The Construction that the Reader Never Learns: ORCs and Adaptation

Caroline Andrews, Adrian Staub & Brian Dillon

University of Massachusetts Amherst

Syntactic Adaptation

Comprehenders have been argued to rapidly adjust to the statistics of the syntactic environment:

> Fine et al. (2013) found that reading times on disambiguating material in garden path sentences decreased as a function of the number of similar garden path sentences a subject had already seen

Fine et al. characterize this syntactic adaptation as

- Rapid and Incremental:
  → trial-to-trial adaptation
- Statistically Sensitive:
  → processing difficulty scaled to surprisal of a syntactic structure in the local environment

Current: Does adaptation obtain for the ORC penalty in naturalistic reading?

Object Relative Clauses and Adaptation

Object RCs are read slower than Subject RCs (Gordon, Hendrick, Johnson, 2001)

The chef [that **the waiter** **distracted** ___] poured...
High Surprisal **Retrieval**

- Staub et al. (2016) found the primary ORC penalty at the **Relative NP**
  - As expected by surprisal accounts (Levy, 2008)
- ORCs provide useful comparison to Fine et al. because unlike garden paths, ORCs do not regularly induce catastrophic misparsing
  - May be more representative of normal parsing

Expectation-based adaptation accounts predict that exposure to ORCs will increase the expected probability of encountering them in context

- This will decrease surprisal and therefore processing difficulty at the Rel NP

Conflicting ORC-adaptation findings

- Wells et al. (2009) self-paced reading (SPR) study:
  - Exposed participants to ORCs over four sessions
  - Compared ORC reading times (RTs) at the beginning and end of the experiment to a control group with no special exposure
  - **Finding:** Exposure-based facilitation for ORCs relative to SRCs in pre- vs post-test RTs
- Andrews et al. (2017) reanalysis of Staub et al. eye tracking experiment:
  - **Finding:** General facilitation for all conditions due to order, but no evidence for adaptation of ORCs relative to other conditions

Ways to resolve conflicting ORC adaptation findings:

i. Wells et al. findings could reflect SPR task effects

ii. Data used in Andrews et al. was not originally meant to test adaptation

Task-Effects vs Adaptation

Both Andrews et al. and Stack et al. (2018) propose that task-adaptation might mimic syntactic adaptation in SPR

- If so, SPR results may not reflect *syntactic* adaptation
- But eyetracking would reduce task adaptation concerns

Alternatively, the Andrews et al. data lacks proper controls for ORDER effects

- May reduce ability to detect true adaptation

→ Current Goal: Specifically test ORC adaptation in eye tracking

Predictions

Syntactic adaptation should manifest as an interaction of ORDER x RC TYPE (facilitation for later ORC trials, but reduced or no facilitation for SRCs), because:

- Rel NP in an ORC disambiguates to an ORC structure
  → NP has high surprisal
  - Many ORCs in the environment should reduce surprisal of resolving to an ORC and facilitate RTs
- NP region in SRCs is post-disambiguation
  → SRC NP has low surprisal
  - Much less predicted facilitation (or even increased RTs)

References

Fine, Jaeger, Farmer, Qian. (2013). *PloS one*; Gordon, Hendrick & Johnson.(2001). *JEP*; Staub, Dillon, & Clifton. (2016). *Cognitive Science*; Wells, Christiansen, Race, Acheson & MacDonald. (2009). *Cognitive Psychology*; Levy. (2008). *Cognition*; Andrews, Staub, Dillon. (2017). *AMLaP*; Stack, James, Watson. (2018). *Mem & Cognition*; Bock & Loebell. (1990). *Cognition*;

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Contact: ceandrews@linguist.umass.edu

Experiment Design

Eyetracking:

Skewed presentation rates: Four times more ORCs than each control condition

- Greater reduction in ORC surprisal should lead to greater facilitation for RTs at the Rel NP
- Two baseline conditions
  - SRCs: Compete with ORCs for expectation; Rel NP has a different linear position
  - Complement Clauses: Rel NP has identical position to ORCs; do not compete for expectation

(1) a. **32 ORC:** The marine biologist [that the botanist consulted ____] presented a paper at...
b. **8 SRC:** The marine biologist [that ____ consulted the botanist] presented a paper at...
c. **8 Complement**: The marine biologist believed [that the botanist consulted a statistician at...]

Before-and-After Sentence Completion Task

- Production-based measure of adaptation (i.e. comprehension-to-production priming)
  - If adaptation is possible in principle and simply doesn't appear in comprehension (eye tracking), then it should obtain in production
- Included dative fragments as a control
  - Unlike RCs, datives are well-known to participate in priming → Even if ORCs resist priming, it should appear with datives
  - 32 PO datives were also included in the eye tracking sentences to match exposure to ORCs

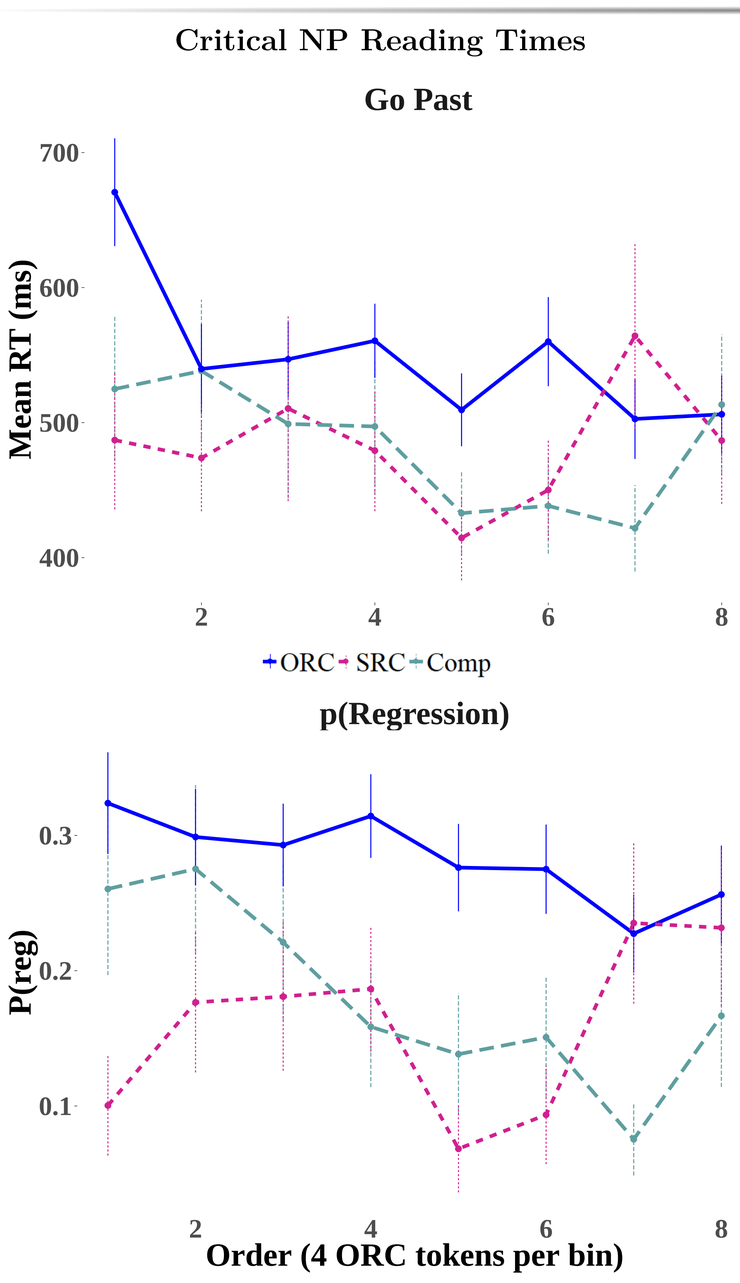
(2) a. RC: The brilliant inventor that ____
b. Dative: The reclusive novelist gave ____

Details

N=72

ORDER: The number of tokens a participant had seen relative to the number of ORCs
(SRCs & Comp which appear before any ORCs have position 0; SRCs & Comp between ORC_1 and ORC_2 are position 1, etc...)

Eyetracking Results



Critical NP Go Past	ORC vs SRC $\beta(SE)$	$\lvert t\rvert$	ORC vs Comp $\beta(SE)$	$\lvert t\rvert$
INTERCEPT	512.96 (22.4)	22.88	478.42 (24.29)	19.69
EMBEDDEDTYPE	68.30 (21.68)	3.15	137.26 (41.91)	3.28
ORDER	**-2.35 (1.17)**	2.01	-1.035 (1.77)	0.58
ORDERXEMBEDDED	**2.65 (2.00)**	-1.33	**-5.29 (3.83)**	1.38

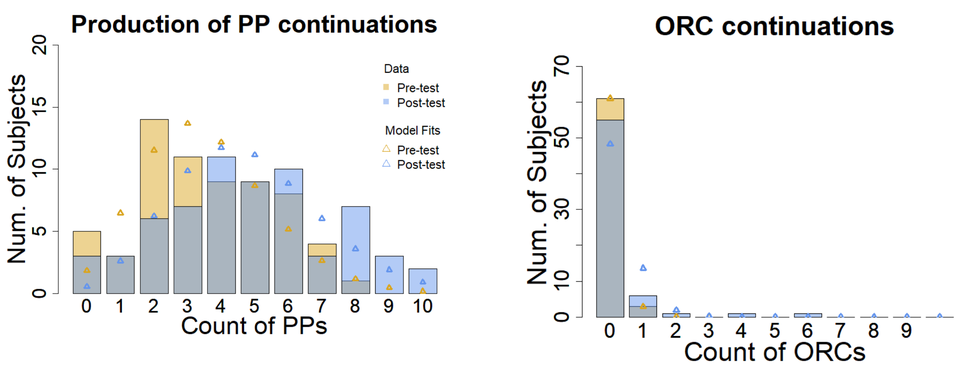
- Sig. ORC main effect compared to both baseline conditions
- Greatest difference between ORCs and controls (SRCs & Comp) is in p(Regression)
  - Suggests that ORC penalty is due to re-reading (replicating Staub et al.)
- However, the critical interaction of **Order x RCType was not sig.** in either model
- ORDER main effect was sig. relative to SRCs, but not Comp
- Early speed-up in ORCs could be adaptation
- But then surprising that it isn't reflected in p(Reg), where the ORC penalty is strong
  - Also consistent with ORCs bearing brunt of experiment adjustment because there are so many more than controls
- At the Rel V:
  - Main effect of ORCs vs SRCs (β=64.31, SE=25.11)
  - Main effect of ORDER (β=-2.35, SE=1.17)
  - No interaction (β=-2.65, SE=2.00)

Bayes Factor Analysis

Model with no ORDER x RCTYPE interaction was preferred with a Bayes Factor of 5.51 (±0.01%) over the interaction model

Critical NP p(Reg) (Logistic)	ORC vs SRC $\beta(SE)$	p	ORC vs Comp $\beta(SE)$	p
INTERCEPT	-1.29 (0.06)	<.0001	-1.65 (.12)	<.0001
EMBEDDEDTYPE	0.73 (0.13)	<.0001	1.46 (0.25)	<.0001
ORDER	-0.004 (0.01)	0.59	-1.04 (1.77)	0.66
ORDERXEMBEDDED	-0.02 (0.01)	0.18	-0.04 (0.03)	0.18

Sentence Completion Results



Poisson Regression: Dative Continuations

		$\beta(SE)$	p
Dative PPs Only	*Intercept*	1.06 (0.07)	<.0001
	Before/After	0.18 (0.09)	0.07
Any VP-attached PP	*Intercept*	1.27 (0.07)	<.0001
	Before/After	0.29 (0.09)	<.001

*Non-dative PPs (e.g. locatives) are also primed by PO datives (Bock & Loebell, 1990)

ORC Continuations

	$\beta(SE)$	p
Intercept	-4.85 (1.18)	<.0001
Before/After	1.79 (0.62)	<.005

- Both ORCs and PO datives show significantly increased production following eye tracking
- However, the priming effect was much smaller for ORCs than dative PO continuations
- Neither model shows substantial over- or underdispersion
  - (Estimate Scale ORCs: 1.12; PP: 1.07; Ideal: 1)
  - Indicates that model fit does not vary systematically from the data despite small number of ORC data points and variation within the model
- Pre-test finds a pre-experimental surprisal for ORCs=8.38 bits (cf. S(RelV)= 6.97 in Fine et al.)
  - Low initial surprisal cannot be the reason for different adaptation findings than Fine et al.

Conclusions

- No reliable evidence for incremental statistically-sensitive syntactic adaptation in relative clauses in natural reading
- However, ORCs *are* primable in principle
  - Sentence completion shows that exposure to ORCs led to slightly higher, but reliable, rates of production
- But ORCs appear to be less susceptible to priming overall that PO datives
  - Even though pre-experimental expectation for ORCs was quite low
- Results may argue against statistically-sensitive syntactic adaptation theories