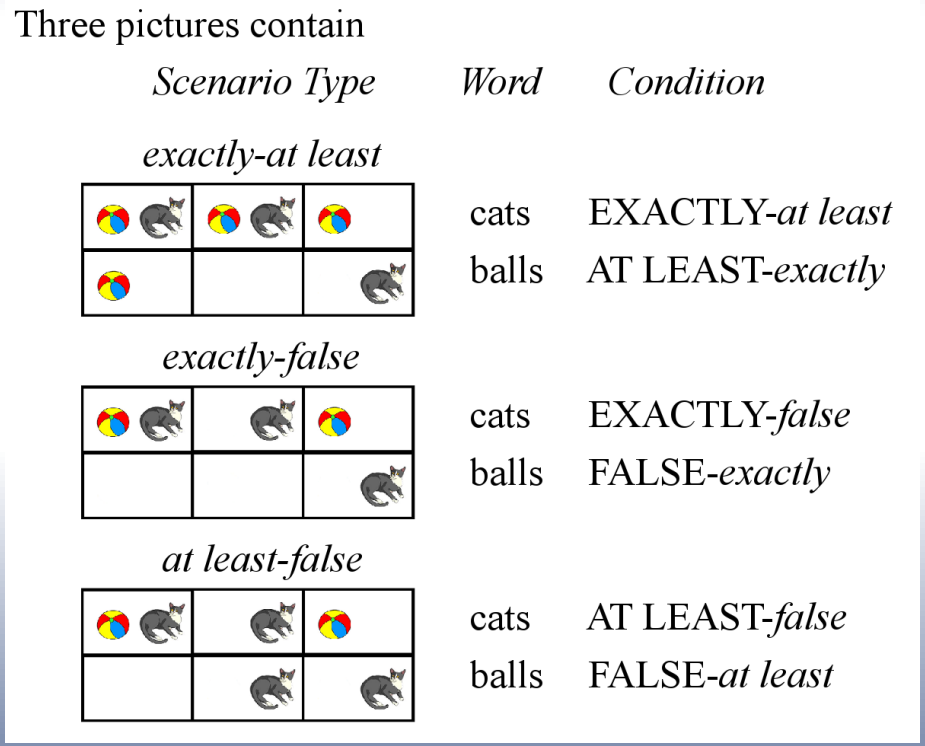


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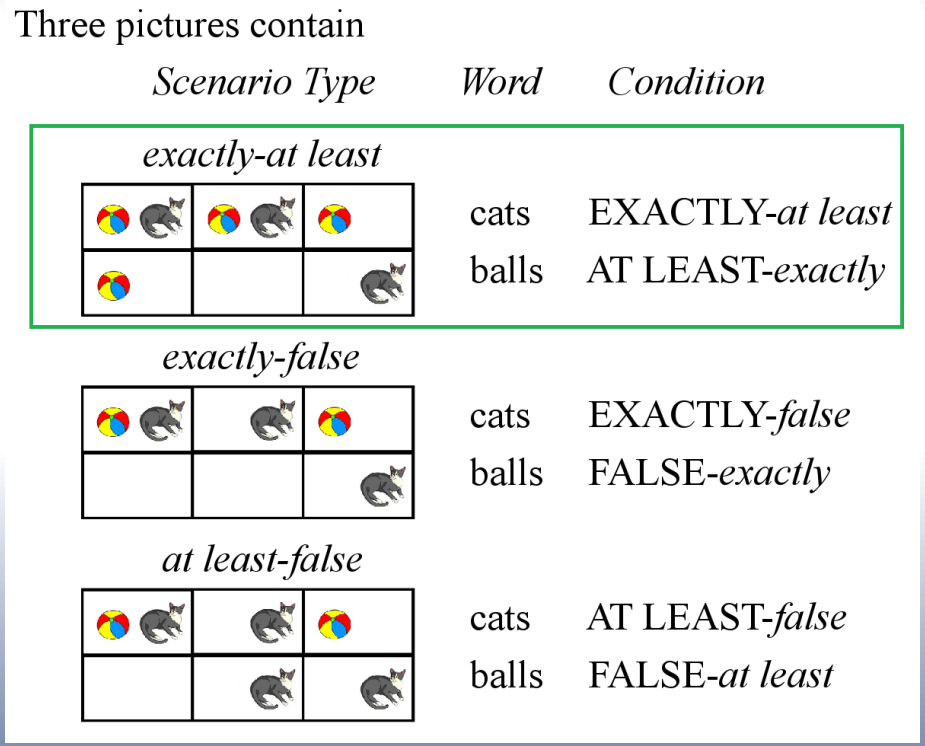
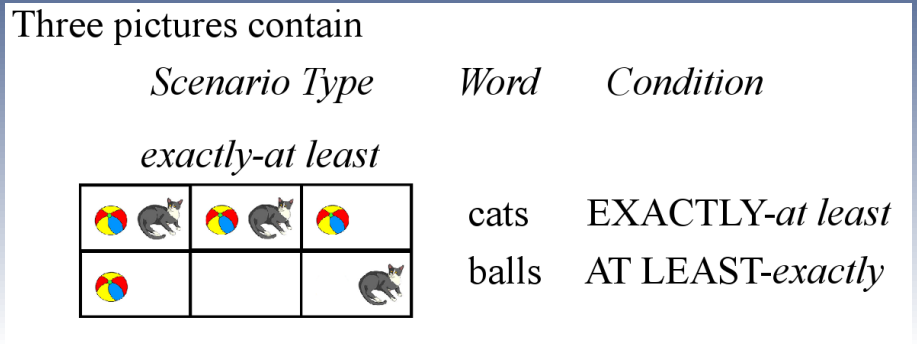
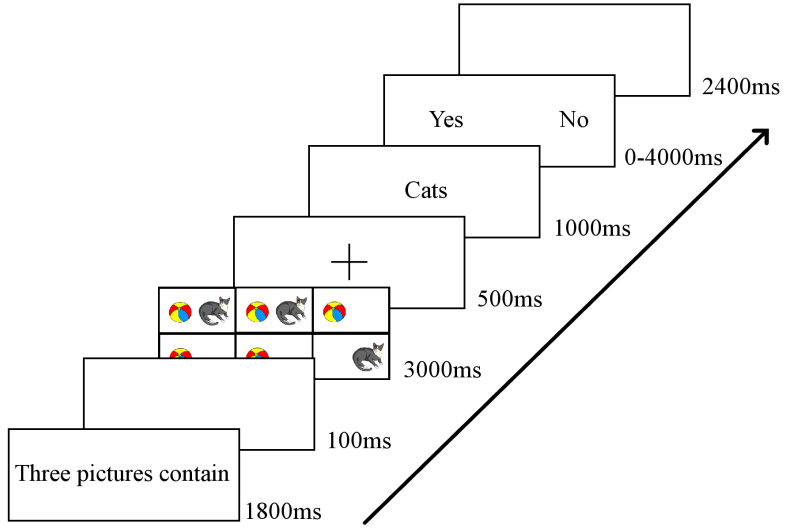
Figure: Six conditions as combinations of the numeral, scenario types and critical words.





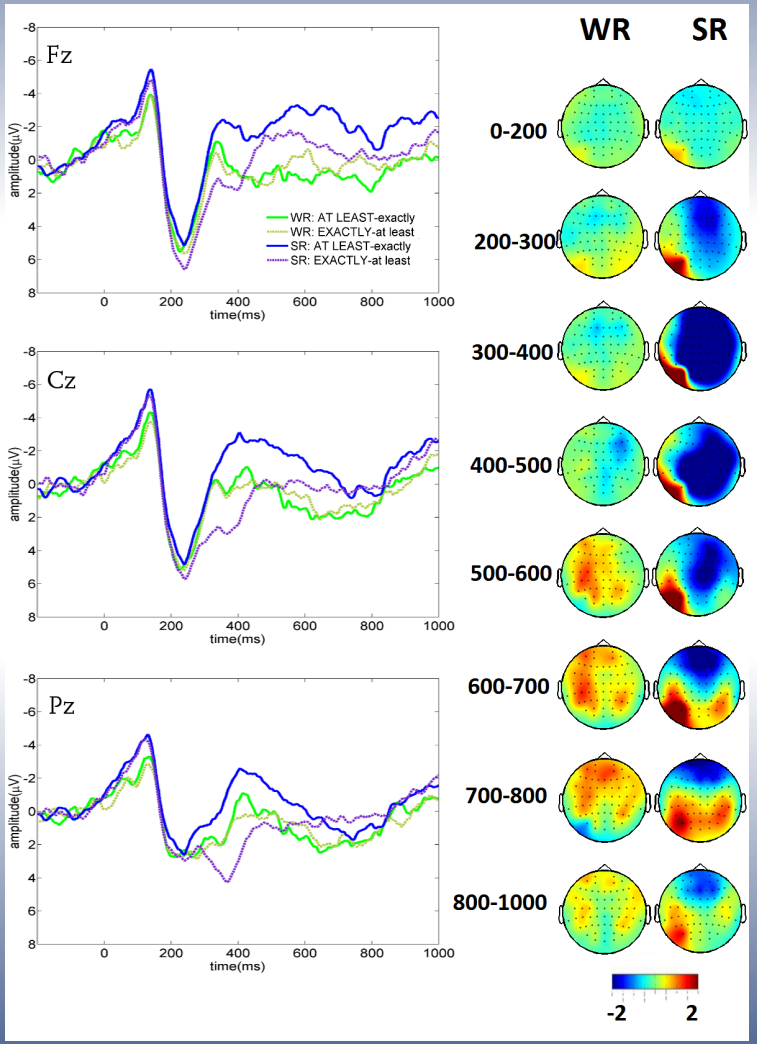


Divergent truth-value judgements regarding the **AT LEAST** condition:

Strong readers: $N = 30$, 66.7% consistently said "false" to the **AT LEAST** cases (the proportion of **exactly**: 88.46 – 100% in all **AT LEAST** trails).

Weak readers: ($N = 15$, 33.3%) consistently said "true" to the **AT LEAST** cases.

AT LEAST-exactly vs. EXACTLY-at least



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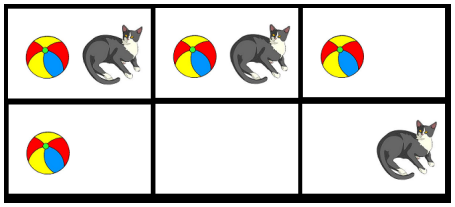
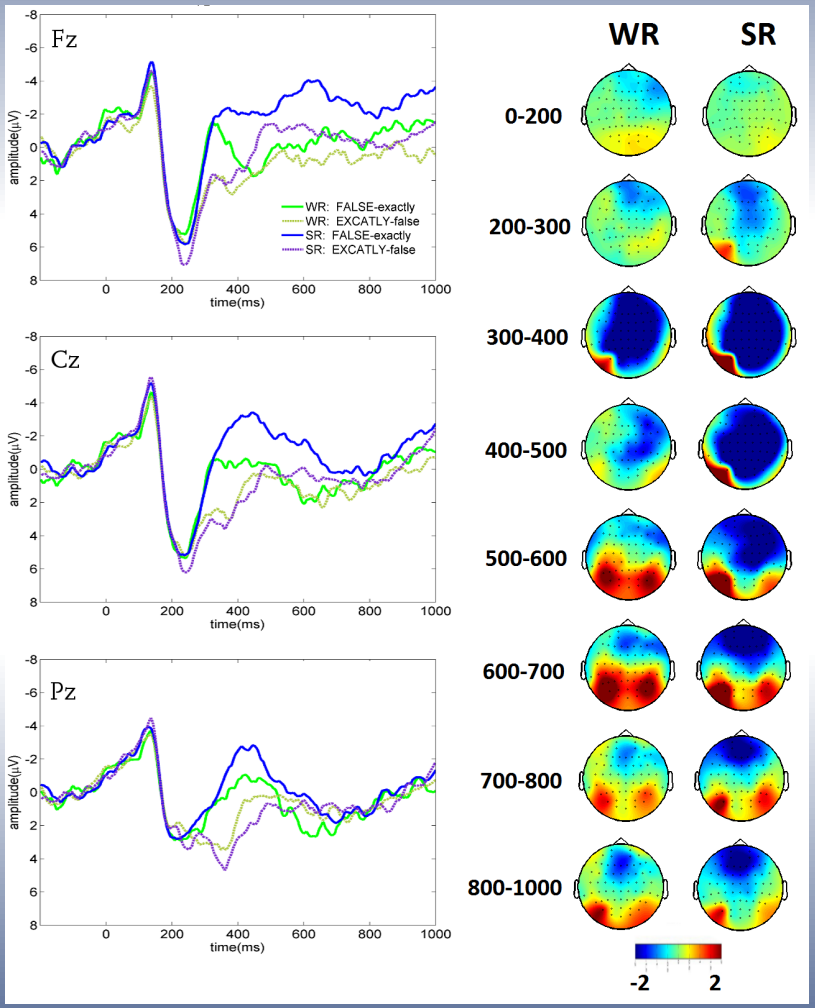


cats/balls.

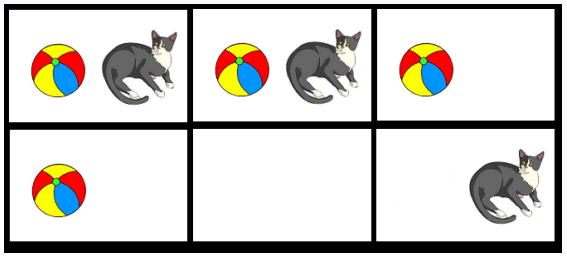
SR: $p < .0002$; N400, Sustained Anterior

WR: Not sig.

FALSE-exactly vs. EXACTLY-false



Four pictures contain...

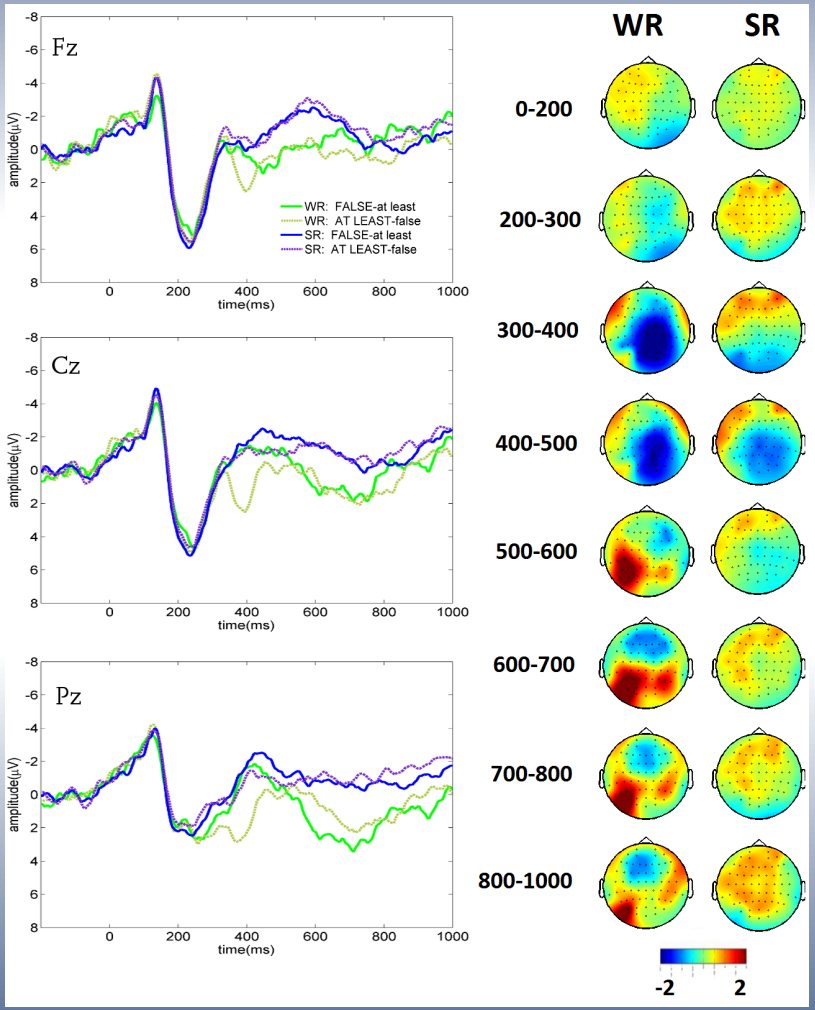


cats/balls.

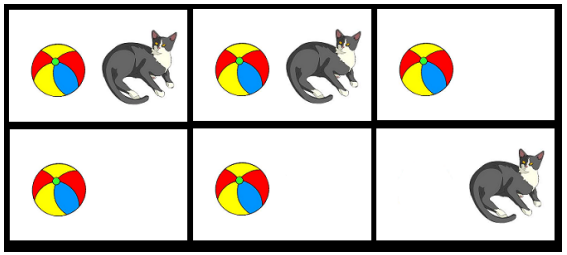
SR: $p < .0001$; N400, Sustained Anterior

WR: $p < .016$; N400

FALSE-at least vs. AT LEAST-false



Four pictures contain...



cats/balls.

SR: Not Sig.

WR: $p < .049$; N400

Highlight

- Both for **some** and for numerals:

  only those responders who applied the strengthened reading had more negative ERPs for the condition violating this reading relative to the unambiguously true case.

The role of speaker's epistemic state: work in progress

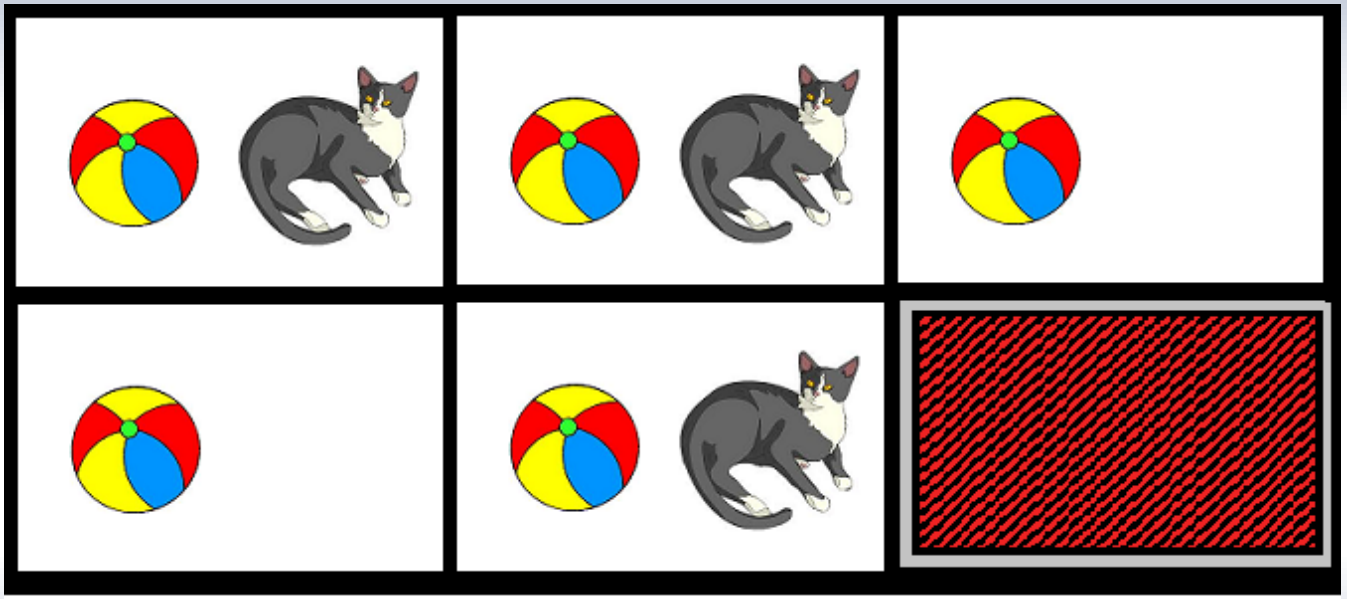
Some As are B

$\rightsquigarrow \neg B_s$ **(all As are B)**

$\rightsquigarrow B_s \neg$ **(all As are B)** (by assuming the competence)

- Question: Are SIs generated when the competence assumption is violated?
- Is the information about the speaker's knowledge incrementally processed by the listener?
- Addressed by manipulating linguistic context by [Bergen and Grodner, 2012] and a sentence-picture paradigm by [Dieuleveut et al., 2016]

Partial information



Some pictures contain (cats/balls).

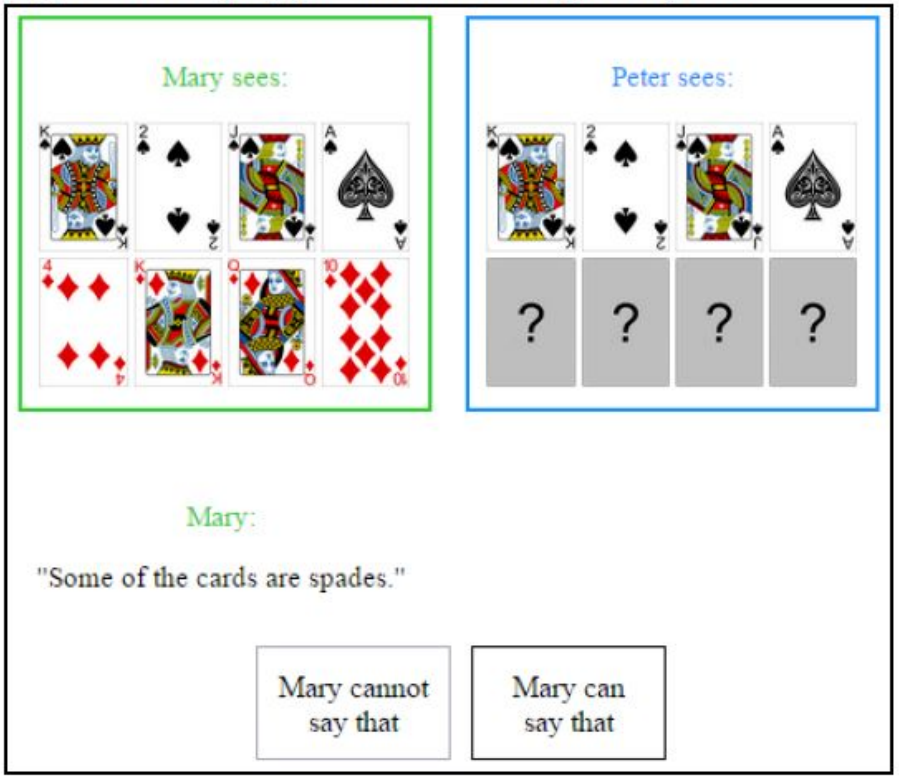
Is it required from the speaker to know whether **all**, to utter **some**?

- Gricean view: No!
- “lexical” view: Yes? (“strong pragmatic reading”)

Do strong implicatures exist?

See [Dieuleveut et al., 2016] (online manuscript), which attempts to address this issue in an online questionnaire using a sentence-picture verification task, and where a significant proportion of strong implicature readings is observed.

Figure 1. Display presented to the participants.



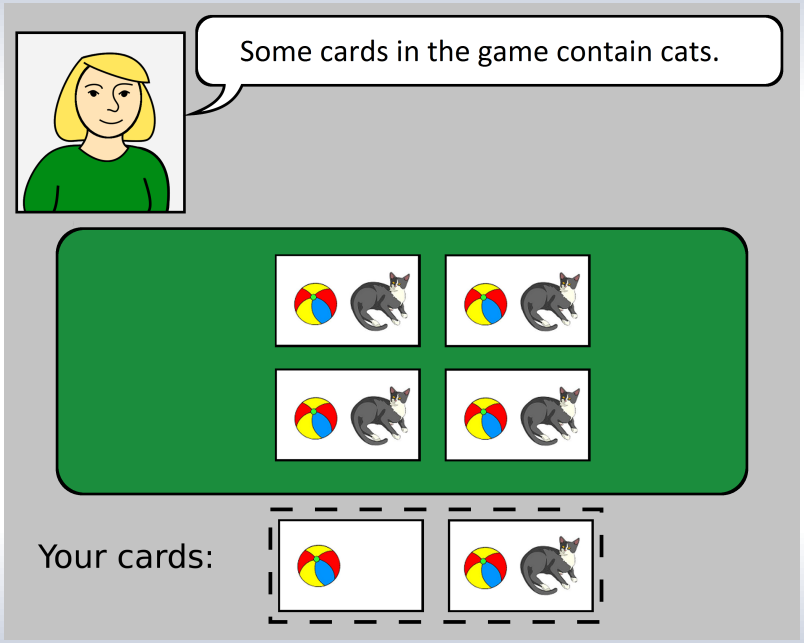
Speaker's perspective & processing quantity implicatures

- Director's task
- [Breheny et al., 2013]: "ad hoc" implicatures:

  The woman put a spoon into box A. $\rightsquigarrow$ The woman put nothing else into box A.

  - Eyetracking experiment in an interactive paradigm where both the participant (listener) and a speaker (confederate) observe an agent moving objects to two boxes
  - Knowledge (both parties saw all the agent's activities) vs. Ignorance condition (the speaker did not see the last activity)
  - The listeners contextually specific implicature in on-line comprehension while being sensitive to the **epistemic state of the speaker**.

Epistemic step in SI processing

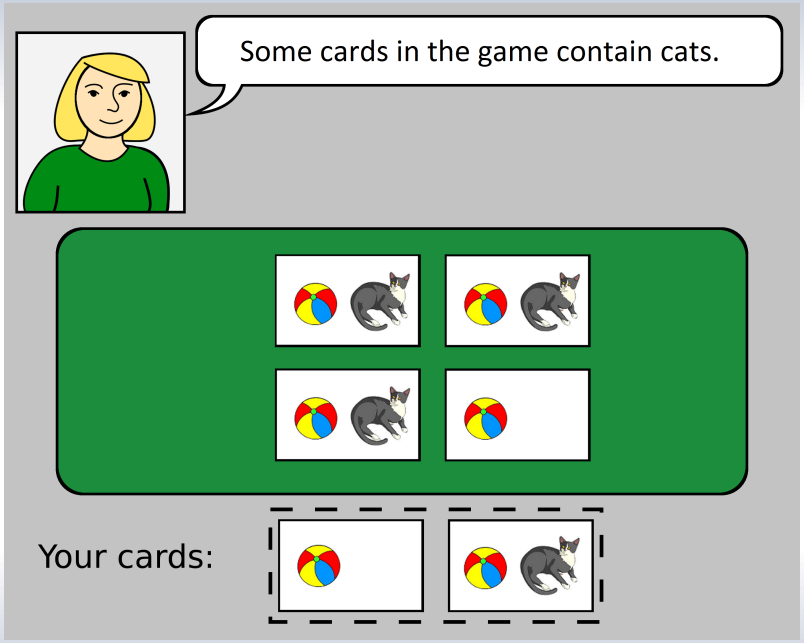


Compare:
Some cards in the game contain...

- *cats* (the listener **knows** that the sentence is **felicitous**)
- *balls* (the listener **knows** that the sentence is **infelicitous**)

No difference from the perspective of the **speaker**, who is **ignorant** with respect to whether or not the implicature is satisfied!

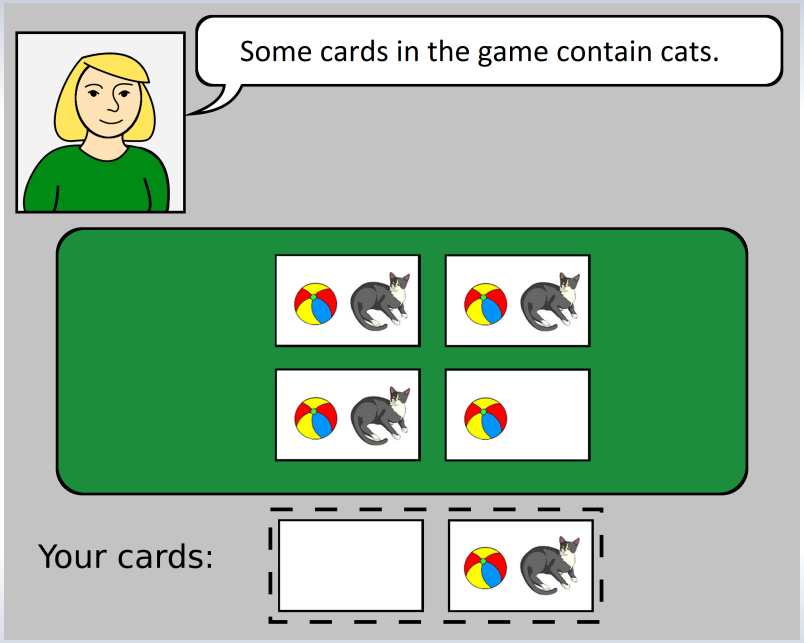
Epistemic step in SI processing



Compare:
Some cards in the game contain...

- *cats* (the listener **and speaker know** that the sentence is **felicitous**)
- *balls* (the listener **knows** that the sentence is **infelicitous**)

Epistemic step in SI processing



Compare:
Some cards in the game contain...

- *cats* (the listener **and speaker know** that the sentence is **felicitous**)
- *balls* (the listener **knows** that the sentence is **felicitous**)

Establishing the basis

- The planned experiment involves both: case when the speaker has partial information about the context model AND the listener has a privileged access to the context model

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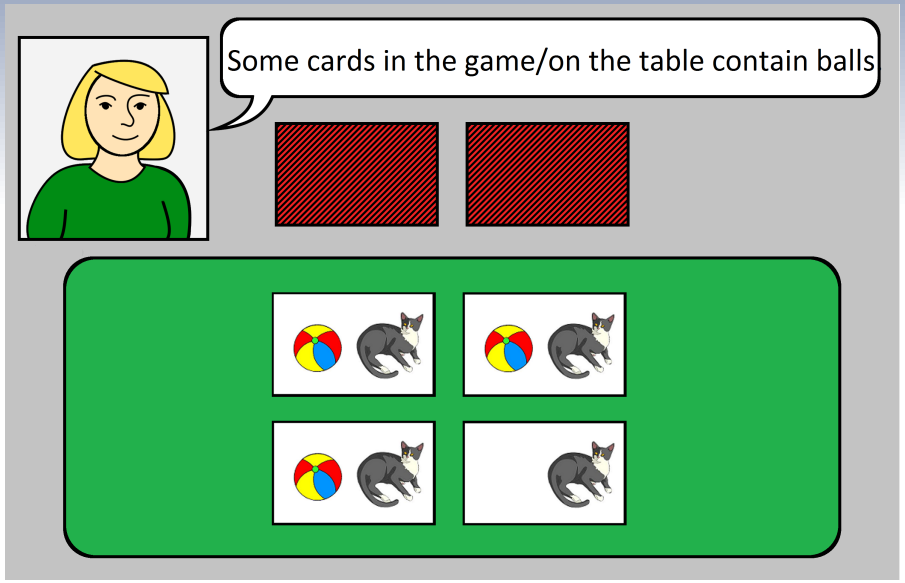
Establishing the basis

- The planned experiment involves both: case when the speaker has partial information about the context model AND the listener has a privileged access to the context model
- Yet, so far little is know about the first issue!
- Intermediate step: test how weak scalars are processed in the context of partial information

  (part of the short-term collaboration project with Schumacher, Werning, Vogeley; master student: Ludmila Reimer)

SIs in the context of full and partial information



Some cards (in the game/on the table) contain...

situation	place	Noun		
		cats	**balls**	**dogs**
Partial Inf	**in the game**	**Game-Underinformative** Unknown infelicitous Yes/No	**Game-Informative** Known felicitous Yes	**Game-False** Unknown false No
Full Inf	**on the table**	**Table-Underinformative** Known infelicitous Yes/No	**Table-informative** Known felicitous Yes	**Table-False** Known false No

spiel

Behavioral data

- Task: Is the utterance **appropriate** (given what the speaker knows)?
- **Tested:** 36 participants; 11 responded pragmatically (consistently) in condition **Table-Underinformative**

  3 pragmatic responders had to be excluded: 2 were confused about condition **Game-False** and responded incorrectly; 1 responded pragmatically in condition Game-Underinformative, but the experiment was not finished due to technical errors.
- **Final analysis:** 8 pragmatists plus 25 logicians.
- High accuracy in all conditions.

Reaction times

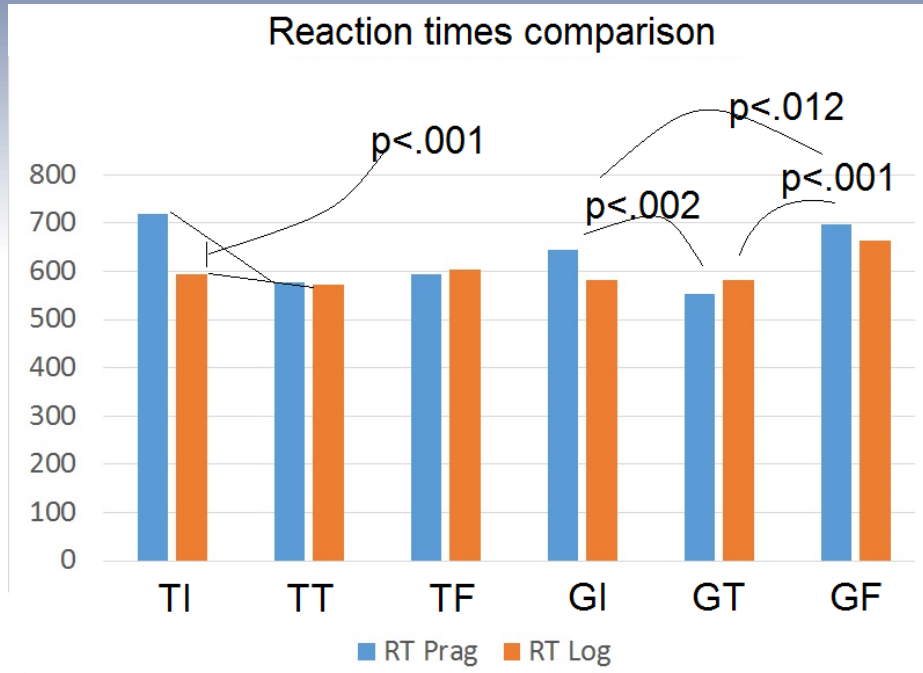
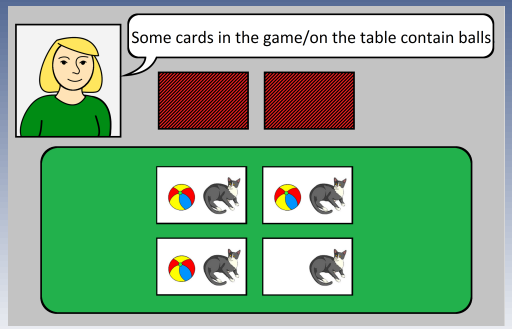


Table
Truth: F(2,62)=20.63, p<.001
Truth*Group: F(2,62)=16.79, p<.001
Group: not sig.
Pragm(TI-TT) > Log(TI-TT):
F(1,31)=26.77, p<.001

Game
Truth: F(2,62)=15.14,p<.001
Truth*Group: not sig.
Group: not sig.

Full-factorial ANOVA: Truth (true/infelicitous/false): $F(2, 62) = 15.13$, $p < .001$;
Place (table/game): not sig.;
Group (pragmatic vs. logical response): not sig.;
Truth*Group: $F(2, 62) = 7.83$,$p = .001$; Truth*Place: $F(2, 62) = 19.51$,$p < .001$;

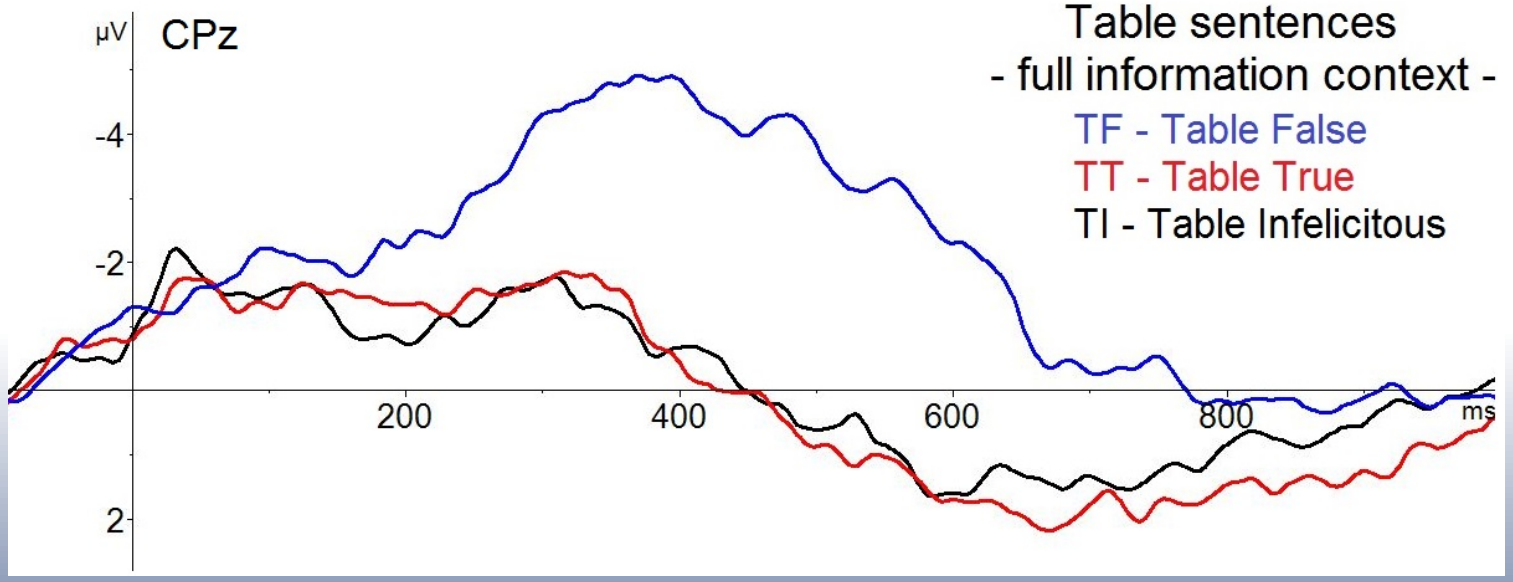
Truth*Place*Group: $F(2, 62) = 3.85$, $p < .027$.

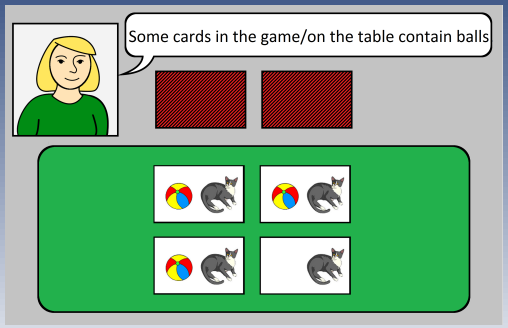


Some cards on the table contain dogs/ cats/ balls

Table-False vs. **Table-True**: $p < .0001$;
Table-False vs. **Table-Infelicitous**: $p < .0001$;

Table-True vs. **Table-Infelicitous**: not sig! (no difference between pragmatists and logicians, also in other comparisons!)

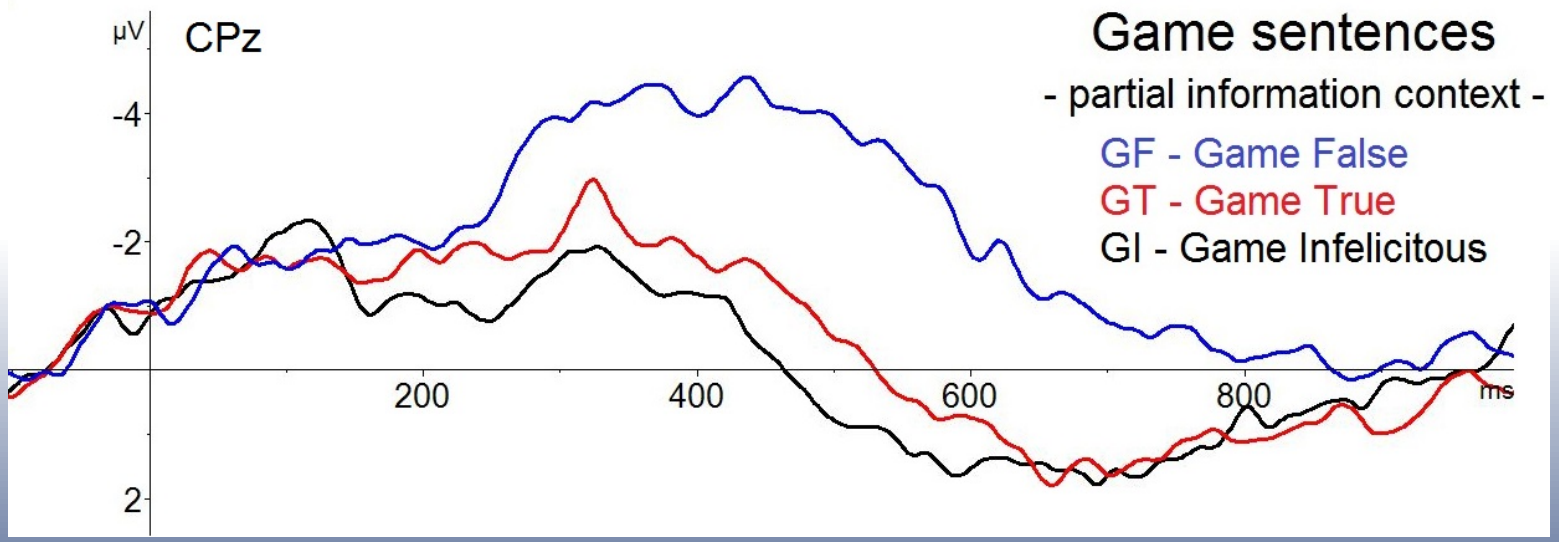


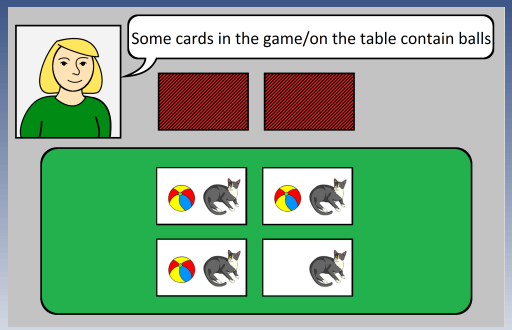


Some cards in the game contain

dogs/ balls/ cats

Game-False vs. **Game-True**: $p < .0001$; **Game False** vs. **Game-Infelicitous**: $p < .0001$; **Game-True** vs. **Game-Infelicitous**: a significant negativity effect! $p < .01$, cluster extension $438 - 526ms$.

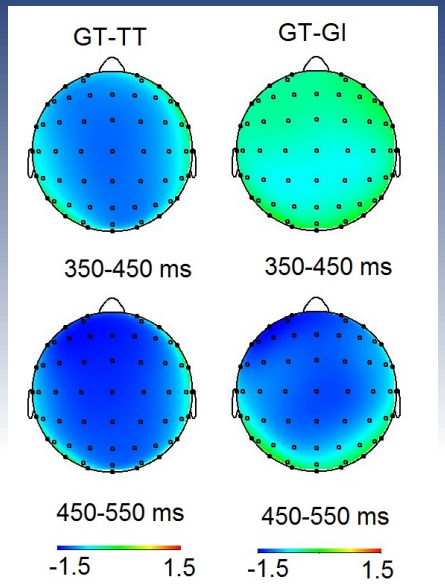


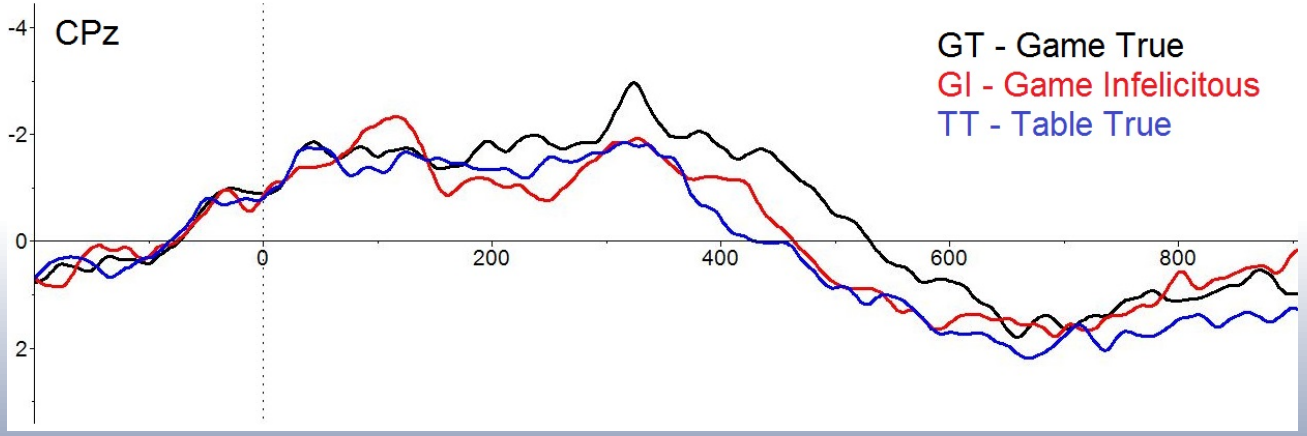


Some cards in the game contain balls

Some cards in the game contain cats

Some cards on the table contain balls





No significant differences between Game and Table counterpart conditions, except for **Game-True** showing more negative ERPs than **Table-True** ($p < .006$, cluster extension $372 - 538ms$)

Logicians vs. Pragmatists

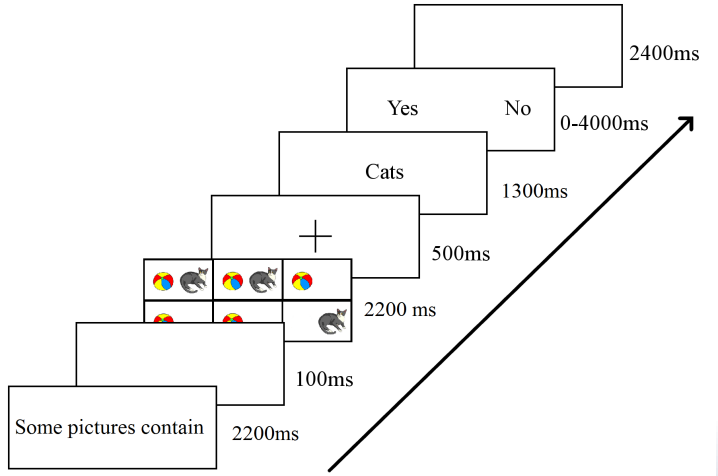
No significant differences in the size of the effects: difference curve comparison

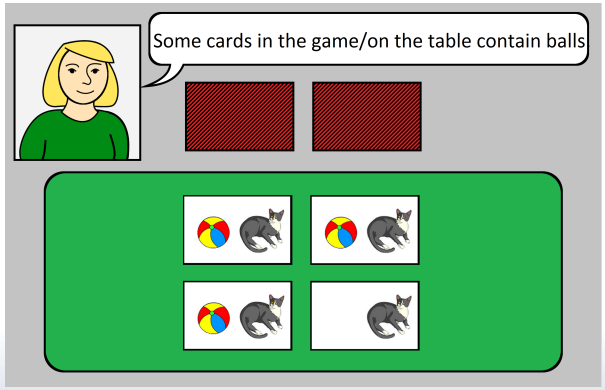
- No differences between the **underinformative** and **true** conditions in the full information context!
- No significant differences related to the “appropriateness” judgment.

- No differences between the **underinformative** and **true** conditions in the full information context!
- No significant differences related to the “appropriateness” judgment.
- Puzzle: why the true sentences in the partial information context (**game-true**) are more negative than the true sentences in full information context (**true-table**) or the potentially underinformative sentences (**game-underinformative**)?

Which factors play a role? I

- Auditory presentation of the stimuli ⇢ different time-course of the sentence presentation





↦ More time in the first set-up to make predictions regarding the upcoming noun

Which factors play a role? II

- proportion of alternative quantifiers

120 trials with “some” (40%)
120 trials with “all” (40%)
60 filler trails (20%): 24 with “no” (8%), 12 with “most” (4%), 24 with numerals (8%)

240 trials with “some” (57%): half “table”, half “game”
180 (43%) filler trails:

some	all	no	Fewer than 2/3	More than 2/3	(bare) 2/3
40	40	40	10/10	10/10	10/10

total:
66.6% trials with “some”
9.5% trials with “all”
9.5% trials with “no”
14.3% trials with modified or bare numerals

Which factors play a role? III

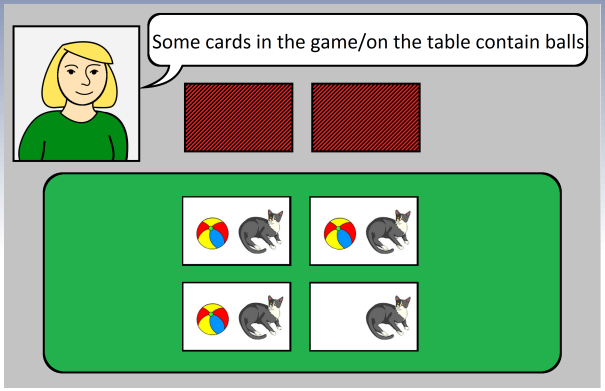
- Epistemic context, i.e. the violation of the speaker competence assumption

First Experiment:
No speaker; full information available

Current experiment:
Speaker involved;
Partial information: Half of the trials refer to the set of all cards, including the face-down cards

- No support of the scalar implicature
- “some” is the most optimal quantifier to apply to the case where the full information is not available
- The weak interpretation of “some” is endorsed
- As a result, even in the situation of full information the scalar implicature is not endorsed and even for (a minority of) participants who ultimately do adopt the implicature in their judgment, the implicature is not processed incrementally and occurs rather as a post-propositional inference.

Which factors play a role? IV



The use of underinformative expression “some cards in the game” is pragmatically more suitable when applied to the object category contained in all visible cards (completing a sentence whose pragmatic status is not determined), rather than to the object category contained by only a proper subset of visible cards. $\dashrightarrow$ for the latter there is a more informative expression available, i.e. “some cards on the table”!

Follow-up

- Test the relevance of the factors, especially the proportion of “all” vs. “some”; the role of partial information context (remove the Game trials and mirror the full information context experiment in the auditory stimuli setup)
- Conduct the study that manipulates the listener’s privileged information in a **virtual reality** setup (planned cooperation with Max Planck, Nijmegen, David Peeters)

Why virtual reality?

(from David Peeters)[Tromp et al., 2017]

Why virtual reality?

- Allows immersion in the experimental situation that closely resembles everyday communicative situation while retaining full experimental control over the stimuli
- Participants may communicate with virtual agents (the 3-D virtual agents can “speak” the sentences)
- 3-D scenario would make it possible to more realistic represent the situation where only part of the information is visible to the virtual agent whereas the listener has access to full information

The project goals

- Investigate implicatures in contexts of full and partial information:
  - Disjunctions (including ignorance inferences)
  - Conjunctions (temporal implicatures)
- Combine EEG and VR to test the role of perspective and information/epistemic state in the implicature processing in an ecologically-valid experimental situation



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Assistants: Theresa, Natalia, Alex, Adinah, Emma, Jennifer, Nina
Auditory stimuli recording: Lena & Janina

Thank you!

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Differences with the case of “some”

- Different proportion of weak and strong readers.
- Different type of the observed negativity, i.e. Sustained Negativity instead of the standard N400.
  - referential ambiguity [Van Berkum et al., 2003, Van Berkum et al., 1999, Van Berkum et al., 2007]
  - recomputation of a discourse model [Münte et al., 1998, Baggio et al., 2008, Baggio et al., 2010].
  - linked to working memory processes [Van Berkum et al., 1999, Van Berkum et al., 2003, Münte et al., 1998]
  - inference revision (defeasible reasoning task) [Pijnacker et al., 2010]; for ambiguous assignment of referent set in the case of pragmatically infelicitous quantifiers [Politzer-Ahles et al., 2012]

Further differences between numerals and some

In an fMRI study, [Shetreet et al., 2014a] showed that a subregion of the left inferior frontal gyrus, which previously had been consistently linked to semantic processing, was involved in the generation of scalar implicatures.(Partially supported by [Politzer-Ahles and Gwilliams, 2015].)
But: the processing of numerals was associated with partially non-overlapping regions than the processing of “some” [Shetreet et al., 2014b].

Conclusions

1. We show that for numerals and for “some” the two alternative readings led to quantitatively different ERP patterns reflecting presumably different cognitive processes they engage.
2. For quantifiers that allow alternative readings: the reading chosen by the comprehender is incrementally interpreted during online sentence processing and determines the lexical prediction for words consistent with this reading in a given context.

Filler details

Note on fillers: ca. 50% of fillers had the two hidden cards, 25% had no extra cards, and 25% had two additional open cards; variance with respect to the number of object types (1, 2 or 3); haf/half Table- and Game-sentences;
Appropriateness judgment: Target trials: 1/3, i.e. 80 inappropriate (false or unknown);
1/3, i.e. 80 visibly true $\mapsto$ appropriate;
1/3 ambiguous, including half (40) based on the strong pragmatic interpretation and half (40) based on the weak interpretation
Filler trials: ca. 57% (102) inappropriate (78 visibly false plus 24 unknown)
36% (65) appropriate (unambiguously true)

7% (13) ambiguously appropriate, i.e. logically true, but inappropriate for the pragmatists

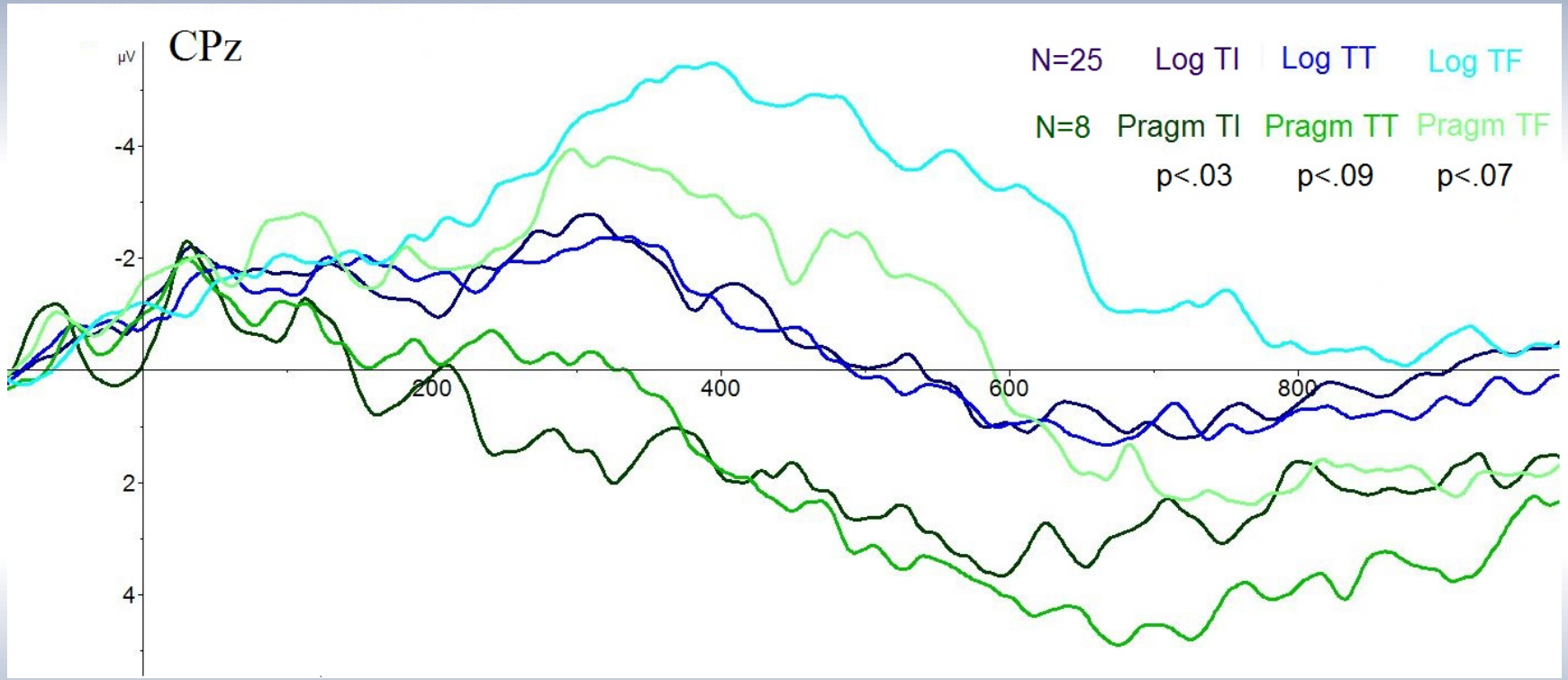
(including both cases with "some" (9: 4 under strong interpretation and 5 under weak)) and

numerals (4: 3 weak and 1 strong implicature)
Overall:
43.3% inappropriate
34.5% appropriate
10.7% (45) that would be considered inappropriate only based on the strong pragmatic interpretation (but almost everyone judged it as appropriate)
11.4% (48) inappropriate for weak pragmatists

This gives 43% inappropriate vs. 57% appropriate divide for "logicians" and 55%

inappropriate vs. 45% appropriate for "pragmatists".

Predictability modulates the ERPs: between-group conditions comparison



No sig difference for Game-sentences (the same number of truth-makers for both groups!)