Adjectives of comparison (AOCs) and their readings

Languages have lexical means to compare two elements and express identity, difference or similarity between them.

English uses adjectives of comparison (AOCs) like *same*, *different* and *similar* for this purpose.

AOCs can have two readings:

- sentence external readings: compare an element in the current sentence and an element mentioned in a previous sentence

  (1) a. Arnold saw *Waltz with Bashir*.
      b. Heloise saw the *same* movie.

- sentence internal readings: the comparison is internal to the sentence in which the AOC occurs without any reference to a previously introduced element

  (2) \{ All the students, Each student, Every student, The students \} saw the *same* movie.

Sentence-internal readings must be licensed by a semantically plural element (but not necessarily morphologically plural; Carlson 1987).

- replace the semantically plural subjects in (2) with a proper name and the only available reading is the sentence external one

  (3) #Sue saw the same movie.

Further restrictions on licensing sentence internal readings

Further restrictions on licensing sentence internal readings and differences between AOCs wrt these restrictions (Carlson 1987, Moltmann 1992, Beck 2000, Dotlačil 2010, Brasoveanu 2011 a.o.):

- any semantically plural element can license sentence internal *same*
- but the conditions for licensing sentence internal *different* are much more stringent

  (4) \{ ?All the students, Each student, Every student, #The students \} saw a *different* movie.

The generalizations about *different*: based on native speakers’ acceptability intuitions.
(informally or systematically collected, e.g., Brasoveanu and Dotlačil 2012 report an acceptability judgment study)
Our main goals today

Finer-grained experimental methodologies might show that licensing sentence internal *same* is just as complex as *different*.

- the questionnaire study in Brasoveanu and Dotlačil (2012) already provides an indication that distributive quantifiers are somewhat dispreferred with *same*

Today: examine the incremental processing of *same* using self-paced reading. We investigate if:

1. there are any differences between licensors and if there are, at which point they occur
2. the licensing of sentence internal *same* depends on its structural position, i.e., scope, relative to the licensor (Brasoveanu and Dotlačil 2012 consider only surface-scope, i.e., licensor $\succ$ *same*, configurations)

More precisely, we investigate how *same* is processed:

i. with four of its licensors:
   - **ALL** universal quantifiers like *all the students*
   - **EACH** distributive quantifiers like *each student*
   - **EVERY** distributive quantifiers like *every student*
   - **THE** plural definites like *the students*

ii. in two scopes:
   - **SS** SURFACE-SCOPE – see (2) above
   - **IS** INVERSE-SCOPE – see (5) below

(5) The *same* student saw $\{\text{all the movies} \mid \text{each movie} \mid \text{every movie} \mid \text{the movies}\}$.

Preview of the experiments and the main results

Exp. 1: self-paced reading study with the 8 conditions (4 licensors $\times$ 2 orders) investigated in context after the presentation of a background scenario relative to which the target sentence was either true or false

Exp. 2: self-paced reading study in which the same target sentences were presented out of context

Two main results:

1. No across-the-board effect of inverse scope:
   - when licensors occur lower than *same*, they need to take inverse scope to license it, but this does not lead to increased reading times
   - new argument for processing theories of inverse scope that do not assign any inherent cost to covert syntactic and/or semantic operations needed for inverse scope

2. Differences between licensors, but only in Exp. 1:
   - Exp. 1 (in-context) shows that **EACH** and **THE** are slower than **ALL** and **EVERY** in **IS**, but not in **SS**
   - that is, **EACH**/**THE** are slower than **ALL**/**EVERY** only when they need to license *same*
   - the differences between **EACH**/**THE** and **ALL**/**EVERY** disappear in Exp. 2 (out-of-context)
   - participants don’t interpret *same* deeply enough in out-of-context tasks to really enforce the licensing requirement associated with its sentence internal reading (participants paid attention to the task: most of them correctly answered the majority of comprehension questions)
   - investigating deep interpretive effects of the kind formal semanticists care about, i.e., that mainly arise as a consequence of semantic composition, require fairly rich and explicit contexts to manifest themselves behaviorally
Road map for the talk

I. Why is the processing of same relevant to the semantics of distributive quantifiers and scope?

II. Introduce the first (in-context) self-paced reading experiment and the resulting generalizations.

III. Introduce the second (out-of-context) self-paced reading experiment and brief comparison with Exp. 1.

IV. Propose an account of the generalizations extracted from the two experiments.
   • the results suggest that the processing of AOC licensing and scope happens in two stages, similar to the way interpretation unfolds in Discourse Representation Theory
   • a shallower level of meaning processing that is parallel to constructing a DRS for the current sentence / discourse
   • a deeper level of meaning processing that corresponds to linking this DRS to a real-world background situation, i.e., to constructing an embedding function (partial variable assignment) that verifies the DRS, i.e., links it to the actual, ‘real-world’ model

Explaining the cost of inverse scope

(6) A boy climbed every tree.
   • IS (every tree is s.t. a boy, possibly different for different trees, climbed it) is the less likely interpretation (Ioup 1975, AnderBois et al. 2012 a.o.)
   • . . . where processing difficulty is signaled/measured by increased reading times (RTs)
   • SS (a single boy is s.t. he climbed every tree) is the most salient and easiest interpretation (Anderson 2004).

Two ways to explain this observation:
   a. covert scope operations
   b. changes to discourse model structure

a. Inverse scope via covert operations

• IS requires an extra operation (Tunstall 1998, Anderson 2004, Reinhart 2006 a.o.) to derive the requisite logical form/semantic representation
• we can say that the quantified object has to undergo an extra quantifier raising (QR) in the inverse-scope reading – see, e.g., trees on next slide, following Fox (2000)
• another version appeals to type-shifting instead of QR: an optional type-shifter has to be inserted to derive inverse scope readings (Hendriks 1993)
• either way, an extra operation is needed for IS relative to SS

a. Inverse scope via covert operations
b. Inverse scope via model revision

- alternatively, explain IS processing difficulties in terms of changes to the discourse model structure
- IS is harder because it requires revising the already built discourse model structure (Fodor 1982; see also Crain and Steedman 1985, Altmann and Steedman 1988)

To see this, consider how (6) is interpreted in real time:

→ we first hear/read *A boy climbed...*
  - we add a new entity to our discourse model that is a boy and that stands in the climbing relation to whatever direct object we are about to interpret
→ then we hear/read the direct object . . . *every tree*
  - if we want the direct object quantifier to take wide scope, we need to revise the current discourse structure
  - we need to introduce a set of boys, each of which is associated with a possibly distinct tree

Predictions of the two theories of IS difficulty

The AOG same on its sentence internal reading enables us to distinguish between these two approaches:

- sentence internal *same* has to be in the scope of a semantically plural noun phrase (Carlson 1987)
- but because of its meaning, no model-structure revision is necessary when a quantifier takes IS over it

(7) The same student saw every movie.

- *every movie* scopes and distributes over *same* to license its sentence internal reading
- but the model doesn’t need to be revised: it contains one student both before and after *every movie* is processed
  ▶ if covert scope operations are costly:
    IS needed to license *same* ⇒ processing difficulties
  ▶ if model revision is costly:
    IS needed to license *same* ⇒ processing difficulties

Exp. 1: Method

A self-paced reading task (Just et al. 1982) testing how easy it is to process sentence internal *same*:

- with 4 licensors: ALL, EACH, EVERY and THE
- in 2 scopes: SURFACE-SCOPE (quantifier precedes *same*) and INVERSE-SCOPE (*same* precedes quantifier)
- for a total of 4 × 2 = 8 conditions
- each condition tested 4 times
  - 2 times in sentences most likely judged as true relative to the background scenarios
  - 2 times in sentences most likely judged as false
  - for a total of 32 items
To prepare for fieldwork, three researchers – a botanist, a linguist and an anthropologist – had to learn one of two languages spoken in the eastern Indonesian islands – Bahasa Indonesia or Ternate. The botanist learned Bahasa Indonesia, the linguist learned Bahasa Indonesia and the anthropologist learned Bahasa Indonesia too.

I think that each researcher learned the same language spoken in the eastern Indonesian islands.

Am I right to think that?

To prepare for fieldwork, two researchers – a botanist and an anthropologist – had to learn at least one out of three languages spoken in the eastern Indonesian islands – Bahasa Indonesia, Ternate or Tidore. The botanist learned Bahasa Indonesia, Ternate and Tidore. The anthropologist learned nothing and used the botanist as his guide and advisor.

I think that the same researcher learned each language spoken in the eastern Indonesian islands.

Am I right to think that?

scenarios consisted of
- 2 sets of entities, e.g., researchers and languages
- a relation between them, e.g., the 'learn' relation
true scenarios: all the members of one set of entities were related to only one member in the other set
false scenarios: one member of one set of entities was related to a different entity than the other two members
43 participants in the experiment, all of them UCSC undergraduate students
completed the experiment online on a UCSC installation of the IBEX platform (http://code.google.com/p/webspr/) for course (extra-)credit
32 items in the experiment (4 per condition); Latin square design
67 stimuli total (32 experimental items + 35 fillers), order randomized for every participant

4 outlier participants were excluded; they had 15% or more incorrect answers; final number of participants: 39
all responses ≤ 50 ms and ≥ 2000 ms removed; remaining observations log transformed to mitigate the right-skewness characteristic of RT data
factored out the influence of word length and word position by running a linear mixed-effects regression (Trueswell et al. 1994 a.o.); the regression had intercept-only random effects for subjects and two fixed effects: word length in characters and word position in the sentence
the resulting residualized log RTs used for all subsequent analyses
Exp. 1: Data analysis and resulting generalizations

The main regions of interest (ROIs):

• the 4 words immediately following *same/the quantificational licensor in object position*
• they are identical (modulo sg./pl. agreement) across all 8 conditions

(14) ... \{all the\}
\{each\}
\{every\}
\{the\}
researcher(s) learned the same **language**

spoken in the eastern Indonesian islands.

(15) ... the same researcher learned \{all the\}
\{each\}
\{every\}
\{the\}
**language(s)**

spoken in the eastern Indonesian islands.

Two other important ROIs: the 2 words immediately following the quantifiers when they occur early, i.e., in **ss** order.

(16) ... \{all the\}
\{each\}
\{every\}
\{the\}
**researcher(s) learned** the same **language** spoken in the eastern Indonesian islands.

• suppose we observe that **each** is slower than **every** when we examine the main/late ROIs (this will turn out to be true)
• this slowness could be due to:
  - the semantic combination of **same** and the licensors: **each** is a worse licensor of **same** than **every**
  - the fact that **each** is inherently more difficult to process than **every**
• we rule out the latter if there is no difference between **each** and **every** in the early ROIs (this will turn out to be true)

Exp. 1: Plot of all ROIs in Exp. 1 (in context) – ss only

Exp. 1 (in context): Surface scope

Mean RTs (in ms) and SEs

Regions

<table>
<thead>
<tr>
<th>quantifier</th>
<th>SS</th>
<th>IS</th>
</tr>
</thead>
<tbody>
<tr>
<td>all</td>
<td></td>
<td></td>
</tr>
<tr>
<td>each</td>
<td></td>
<td></td>
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<tr>
<td>every</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

We follow the x-axis labels in these plots from now on:

• refer to the two early ROIs (**researcher(s)** and **learned**) as Word 2 and Word 3
• refer to the four late/main ROIs (**language(s)**, **spoken**, **in** and **the**) as Word 5, Word 6, Word 7 and Word 8

Let’s take a look at the RT plots for all these 6 ROIs.

• the figures also plot the quantifier/ *same* in subject and object position for completeness
  (ignore them: quant.s/ *same* differ in many respects, frequency, quant. vs. anaphoric nature etc. – possible confounds)
• the other regions are identical in all respects (except for sg./pl. number in certain cases)
• no clear difference between SS and IS: no systematic upward shift associated with all the IS lines
• in addition to these six ROIs, we are interested in the RTs for full sentences – they have been argued to reveal the processing cost of IS (Anderson 2004).

We follow the x-axis labels in these plots from now on:

• refer to the two early ROIs (**researcher(s)** and **learned**) as Word 2 and Word 3
• refer to the four late/main ROIs (**language(s)**, **spoken**, **in** and **the**) as Word 5, Word 6, Word 7 and Word 8
Exp. 1: Generalizations 1 and 2
First generalization – no processing difficulty associated with INVERSE-SCOPE in any of the late (main) regions, i.e., Word 5 through Word 8:

(17) Generalization 1. INVERSE-SCOPE is not inherently slower / more difficult than SURFACE-SCOPE.

Second generalization – some of the licensors are slower/more difficult to process than others:

(18) Generalization 2. EACH and THE are slower/more difficult than EVERY and ALL in the object but not the subject regions.

• EACH/THE are not inherently more difficult to process than EVERY/ALL
• the increased difficulty is associated with their semantic combination with sentence internal same
Exp. 1: Additional but orthogonal observations

• this facilitation is orthogonal to our experimental manipulation
• when reading Word 2, readers had an extra word – the: all the researchers / languages – during which they were able to process the meaning of preceding quantifier ALL
• in the case of EACH, EVERY and THE, Word 2 immediately follows the quantifier
• the facilitation we observe with ALL in Word 5 might be due to the fact that ALL is an even better licensor of sentence internal same than EVERY
• but it might simply be due to the fact that by the time readers reached Word 5, they had an extra word (the) to process ALL, just as in the case of Word 2

Exp. 1: RTs for full sentences

• again, the interaction of quantifier and order does not significantly improve the data fit
• the results reinforce Generalizations 1 and 2: IS and SS seem to be indistinguishable, and EACH/THE are numerically slower than ALL/EVERY

Exp. 1: Answer times – data analysis

• finally, we analyze the answer times and the pattern of (in)correct answers
• we examine the (log transformed) data of the same 39 participants (answer times ≤ 50 ms or ≥ 10000 ms were trimmed)
• the best (minimal deviance) model with maximal random-effect structure that converged:
  • main effects for quantifier type and scope and no interaction between them (same as for RTs)
  • a main effect for (IN)CORRECT answers, and two-way interactions between (IN)CORRECT answers and quantifier type, as well as (IN)CORRECT answers and scope
• answer correctness is a significant predictor of answer time, based on an LR test comparing the above model and a model with identical random-effect structure but with answer correctness dropped as a fixed effect ($p = 0.01, \chi^2 = 14.46, df = 5$)

Exp. 1: Answer times – generalizations

• we see that INCORRECT answers take longer than CORRECT ones
• as expected: lack of certainty about the answer should translate in extra processing time
• the processing difficulty associated with THE (but not EACH) is visible this late in the processing of the sentence and background scenario – when the given answer is CORRECT
• when the given answer is INCORRECT, we actually notice a significant speed-up for THE relative to the other quantifiers
• this speed-up might be due to the fact that THE is much worse/harder than the other quantifiers, and participants simply give up processing the stimuli occurring in this condition
Exp. 1: Estimated answer times

- IS seems to be slightly more difficult than SS, but the difference does not reach significance (95% CI includes 0).
- This very late point in processing is the first time we see any indication that IS might incur a processing cost.
- The effect of IS becomes clearer if we examine the pattern of (IN)CORRECT answers.
- Response variable (answer correctness) is binary categorical, so mixed-effects logistic regression.
- Random-effect structure: the same as for the answer-time model.
- Once again, the best model is the one without interactions.
- IS has a sizeable effect that is very highly significant.

Exp. 1: Answer times and answer accuracy

- IS significantly reduces the probability of giving a CORRECT answer relative to SS.
- Important consequence: the effect on answer times associated with INCORRECT answers might be partly due to IS.
- That is, the uncertainty associated with INCORRECT answers causes participants to answer more slowly . . .
- . . . but part of that uncertainty might be due to the increased processing load associated with IS.
Interim summary

- we examined three distinct points in the processing of quantifiers, scope and the licensing of sentence internal same
- early regions: Word 2 and Word 3; of the four quantificational licensors we considered, EACH, EVERY and THE do not exhibit inherent processing differences; ALL faster in SS due to an extra word/extra time to process ALL before Word 2
- late regions: Word 5 through Word 8; no effect of IS (Generalization 1); effect of quantifier type: EACH/THE more difficult than EVERY/ALL (Generalization 2)
- quantifier effects in late but not early regions \( \Rightarrow \) EACH/THE are not more difficult on their own; processing difficulties are due to the semantic combination of quantificational licensors and same
- additional evidence for this hypothesis: Exp. 2, sentences out of context; late-region effects disappear

Exp. 2: Method

- method, materials and procedure very similar to Exp. 1
- same experimental manipulation (4 quantifiers \( \times \) 2 orders) and same 32 target sentences
- main difference: sentences were read out of context
- 62 participants, Latin square design, 135 stimuli (32 experimental items + 103 fillers), order randomized for every participant
- some of the experimental items and fillers were followed by yes/no comprehension questions; total number of comprehension questions: 61, 16 of which for exp. items
- 8 outlier participants excluded b/c of low answer accuracy (\( \geq 17\% \) incorrect); final number of participants: 54
- all responses \( \leq 50 \text{ ms} \) and \( \geq 2000 \text{ ms} \) removed, remaining observations log transformed, log RTs residualized wrt word length and position (int. ran.ef.s by subj.) as in Exp. 1

Interim summary

- third and final processing stage: answer times and answer accuracy
- effect of THE visible in both: increased answer latencies and diminished answer accuracy
- highly significant effect of IS on answer accuracy: IS reduced the probability of giving a CORRECT answer for all quantifier types
- importantly, we also observed a significant effect of giving an INCORRECT answer: INCORRECT answers take longer than CORRECT answers
- this is expected: higher uncertainty about the answer causes lengthier decision times
- part of that uncertainty might be due to the increased processing load associated with IS (Generalization 3)
Exp. 2: Data analysis and generalizations

- again, no difference between SS and IS
- overall upward shift associated with both scopes in Exp. 2 relative to Exp. 1; as expected: no context in Exp. 2, so the words in the target sentence were less predictable
- just as for Exp. 1, we analyze the words/ROIs with linear mixed-effects regression models
- same fixed effects, maximal random-effect structure that converges (backward selection), select maximal random-effect structure model with lowest deviance
- no interaction of quantifier and order, main-effects-only models are the best according to LR tests; adding interactions did not reduce deviance significantly except in 2 regions, Word 2 ($p = 0.01, \chi^2 = 11.2, df = 3$) and Word 5 ($p = 0.04, \chi^2 = 8.16, df = 3$)
- we’ll return to this shortly

Exp. 2: Data analysis and generalizations

- most important observation: the effects of EACH and THE we observed in Exp. 1 in Word 6 and Word 8 are gone (null effects for full sentence RTs also)
- indicates that readers do not process same deep enough to (fully) trigger its requirement that the sentence internal reading needs to be licensed by an appropriate quantificational NP
- recall that we had a fairly large number of participants (54) whose accuracy on comprehension questions was high ($\leq 17\%$ incorrect answers); participants paid attention to the task and read for comprehension
- the phenomenon of properly licensing sentence internal readings of same is a crucially compositional phenomenon
- it requires the non-local combination / integration of the semantic representations contributed by both anaphoric same and the quantificational licensors
Exp. 2: Data analysis and generalizations
• let’s return to the fact that the interaction models are better than the main-effects models in Word 2 and Word 5 and that there is a significant effect of IS in Word 7
• start with the data summary for Word 2

Exp. 2: Data analysis and generalizations
• the interaction model is better for the Word 2 region primarily because EVERY takes significantly more time in SURFACE-SCOPE than ALL and EACH
• we observe the same effect for THE, but this is less surprising given the anaphoric nature of the definite article
• we observe this effect in an early region, which indicates that it is inherent to EVERY and unrelated to our experimental manipulation
• no explanation for this except to suggest that it might be due to the fact that inadvertently, a higher number of fillers and associated comprehension questions featured EVERY
• this might have prompted participants to flag this particular quantifier and pay more attention to the regions immediately following it

Accounting for the generalizations & summary

Generalization 2: EACH/THE are more difficult than EVERY/ALL in the late but not the early regions.
Account: readers process the sentence internal requirement and look for a semantically-plural NP to license it, but not all licensors are born equal (Brasoveanu and Dotlačil 2012 a.o.).
Accounting for the generalizations & summary

• EACH: requires event differentiation in its scope (Tunstall 1998) – every object in the restrictor set of each needs to be associated with its own subevent, and the subevent should be clearly distinguishable from the other subevents
• distinguishing subevents: assume they occurred at different time points or different locations . . .
• . . . or if other entities appear in the subevents, it’s enough if these entities differ from each other
• this explains why we have a very strong preference for associating different researchers with different languages in (20) (Anderson 2004, Roeper et al. 2011)

(20) Each researcher learned a language.

Accounting for the generalizations & summary

• event differentiation explains why each is a dispreferred licensor of sentence internal same
• licensing same, e.g., in (21), goes against the default tendency to establish event differentiation in terms of a direct object with varying dependent reference
• event differentiation can still be satisfied in (21), but requires an extra inference not explicitly supplied by the sentence or the background scenario
• e.g., each researcher is associated with a subevent that took place at a time point/location different from the time points/locations of the other subevents

(21) Each researcher learned the same language.

Accounting for the generalizations & summary

• how about the slowdown associated with THE? Brasoveanu and Dotlačil (2012) does not predict it – no significant difference between ALL and THE even though there is a numerical tendency
• indicates that an on-line/real-time task can make subtler distinctions than an off-line (acceptability judgement) task
• THE has many readings – collective, cumulative and distributive – and they are not equally acceptable/accessible
• THE prefers a collective interpretation over a distributive one (Dotlačil 2010, Pagliarini et al. 2012), but collective readings don’t license sentence internal same:

(22) The students elected {Harry / # the same representative}.

• the incompatibility of collective readings and sentence internal same forces the dispreferred, distributive interpretation of the
• this is available for Exp. 1 sentences (unlike (22) above) but costly ⇒ higher latencies during reading

Accounting for the generalizations & summary

Generalization 1: IS is not inherently slower/more difficult than SS in the self-paced reading part of the task.
Generalization 3: strong, diminishing effect of INVERSE-SCOPE on the probability of giving a CORRECT answer; this effect might be part of the reason INCORRECT answers take significantly longer than CORRECT ones.

• support for a model-structure account of the cost of inverse scope (Fodor 1982) rather than an LF-operations account (QR/type-shifting, Anderson 2004)
• we see no difference in RTs between IS and SS: suggests no processing cost associated with covert scoping operations
• expected if processing cost is due to model-structure revision: no revision takes place in our experimental items
• alternative explanation: AOCs somehow do not cause processing difficulties when requiring inverse scope . . .
• . . . but different leads to slowdown in IS conditions (Anderson 2004)
Accounting for the generalizations & summary

- the model-structure revision hypothesis predicts that \textit{same} is less difficult than \textit{different: different}, but not \textit{same}, leads to revision when its licensors take IS
- yet another possibility: our experiments did not enough have power to detect the effect of IS, especially if this effect is small
- need a power analysis to investigate this for each of the relevant ROIs in both experiments
- simulate data based on the MLEs of the main-effects-only models + the addition of IS & QUANT interaction terms, with magnitude set at several distinct levels
- small pilot analysis along these lines, but much more significant endeavor than initially expected
- if we simulate data based on MLEs of models with rich random effect structures (like we did, following Barr et al. 2013), the original model will often not converge on the simulated data
- need to run backwards model selection for each of the simulated data sets (about 10,000 per region per experiment for a reliable analysis); this is a fully-fledged follow-up study

Accounting for the generalizations & summary

(23) The same researcher learned every language.
(24) A different researcher learned every language.

- the deeper level involves taking the discourse model we built for the sentence and ‘matching’ it against a real-world background model
- for both \textit{SAME} and \textit{DIFFERENT}, we need to go through the list of languages and check whether their corresponding researchers are identical or distinct
- that is, both require readers to actually retrieve the list of contextually-specified languages
- this list is less salient, hence more difficult to retrieve, when the target sentence involves IS and places the relevant quantificational NP in the less prominent direct object position

Accounting for the generalizations & summary

- this truth verification ‘procedure’ is exactly what is encoded by embedding functions in Discourse Representation Theory (DRT; Kamp 1981 and Kamp and Reyle 1993)
- embedding functions relate Discourse Representation Structures (DRSs, i.e., mental discourse models) and the actual, ‘real-world’ model
- the shallower level of discourse model processing would correspond to constructing a DRS for the current sentence / discourse
- the deeper level of discourse model processing would correspond to linking this DRS to a real-world background situation, i.e., to constructing an embedding function (partial variable assignment) that verifies this DRS
Acknowledgments

We want to thank Judith Aissen, Sandy Chung, Amy Rose Deal, Donka Farkas, Berit Gehrke, Louise McNally, Tamara Vardomskaya, three anonymous SALT 22 reviewers, and the audiences of UCSC’s S-Circle (2012 and 2014) and SALT 22 for comments and discussion.

Adrian Brasoveanu was supported by an SRG grant from the UCSC Committee on Research for part of this research, and Jakub Dotlačil was supported by a Rubicon and a Veni grant from the Netherlands Organization for Scientific Research.

The usual disclaimers apply.

References I

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References II


References III

References IV


Exp. 1, MLEs and 95% CIs for early ROIs

<table>
<thead>
<tr>
<th>Word 2 [researcher/s]</th>
<th>Word 3 [learned]</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT</td>
<td>−0.007(−0.04, 0.03)</td>
</tr>
<tr>
<td>ALL</td>
<td>−0.02(−0.06, 0.01)</td>
</tr>
<tr>
<td>EACH</td>
<td>−0.02(−0.06, 0.01)</td>
</tr>
<tr>
<td>THE</td>
<td>−0.03(−0.07, 0.004)</td>
</tr>
<tr>
<td>INVERSE</td>
<td>0.01(−0.02, 0.05)</td>
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Exp. 1, MLEs and 95% CIs for late ROIs

<table>
<thead>
<tr>
<th>Word 5 [language/s]</th>
<th>Word 6 [spoken]</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT</td>
<td>−0.03(−0.07, 0.01)</td>
</tr>
<tr>
<td>ALL</td>
<td>−0.06(−0.11, −0.01)</td>
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<tr>
<td>EACH</td>
<td>0.03(−0.01, 0.08)</td>
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<tr>
<td>THE</td>
<td>−0.01(−0.06, 0.03)</td>
</tr>
<tr>
<td>INVERSE</td>
<td>0.01(−0.02, 0.04)</td>
</tr>
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Exp. 1, MLEs and 95% CIs for full-sentence RTs

<table>
<thead>
<tr>
<th>Word 7 [in]</th>
<th>Word 8 [the]</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTERCEPT (EVERY&amp;SURFACE)</td>
<td>−0.07(−0.12, −0.03)</td>
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<td>THE</td>
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</tr>
</tbody>
</table>

| INTERCEPT (EVERY&SURFACE) | 0.45(0.80, 0.11) |
| ALL         | −0.08(−0.46, 0.30) |
| EACH        | 0.21(−0.16, 0.59) |
| THE         | 0.28(−0.09, 0.69) |
| INVERSE     | 0.05(−0.24, 0.34) |
### Exp. 1, MLEs and 95% CIs for answer times & prob.s

#### Answer times

<table>
<thead>
<tr>
<th>Intercept (EVERY&amp;SURFACE&amp;CORRECT)</th>
<th>7.31 (7.23, 7.38)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>−0.0001 (−0.04, 0.04)</td>
</tr>
<tr>
<td>Each</td>
<td>0.01 (−0.03, 0.06)</td>
</tr>
<tr>
<td>The</td>
<td>0.06 (0.02, 0.10)</td>
</tr>
<tr>
<td>Incorrect</td>
<td>0.02 (−0.02, 0.05)</td>
</tr>
<tr>
<td>Incorrect × All</td>
<td>−0.03 (−0.28, 0.22)</td>
</tr>
<tr>
<td>Incorrect × Each</td>
<td>−0.06 (−0.30, 0.18)</td>
</tr>
<tr>
<td>Incorrect × The</td>
<td>−0.26 (−0.48, −0.03)</td>
</tr>
<tr>
<td>Incorrect × Inverse</td>
<td>0.09 (−0.06, 0.25)</td>
</tr>
</tbody>
</table>

#### Answer prob.s

<table>
<thead>
<tr>
<th>Intercept (EVERY&amp;SURFACE)</th>
<th>4.16 (3.36, 4.96), p &lt; 2 × 10^{-16}</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>−0.32 (−1.02, 0.37)</td>
</tr>
<tr>
<td>Each</td>
<td>−0.47 (−1.16, 0.21)</td>
</tr>
<tr>
<td>The</td>
<td>−0.88 (−1.53, −0.22), p = 0.008</td>
</tr>
<tr>
<td>Inverse</td>
<td>−1.44 (−2.02, −0.86), p = 1.2 × 10^{-6}</td>
</tr>
</tbody>
</table>

### Exp. 2, MLEs and 95% CIs for early ROIs

<table>
<thead>
<tr>
<th>Word 2 [researcher/s]</th>
<th>Word 3 [learned]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept (EVERY&amp;SURFACE)</td>
<td>−0.02 (−0.06, 0.02)</td>
</tr>
<tr>
<td>All</td>
<td>−0.02 (−0.07, 0.02)</td>
</tr>
<tr>
<td>Each</td>
<td>−0.006 (−0.04, 0.03)</td>
</tr>
<tr>
<td>The</td>
<td>−0.01 (−0.06, 0.03)</td>
</tr>
<tr>
<td>Inverse</td>
<td>−0.02 (−0.05, 0.01)</td>
</tr>
</tbody>
</table>

### Exp. 2, MLEs and 95% CIs for late ROIs

### Exp. 2, MLEs and 95% CIs for full-sentence RTs