Dynamics of memory retrieval in parsing double relative clauses: The interplay of parallelism, animacy, and case markers

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Language & Computation Lab

Roadmap

- Processing mechanism
- Structure of double relative clauses (DRCs)
- Main focus:
  - Semantic-syntactic information: Parallelism of grammatical functions
  - Semantic information: Animacy
  - Morphosyntactic information: Case markers
- Results from three self-paced reading tasks
- Discussion

Processing mechanisms: Encoding

- Encoding of representation
  e.g., Melissa knew that **the toy** from her uncle in Bogota arrived today.

[encoding]

$_{NP}6$

category: NP
head: *toy*
case: nominative
number: singular

s7

category: S
head: OPEN
specifier: $_{NP}6$
complement: OPEN

(Lewis et al., 2006, p. 3)

Processing mechanisms: Retrieval

- *Sentence: It was the lawyer that the client interviewed in a small office.*

*It was the lawyer that **the client** interviewed in a small office.*

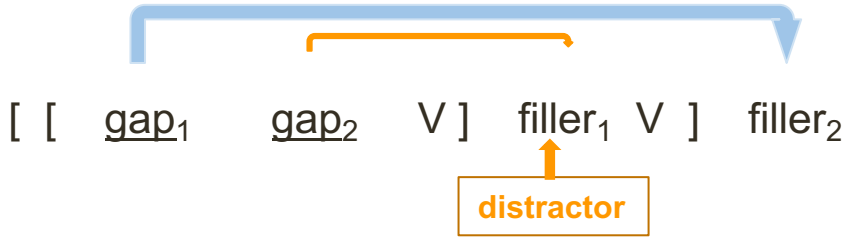
subject
[+NP, +singular, +definite]

distractor
[+NP, +singular, +definite]

- **Complex sentences** cause processing difficulty due to **memory constraints** (Gibson, 1998. a.o).
  - The parser needs to process **another NP** in the dependency chain, then this requires an additional processing load

Main Research question

- How about a distractor involving the dependency formation?
  - Double relative clauses in Korean



1. **Syntactic information: Parallelism of the grammatical functions between the filler and gap positions**
2. **Semantic information: Animacy**
3. **Morpho-syntactic information: case markers**

Double relative clause (DRCs) in Korean

- Double relative clauses (DRCs) in Korean

[RC1[RC2 ___i ___j coaha-nun] kangaci-ka$_j$ cwuk-un] ai$_i$

low head noun *high head noun*

___i ___j like-ADN dog-NOM$_j$ die-ADN kid$_i$

'the kid who the dog which [he] liked died'

(An adnominal marker '*-(n)un*' is used to modify a noun.)

Parallelism effects

(1)

a. SS condition (subject head noun-subject gap)

e.g., The dog$_i$ [that __$_i$ jumps over the pig] bumps into the lion.

b. SO condition (subject head noun-object gap)

e.g., The lion$_i$ [that the horse bumps into __$_i$] jumps over the giraffe.

c. OS condition (object head noun- subject gap)

e.g., The pig bumps into the horse$_i$ [that __$_i$ jumps over the giraffe].

d. OO condition (object head noun- object gap)

e.g., The dog stands on the horse$_i$ that the giraffe jumps over __$_i$.

c. SRC

d. ORC

(Sheldon, 1974: 275)

- Parallelism effect: Parallel function > Non-parallel function (d > c)
- Subject advantage (King & Just, 1991): SRCs advantage over ORCs (c > d)

Parallelism effects

- Prenominal relative clauses
  - No overt cue on retrieving the dependent element

- Double dependencies out of the same clause (co-arguments)

➔ Parallelisms of grammatical functions may play a role in processing DRCs

Double relative clause (DRCs) in Japanese

a. Yoyakusita seki-ga kituensekino tonarini-atta kyaku-wa hokanoseki-ni kaesaseta.

reserved seat-nom smoke-area next-was customer-top other-seat-to changed

'The customer that the seat that (he/she) reserved was next to the smoking section made (them) change to another seat'

b. Yoyakusita kyaku-ga jikan-ni okureta seki-wa hokanokyaku-ni mawasareta.

reserved customer-nom time-to late-was seat-top other-customer was-given

'The seat that the customer that reserved (it) was late was given to another customer'

a. seat (low) — customer (high)

object gap — subject gap

b. customer (low) — seat
subject gap — object gap

(Nakamura & Miyamoto, 2013)

- Processing preferences based on the thematic role assignment (a) > (b)
  → Assigning the role of an object before a subject
- Only one syntactic structure

Processing approaches to Korean DRCs

- Various restrictions for DRCs (Yoon, 2016)
  - The grammatical function of the head nouns
    → Processing difficulty of higher head nouns from object gap positions.
  - Interpretation preference based on lower relative clauses
    → Similar to the conclusion of Nakamura & Miyamoto (2013)

Processing approaches to Korean DRCs

- Various restrictions for DRCs (Yoon, 2016)
  - Interpretation preference based on lower relative clauses
    - The distance between gap and filler

    → Shorter dependencies are preferred over longer dependencies
  - [e e salangha-nun] yeca
    love-and woman

    a. **‘the woman$_j$ [whom$_j$ e$_i$ loves e$_j$]’ (‘the woman whom somebody loves’)**

    b. ? ‘the woman$_i$ [who$_i$ e$_i$ loves e$_j$]’ (‘the woman whom loves somebody’)

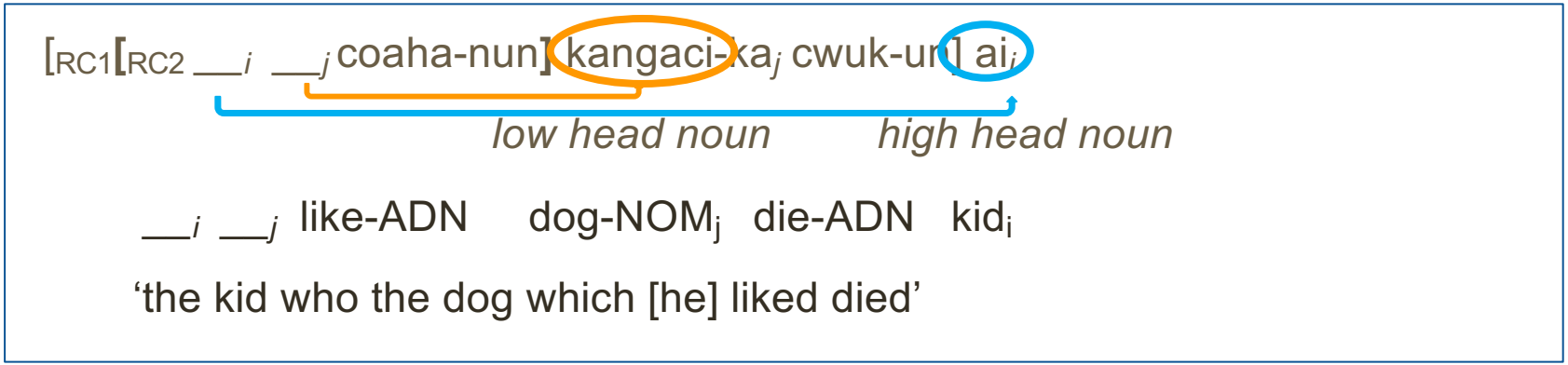
Processing approaches to Korean DRCs

- Various restrictions for DRCs (Yoon, 2016)
  - Interpretation preference based on lower relative clauses
    - Processing difficulty of higher head nouns from object gap positions.
  - [[e e salangha-nun] yeca-ka cwuk-un] namca
    love-Adn woman-Nom die-Adn man
    a. **'the man$_i$ [who$_i$ the woman$_j$ [whom$_j$ e$_i$ loved e$_j$] died]' (man = Subject)**
    b. ??'the man$_j$ [who$_j$ the woman$_i$ [who$_i$ e$_i$ loved e$_j$] died]' (man = Object)
  - same with Japanese DRCs

a. seat (low) — customer (high)	b. customer (low) —seat
object gap — subject gap	subject gap — subject gap

Double relative clause (DRCs) in Korean

- Double relative clauses (DRCs) in Korean



- Pro-drop head-final language: temporary ambiguity is resolved later at the head nouns
  → Delay the postulation of the gap until encountering the head noun (Kwon, 2008)

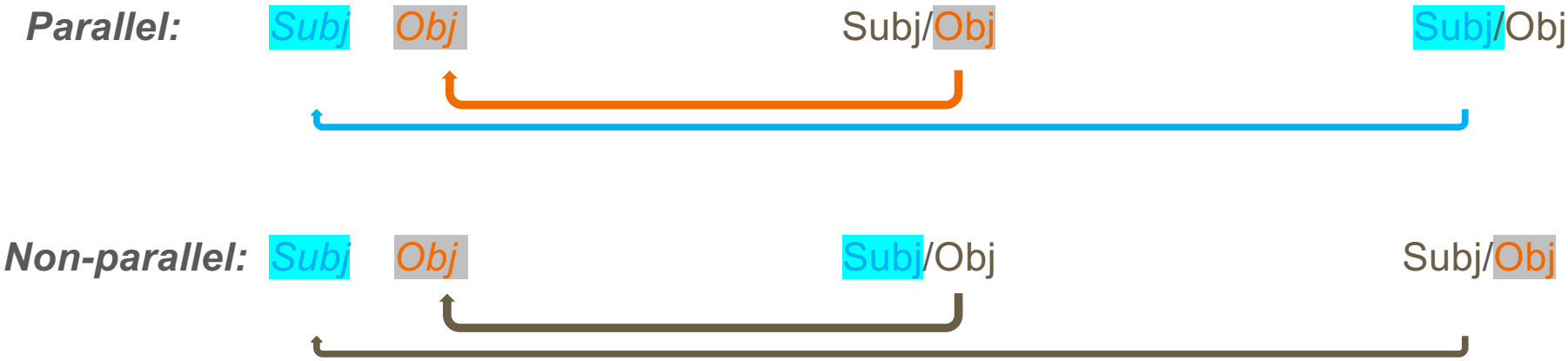
Three main factors

- **Syntactic-semantic cue: parallelism of grammatical functions**
- **Semantic cue: animacy**
- **Morphosyntactic cue: case marker**

Q1. Parallelism of grammatical roles

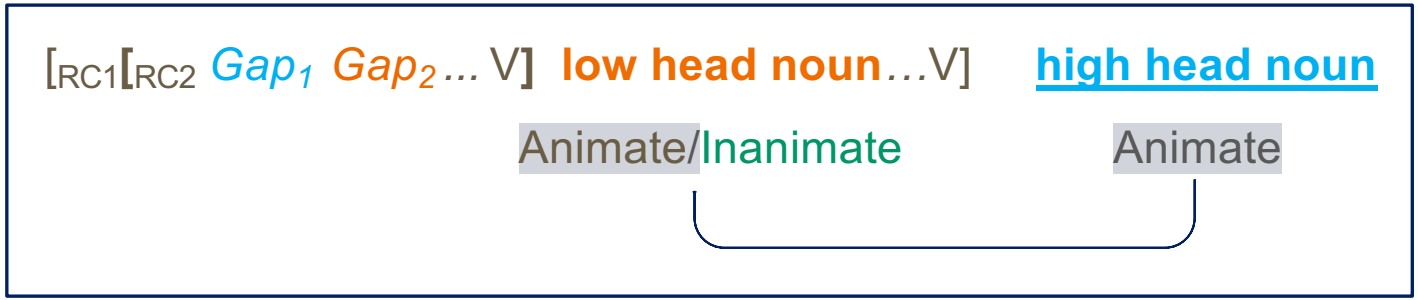
- Parallelism

[RC1[RC2 *Gap*$_1$ *Gap*$_2$ ... V] low head noun(NOM/ACC) …V] high head noun(NOM/ACC)



Q2. Parallelism & Animacy

- Animacy

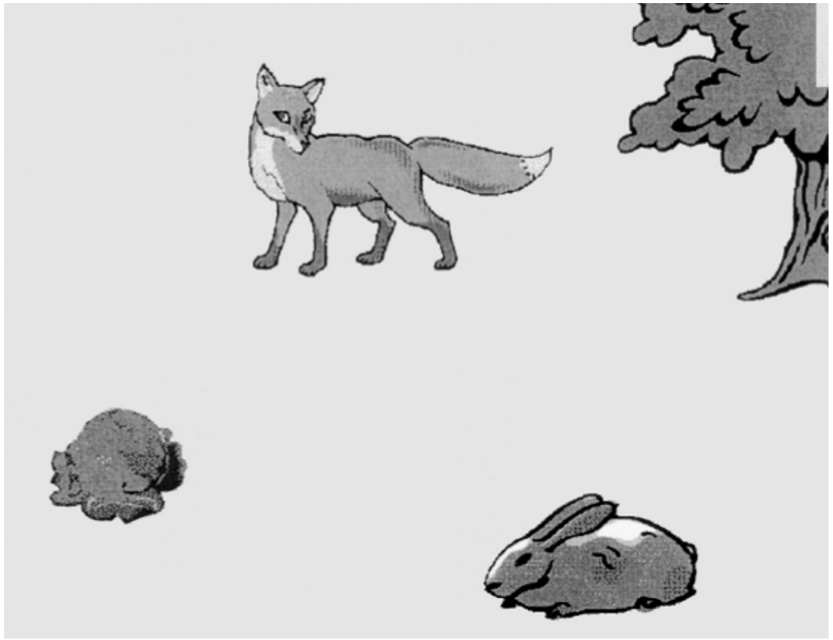


- Syntax-first account: the primacy of syntactic cues over semantic cues
  (Clifton et al., 2003; Ferreira & Clifton, 1986; Frazier & Rayner, 1982)
  - Prediction: No different results depending on the animacy of low head nouns

- Simultaneous processing: interactive use of both syntactic and semantic cues
  (Kwon et al., 2019; Mak et al., 2002; Mertzen, Dillon, et al., 2021)
  - Prediction: More difficulty when the low head noun is animate

Q3. Role of case markers

- Parsers can predict an upcoming argument to bear a different case
  (Kamide et al., 2003; Knoeferle et al., 2005)



a. Der Hase frißt gleich den Kohl.
The hare-nom eats shortly the cabbage-acc.
"The hare will shortly eat the cabbage."
b. Den Hasen frißt gleich der Fuchs.
The hare-acc eats shortly the fox-nom.
"The fox will shortly eat the hare."

- Predictive processing

a. NOM (agent) … a theme (*cabbage*)
b. ACC (theme) … an agent (*fox*)

(Kamide et al., 2003)

Q3. Role of case markers

- Parsers can predict an upcoming argument to bear a different case
  (Kamide et al., 2003; Knoeferle et al., 2005)

- Active use of case information (a, b: slowdown!)
- Selective use of case information based on structure building

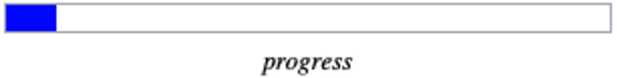
a. Low head noun-NOM	--	High head noun-NOM	Slowdown!!
b. Low head noun-ACC	--	High head noun-ACC	
c. Low head noun-NOM	--	High head noun-ACC	
d. Low head noun-ACC	--	High head noun-NOM	

Experimental methods

- 2 x 2 design: Parallelism (parallel, non-parallel) x Head nouns (low, high)
- 16 target items + 42 fillers (randomized)
- Self-paced reading tasks (PCIbex)

Experimental methods: Procedure

- Non-cumulative moving window display



Experimental methods: Procedure

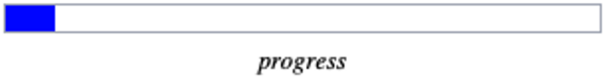
- Non-cumulative moving window display

progress

성가대 민진이는 _____ _____ _____ _____ _____

Experimental methods: Procedure

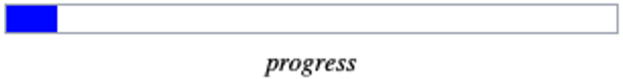
- Non-cumulative moving window display



슬기와 주희가

Experimental methods: Procedure

- Non-cumulative moving window display



민화를

Experimental methods: Procedure

- Non-cumulative moving window display

progress

감상하시게

Experimental methods: Procedure

- Non-cumulative moving window display

progress

전시실로

Experimental methods: Procedure

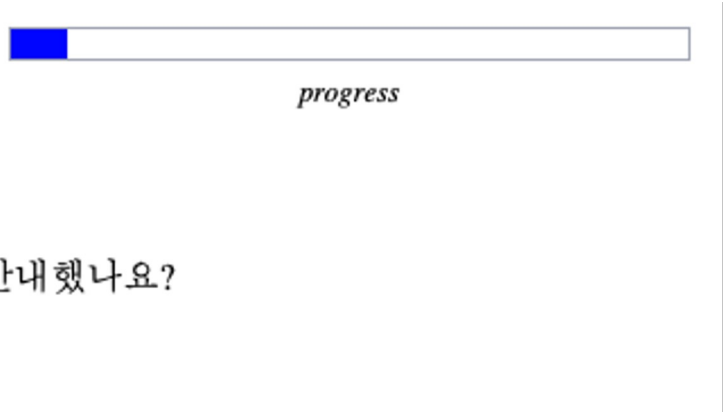
- Non-cumulative moving window display

progress

_____ _____ _____ _____ _____ 안내했다.

Experimental methods: Procedure

- Non-cumulative moving window display



Experimental methods: Analysis

- Statistics: Linear mixed effect models (*lme4* package in R)
- Outlier removal1: removal of participants below 75% accuracy
- Outlier removal2: Three standard deviation above the mean (less than 2%)
- Regions of interest: High head noun (critical region) – Spillover1 – Spillover2
  Low head noun

- Experiment 1: ***inanimate*** low – **animate** high
- Experiment 2: ***animate*** low – **animate** high
- Experiment 3: Follow up experiment

Experiment 1

- A self-paced reading task (n=50)
- A sample set of items: critical region = ‘shoes-ACC/NOM (inanimate)’, ‘kid-ACC/NOM (animate)’

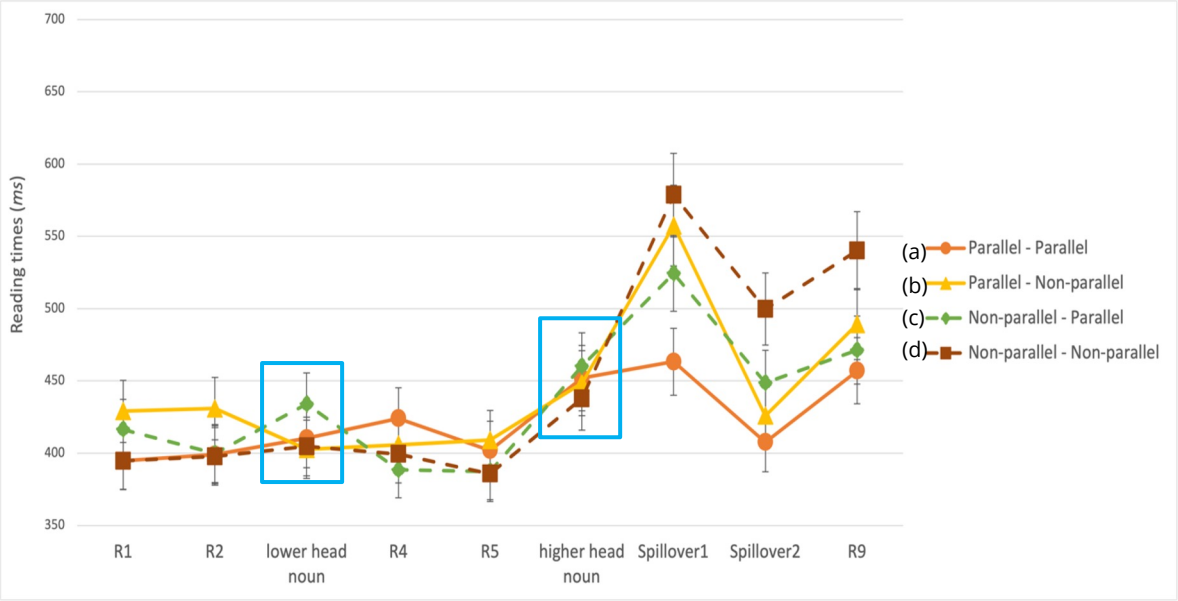
	Factors			Examples
	Parallelism of the low head noun (object gap)	**Parallelism of the high head noun (subject gap)**	**Case**	
(a)	Parallel (ACC-object)	Parallel (NOM-subject)	Mismatch	[$_{RC1}$[$_{RC2}$__$_i$ __$_j$ mollay hwumchi-n] *sinpal*$_j$-ul manhi akki-nun] *ai*$_i$-ka… sneakily steal-ADN shoes$_j$-**ACC** a lot cherish-ADN kid$_i$-**NOM**
(b)	Parallel (ACC-object)	Non-parallel (ACC-object)	Match	[$_{RC1}$[$_{RC2}$__$_i$ __$_j$ mollay hwumchi-n] *sinpal*$_j$-ul manhi akki-nun] *ai*$_i$-lul… sneakily steal-ADN shoes$_j$-**ACC** a lot cherish-ADN kid$_i$-**ACC** ‘the kid$_i$ [who cherisehd the shoes$_j$ [that (the kid)$_i$ sneakily stole __$_j$]]’
(c)	Non-parallel (NOM-subject)	Parallel (NOM-subject)	Match	[$_{RC1}$[$_{RC2}$__$_i$ __$_j$ mollay hwumchi-n] *sinpal*$_j$ -i manhi telewu-n] *ai* $_i$-ka… sneakily steal-ADN shoes-**NOM** very (be) dirty-ADN kid$_i$-**NOM**
(d)	Non-parallel (NOM-subject)	Non-parallel (ACC-subject)	Mismatch	[$_{RC1}$[$_{RC2}$__$_i$ __$_j$ mollay hwumchi-n] *sinpal*$_j$ -i manhi telewu-n] *ai*$_i$-lul… sneakily steal-ADN shoes-**NOM** very (be) dirty-ADN kid$_i$-**ACC** ‘the kid$_i$ [who the shoes$_j$ [that (the kid)$_i$ sneakily stole __$_j$] is dirty]’

Low head noun

High head noun

Experiment 1: Results

- Measurement: low & high head nouns, and spillover regions

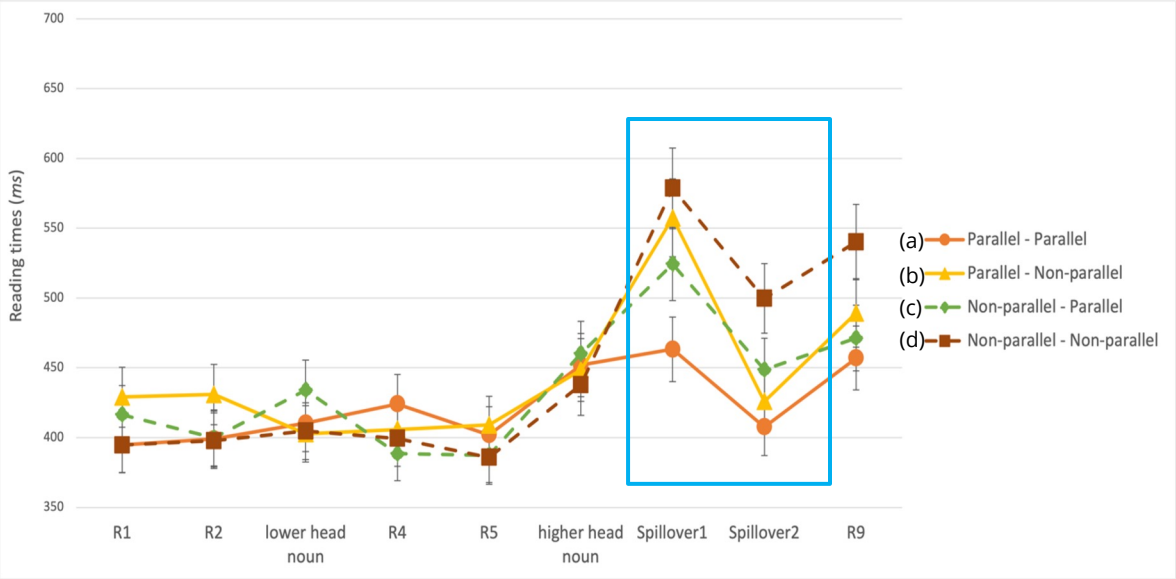


Mean reading time (*ms*) by region by condition. Error bars indicate 95% Confidence intervals.

- **Low head noun region:**
  - No grammatical-function parallelism effect of a lower head noun
- **High head noun region:**
  - No grammatical-function parallelism effect of both head nouns

Experiment 1: Results

- Measurement: low & high head nouns, and spillover regions



Mean reading time (*ms*) by region by condition.
Error bars indicate 95% Confidence intervals.

- **Spillover regions:**
  - Spillover 1 region: the grammatical-function parallelism effect of a **high head noun** was observed (*t*=-2.5)
  - Spillover 2 region: the grammatical-function parallelism effect of **both head nouns** was observed (all *ps* <.05)
- **No case effect**

Experiment 1: Results

Table 3 Summary of statistical analyses by region in Experiment 1[4]

	Regions								
	Critical			Spillover 1			Spillover 2		
	β	SE	*t*	*β*	SE	*t*	*β*	SE	*t*
Parallelism effect of a low head noun	1.06	15.77	.06	-42.35	31.98	-1.32	-56.73	15.82	**-3.58**
Parallelism effect of a high head noun	12.79	15.80	.80	-73.46	29.39	**-2.50**	-33.79	15.65	**-2.15**
Parallelism effect of Low x High head nouns	-19.15	33.89	-.56	-40.66	60.02	-.67	-40.66	60.02	-.67
Case mismatch	9.57	16.91	.56	20.33	30.01	.67	-16.49	13.70	-1.20

A fixed effect was considered to reach the significant level (p=0.05) if its absolute t-value was above 2 (Baayen et al., 2008). Significant coefficients ($|t| > 2$) are in bold.

Experiment 1: Discussion

(1) Low head nouns: No parallelism effects
(2) High head nouns

- No case mismatch effects
- Delayed parallelism effects

  - Possibility 1: immediate syntactic encoding → subsequent integration of the dependency (High-Low)

  - Possibility 2: simultaneous processes of syntactic encoding and linking the gaps at the high head noun but easy processing costs due to distinctiveness of semantic information (i.e., animacy)

- Experiment 2: Animate low head nouns – Animate high head nouns

Q: How parsers handle syntactic and semantic cues in real-time processing?

Experiment 2

- A self-paced reading task (n=50)
- A sample set of items: critical region = ‘teacher-ACC/NOM (animate)’, ‘graduate-ACC/NOM (animate)’

Table 4 A sample set of items for Experiment 2

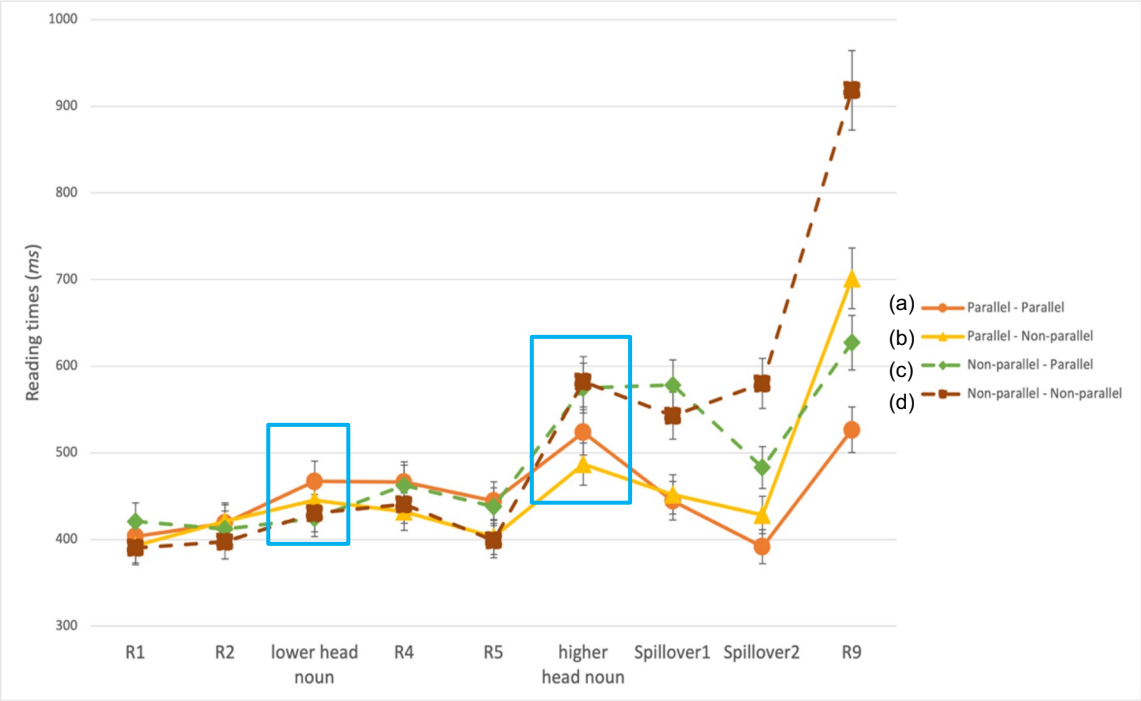
	Factors			Examples
	Parallelism of the low head noun (object gap)	**Parallelism of the high head noun (subject gap)**	**Case**	
(a)	Parallel (object)	Parallel (subject)	Mismatch (ACC-NOM)	[RC1[RC2_i _j manhi conkyengha-te-n] sensayngnim$_j$-ul choykuney kuliweha-te-n] colepsayng$_i$-i… a lot respect-PST-ADN *teacher$_j$*-**ACC** recently miss-PST-ADN *graduate$_i$*-**NOM**
(b)	Parallel (object)	Non-parallel (object)	Match (ACC-ACC)	[RC1[RC2_i _j manhi conkyengha-te-n] sensayngnim$_j$-ul choykuney kuliweha-te-n] colepsayng$_i$-ul… a lot respect-PST-ADN *teacher$_j$*-**ACC** recently miss-PST-ADN *graduate$_i$*-**ACC** ‘the graduate$_i$ [who recently missed the teacher$_j$ [who (the graduate)$_i$ respected __$_j$ a lot]]’
(c)	Non-parallel (subject)	Parallel (subject)	Match (NOM-NOM)	[RC1[RC2_i _j manhi conkyengha-te-n] sensayngnim$_j$-i choykuney unthoyha-n] colepsayng$_i$-i… a lot respect-PST-ADN *teacher$_j$*-**NOM** recently retire-ADN *graduate$_i$*-**NOM**
(d)	Non-parallel (subject)	Non-parallel (subject)	Mismatch (NOM-ACC)	[RC1[RC2_i _j manhi conkyengha-te-n] sensayngnim$_j$-i choykuney unthoyha-n] colepsayng$_i$-ul… a lot respect-PST-ADN *teacher$_j$*-**NOM** recently retire-ADN *graduate$_i$*-**ACC** ‘the graduate$_i$ [who the teacher$_j$ [who (the graduate)$_i$ respected __$_j$ a lot] recently retired]’

Low head noun

High head noun

Experiment 2: Results

- Measurement: low & high head nouns, and spillover regions

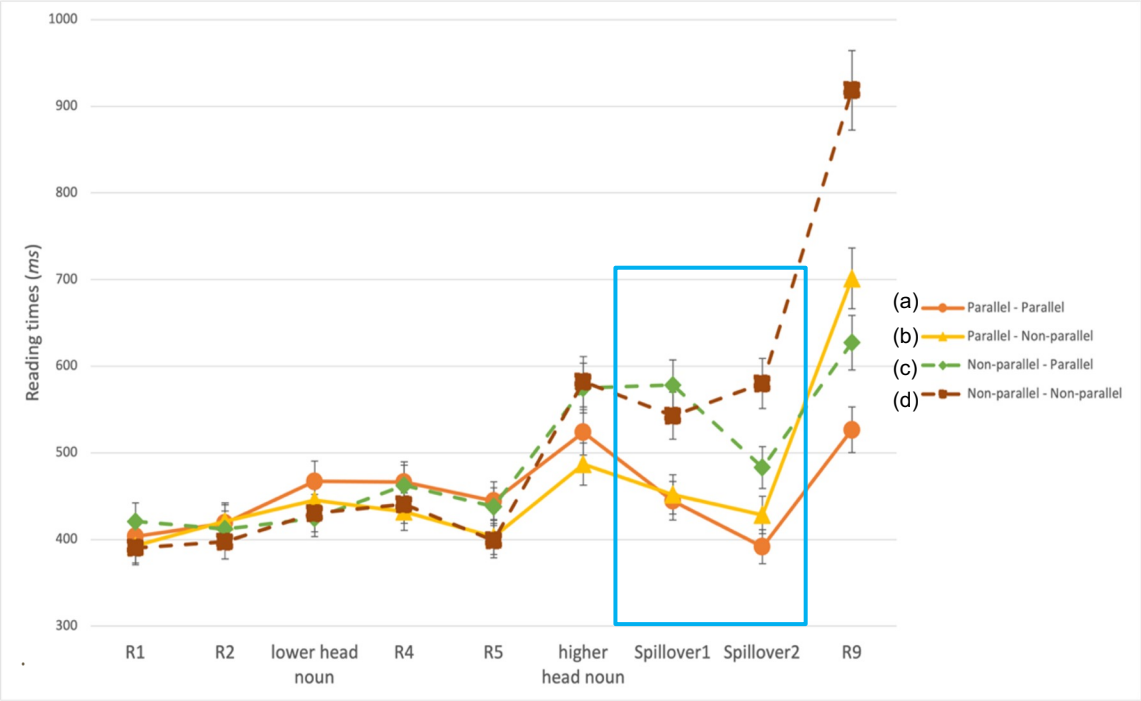


Mean reading time (*ms*) by region by condition. Error bars indicate 95% Confidence intervals.

- **Low head noun region:**
  - No grammatical-function parallelism effect of a lower head noun
- **High head noun region:**
  - Grammatical-function parallelism effect of **low head nouns**

Experiment 2: Results

- Measurement: low & high head nouns and spillover regions



Mean reading time (*ms*) by region by condition. Error bars indicate 95% Confidence intervals.

- **Spillover regions:**
  - Spillover 1 region: the grammatical-function parallelism effect of a **lower head noun** was also observed (*t*=-4.8, *p* <.001)
  - Spillover 2 region: the grammatical-function parallelism effect of **both head nouns** was also observed (all *ps* <.05)
- **No case effect**

Experiment 2: Results

Table 6 Summary of statistical analyses by region in Experiment 2

	Regions								
	Critical			Spillover 1			Spillover 2		
	β	SE	*t*	*β*	SE	*t*	*β*	SE	*t*
Parallelism effect of a low head noun	-93.23	48.17	**-1.93**	-114.71	34.23	**-3.35**	-126.59	21.92	**-5.77**
Parallelism effect of a high head noun	-8.63	35.54	-0.24	7.34	23.30	0.31	-72.21	23.17	**-3.11**
Parallelism effect of Low x High head nouns	61.36	75.43	0.81	-38.30	43.21	-0.88	68.54	38.43	1.68
Case mismatch	-30.05	42.05	-0.71	17.53	20.85	0.84	-34.36	19.20	-1.68

Marginal or significant coefficients ($|t| > 2$) are in bold.

Experiment 2: Discussion

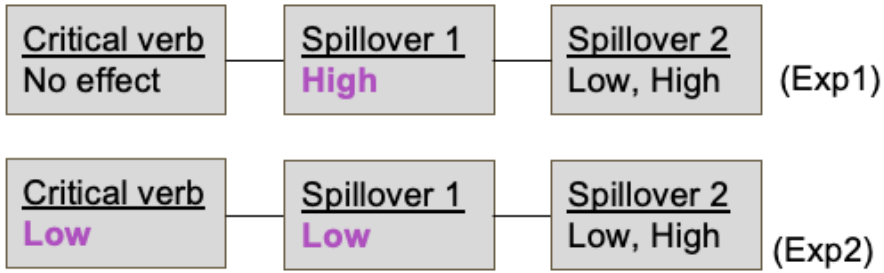
(1) Low head nouns: No parallelism effects

(1) High head nouns: No case mismatch effects

→ not actively use the case markers to predict upcoming argument structure in DRCs

Experiment 2: Discussion

- Parallelism effects



- Immediate reanalysis of the low head noun's grammatical functions
- Subsequent process of dependencies: Low head noun → high head nouns

→ Distinctive semantic information (i.e., animacy) eased integration of low head nouns (Exp1)

Possibility 1: syntactic encoding → subsequent integration of the dependency (High – Low)

Possibility 2: simultaneous processes of syntactic encoding and linking the gaps at the high head noun but easy processing costs due to distinctiveness of semantic information (i.e., animacy)

Experiment 2: Discussion

- Verb transitivity
  - Same across experiments

  → The earlier parallelism effect of low head nouns in Exp 2 is not due to verb transitivity

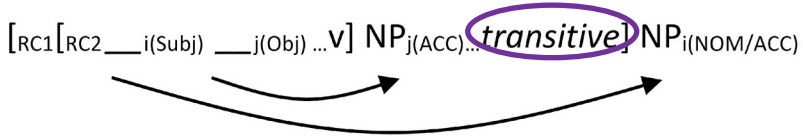
  - Different across conditions!

Table 4 A sample set of items for Experiment 2

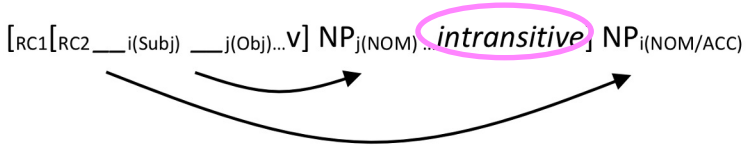
	Factors			Examples
	Parallelism of the low head noun (object gap)	**Parallelism of the high head noun (subject gap)**	**Case**	
(a)	Parallel (object)	Parallel (subject)	Mismatch (ACC-NOM)	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-ul choykuney ku[illegible]liweha-te-n] colepsaying$_i$-i... a lot respect-PST-ADN *teacher*$_j$-**ACC** recently miss-PST-ADN *graduate*$_i$-**NOM**
(b)	Parallel (object)	Non-parallel (object)	Match (ACC-ACC)	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-ul choykuney ku[illegible]liweha-te-n] colepsaying$_i$-ul... a lot respect-PST-ADN *teacher*$_j$-**ACC** recently miss-PST-ADN *graduate*$_i$-**ACC** 'the graduate$_i$ [who recently missed the teacher$_j$ [who (the graduate)$_i$ respected __$_j$ a lot]]'
(c)	Non-parallel (subject)	Parallel (subject)	Match (NOM-NOM)	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-i choykuney unt[illegible]hoyha-n] colepsaying$_i$-i... a lot respect-PST-ADN *teacher*$_j$-**NOM** recently retire-ADN *graduate*$_i$-**NOM**
(d)	Non-parallel (subject)	Non-parallel (subject)	Mismatch (NOM-ACC)	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-i choykuney unt[illegible]hoyha-n] colepsaying$_i$-ul... a lot respect-PST-ADN *teacher*$_j$-**NOM** recently retire-ADN *graduate*$_i$-**ACC** 'the graduate$_i$ [who the teacher$_j$ [who (the graduate)$_i$ respected__$_j$ a lot] recently retired]'

Experiment 3

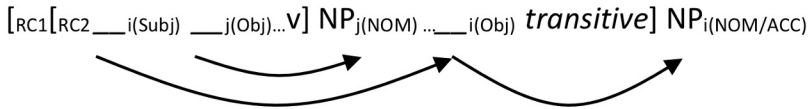
a. Parallel condition



b. Non-parallel condition (intransitives: no intermediate gap)



c. Non-parallel condition (transitives: intermediate gap)

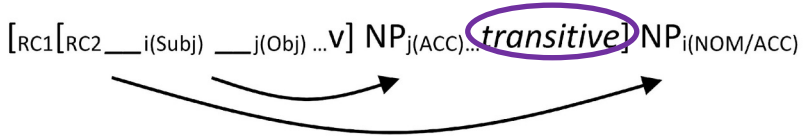


- Parallelism effects of low head nouns
  - Processing loads of non-parallel conditions
- Verb transitivity
  - Parallel conditions: transitive verbs
  - Non-parallel conditions: intransitive verbs

→ Penalty to transitive verbs in language acquisition and dependency movements (Akhtar & Tomasello, 1997; Polinsky et al., 2013 a.o.)

Experiment 3

a. Parallel condition



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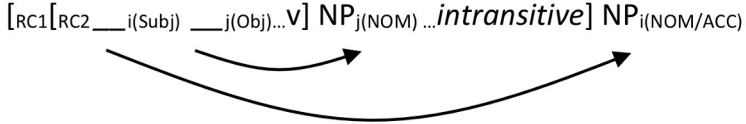

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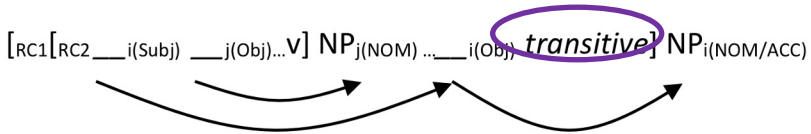


- Parallelism effects of low head nouns
  - Processing loads of non-parallel conditions
- Verb transitivity
  - Parallel conditions: transitive verbs
  - Non-parallel conditions: intransitive verbs

→ Penalty to transitive verbs in language acquisition and dependency movements
(Akhtar & Tomasello, 1997; Polinsky et al., 2013 a.o.)

- **Consistent verb transitivity (c)**
  - **An intermediate gap**
  - **Greater parallelism effects?**

Experiment 3

- A self-paced reading task (n=50)
- A sample set of items: critical region = ‘teacher-ACC/NOM (animate)’, ‘graduate-ACC/NOM (animate)’

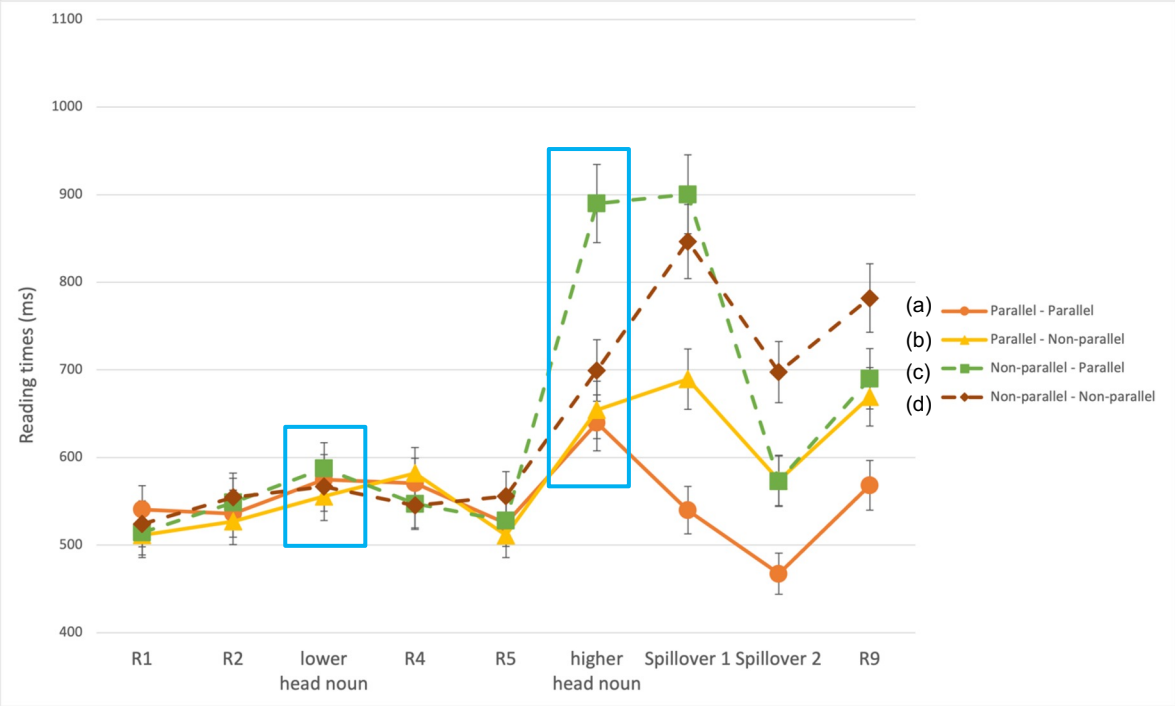
	Factors			Examples
	Parallelism of the low head noun (object gap)	**Parallelism of the high head noun (subject gap)**	**Case**	
(a)	Parallel (ACC-object)	Parallel (NOM-subject)	Mismatch	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-ul choykuney kuliweha-te-n]colepsayng$_i$-i… a lot respect-PST-ADN *teacher$_j$*-**ACC** recently miss-PST-ADN *graduate$_i$*-**NOM**
(b)	Parallel (ACC-object)	Non-parallel (ACC-object)	Match	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-ul choykuney kuliweha-te-n]colepsayng$_i$-ul… a lot respect-PST-ADN *teacher$_j$*-**ACC** recently miss-PST-ADN *graduate$_i$*-**ACC** ‘the graduate$_i$ [who recently missed the teacher$_j$ [who (the graduate)$_i$ respected _$_j$ a lot]]’
(c)	Non-parallel (NOM-subject)	Parallel (NOM-subject)	Match	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-i _$_i$ choykuney kuliweha-te-n]colepsayng$_i$-i… a lot respect-PST-ADN *teacher$_j$*-**NOM** recently miss-PST-ADN *graduate$_i$*-**NOM**
(d)	Non-parallel (NOM-subject)	Non-parallel (ACC-subject)	Mismatch	[$_{RC1}$[$_{RC2}$_i _j manhi conkyengha-te-n] sensayngnim$_j$-i _$_i$ choykuney kuliweha-te-n]colepsayng$_i$-ul a lot respect-PST-ADN *teacher$_j$*-**NOM** recently miss-PST-ADN *graduate$_i$*-**ACC** ‘the graduate$_i$ [who the teacher$_j$ [who (the graduate)$_i$ respected _$_i$ a lot] recently missed _$_i$ a lot]’

Low head noun

High head noun

Experiment 3: Results

- Measurement: low & high head nouns, and spillover regions

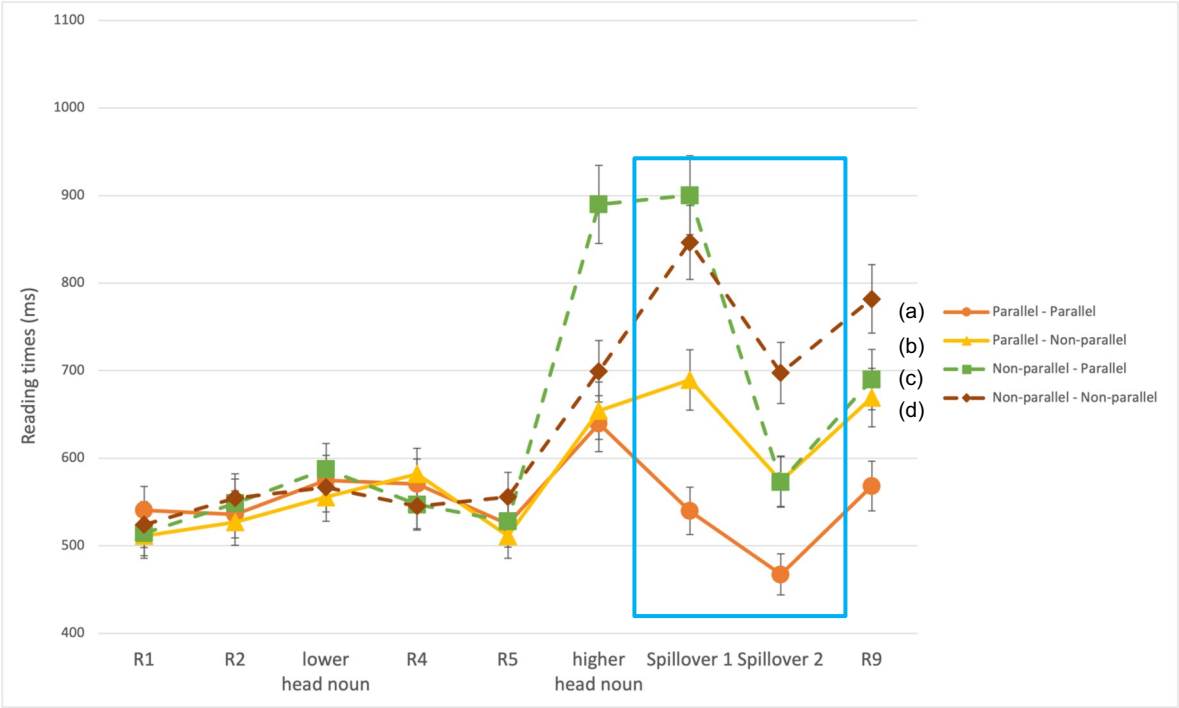


Mean reading time (*ms*) by region by condition. Error bars indicate 95% Confidence intervals.

- **Low head noun region:**
  - No grammatical-function parallelism effect of a lower head noun
- **High head noun region:**
  - Parallelism effect of **low head nouns** (=Exp2)
  - Significantly longer reading time of condition (c)

Experiment 3: Results

- Measurement: low & high head nouns and spillover regions



Mean reading time (*ms*) by region by condition. Error bars indicate 95% Confidence intervals.

- **Spillover regions:**
  - Spillover 1 region: the grammatical-function parallelism effect of a **lower head noun** was also observed (*t*=-4.8, *p* <.001)
  - Spillover 2 region: the grammatical-function parallelism effect of **both head nouns** was also observed (all *ps* <.05)

Experiment 3: Results

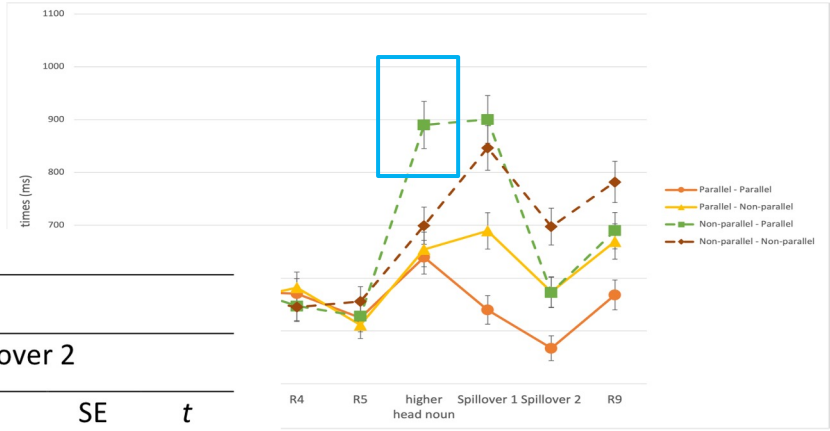


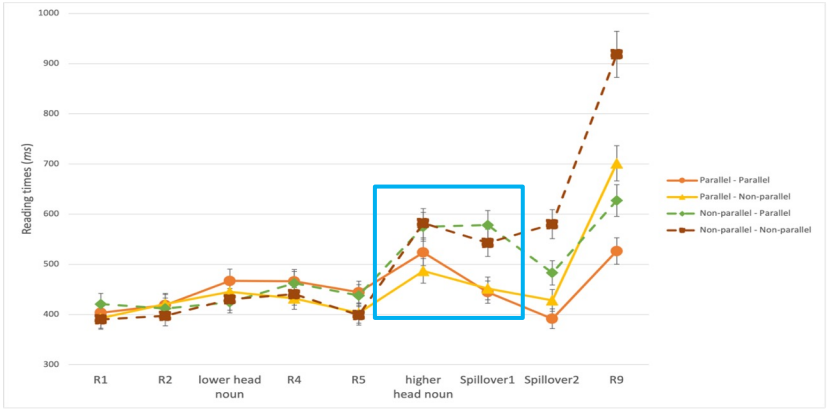
Table 9 Summary of statistical analyses by region in Experiment 3

	Regions								
	Critical			Spillover 1			Spillover 2		
	β	SE	*t*	*β*	SE	*t*	*β*	SE	*t*
Parallelism effect of a low head noun	-153.32	59.27	**-2.58**	-257.58	53.39	**-4.82**	-112.35	32.36	**-2.76**
Parallelism effect of a high head noun	93.88	58.84	1.59	-48.12	47.02	-1.02	-115.50	41.82	**-2.76**
Parallelism effect of Low x High head nouns	-222.79	115.19	**-1.93**	-204.50	77.98	**-2.62**	14.33	46.71	0.30
Case mismatch	111.39	57.59	**1.93**	101.64	36.18	**2.80**	-7.25	27.71	-0.26

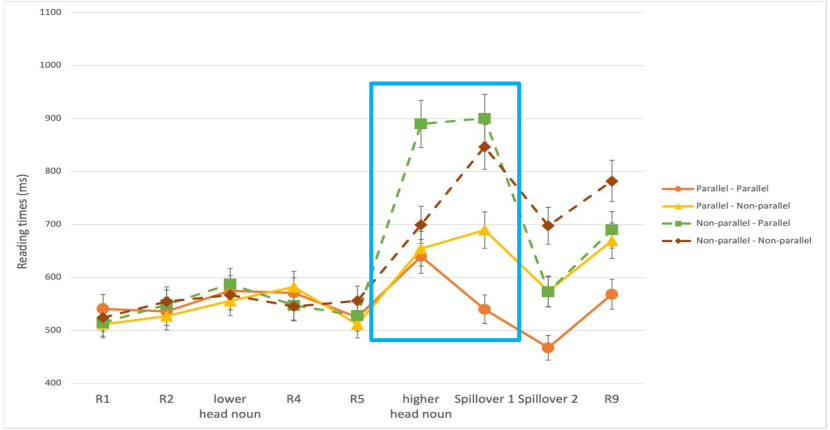
Marginal or Significant coefficients ($|t| > 2$) are in bold.

- Interaction between Parallelism effects of head nouns
- (c) longer than (d) → not parallelism effect

Experiment 3: Discussion



Exp2



Exp3

- Case mismatch effects? –No, asymmetry!
  - Not for double accusative markers

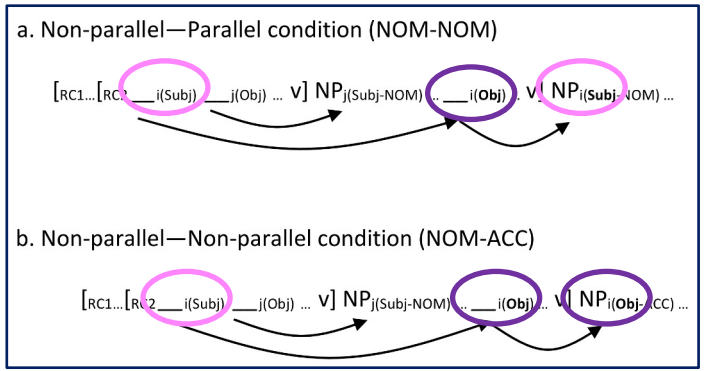
  → Not due to the violation of predictive parsing
- The peculiarity of double nominative constructions?

  → no, Exp2 results of (c)

  (Miyamoto & Takahashi, 2002; Polinsky et al., 2007; Ueno & Kluender, 2003)

Experiment 3: Discussion

- The presence of an intermediate gap of a higher head noun



- Parallelism effects?
  - The status of an intermediate gap is not parallel with neither the high head noun nor its gap

→ accessing an intermediate gap before establishing a long-distance dependency

(Bever & McElree, 1988; Chomsky, 1973, 1995; Gibson & Warren, 2004; Kluender & Kutas, 1993; Love & Swinney, 1996; Nicol & Swinney, 1989)

GENERAL DISCUSSION

1. Semantic-syntactic information: Parallelism

1. Parallelism

- No parallelism effect at lower head noun regions (but higher head noun regions)
  → The lack of a significant role for the parallelism effect in literature on single-gap relative clauses

c. OS condition (object head noun- subject gap)

e.g., The pig bumps into the horse$_i$ [that __$_i$ jumps over the giraffe].

d. OO condition (object head noun- object gap)

e.g., The dog stands on the horse$_i$ that the giraffe jumps over __$_i$.

c. SRC

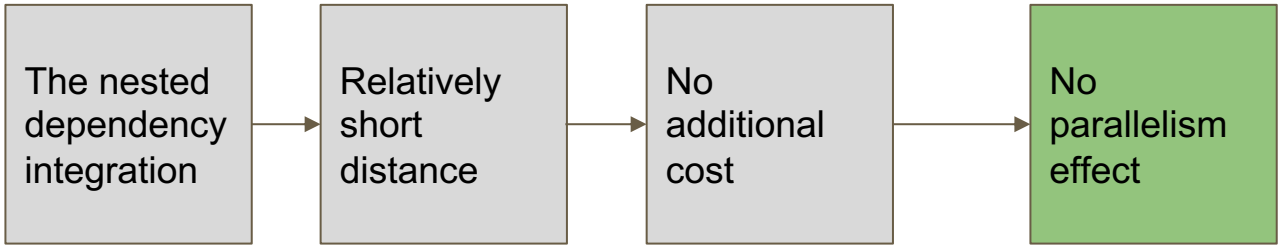
d. ORC

(Sheldon, 1974: 275)

- Parallelism effect: Parallel function > Non-parallel function (d > c)
- Subject advantage (King & Just, 1991): SRCs advantage over ORCs (c > d)

1. Parallelism

- Parallelism effect & dependency distance:
  - Gibson (1998)'s Syntactic Prediction Locality Theory (SPLT):
    - Integration cost and memory cost influenced by "**Locality**": longer distance integrations take more costs than local integrations.



  - No parallelism effects in single gap clauses

➔ Actively employ parallelism **only when dealing with longer FGD, crossing clauses, or involving multiple FGD**.

1. Parallelism

- Nakamura & Miyamoto (2013)
  - Not fully balanced syntactic configuration

    [[gap1 gap2 V] filler1 V] filler2

    NOM **TOPIC** → Both should prefer subject gaps

  - Predicting a distinct grammatical function for the upcoming argument
  - Animacy effects (inanimate low head nouns)
    (Ness & Meltzer-Asscher, 2019; Wagers & Phillips, 2014)

1. Parallelism

- Parallelism effects in various levels of structures and dependencies

- Coordinate structure (Across-the-Board extraction; Williams, 1978)

a. The surgeon who James tricked [object] and Richard annoyed [object] scrubbed up…

b. *?The surgeon who [subject] tricked James and Richard annoyed [object] scrubbed up…

- Subordinate clauses (Sturt et al., 2010)

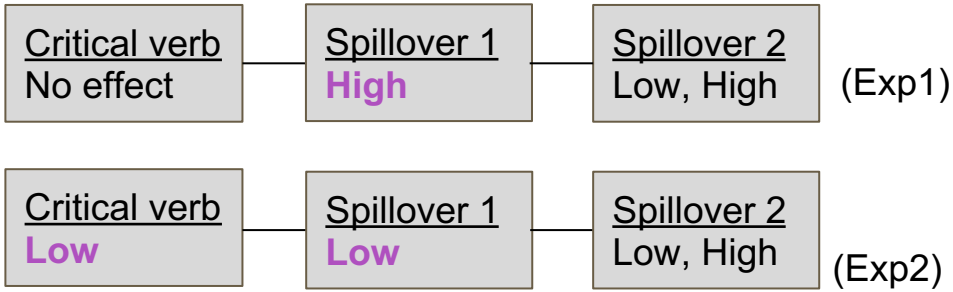
- Pronoun resolution (Hall & Yoshida, 2021)
- Across word categories (Tamaoka et al, 2022)
- Prosodic-level components (Carlson, 2001)

➔ Active use of parallelism in various multiple dependency constructions

2. Interaction with semantic information: Animacy

2. Semantic information: Animacy

- Inanimate Low – Animate High
- Animate Low – Animate High

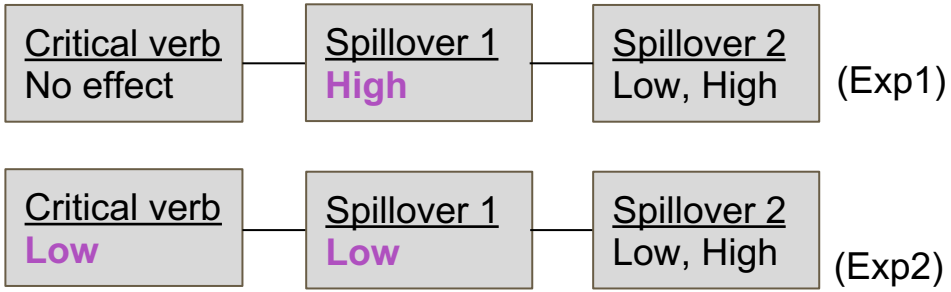


→ No need for reanalysis when low head nouns was inanimate (Exp1)
→ Immediate reanalysis of low head nouns when both head nouns are animate (Exp2)

- Subsequent integration of dependencies (low head noun → high head noun)

2. Semantic information: Animacy

- Inanimate Low – Animate High
- Animate Low – Animate High



1. Syntax-first account (Clifton et al, 2003)

- Primacy of syntactic cues over semantic ones, two-stage parsing
- Prediction: no animacy effect

2. Interactive use of all linguistic information (Boland, 1997; MacDonald et al., 1994)

- immediate integration of semantic information (Altmann & Steedman, 1998; Pickering & Traxler, 1998)

2. Semantic information: Animacy

- Animacy effect on processing relative clauses (SRC & ORC)
  - Reduced when the object within the RC was inanimate (Dutch, Mak et al. 2002)
  - Greater interference from an animate object than from an inanimate object
    (Hofmeister & Vasishth, 2014; Kush et al., 2015; Nairne, 1990; Villata et al., 2018)
- Semantic information outweights structural information (Ferreira, 2003; Stoops et al., 2014)
  - Syntax-first accounts based on languages with rigid word orders (English) or less complex morphological systems (German)
    (Bornkessel-Schlesewsky & Schlesewsky, 2006, 2009b; van Dyke & McElree, 2006)
  - Korean: active use of semantic information for multiple dependency integrations (ambiguous sentences in Russian, Stoopes et al., 2014)

3. Morphosyntactic information: Case markers

3. Morphosyntactic information: Case markers

- Reliable cue for assigning both grammatical and thematic roles in rich case marking systems (Kamide, Altmann, et al., 2003; Knoeferle et al., 2005; Traxler & Pickering, 1996)
- Distinctiveness of case marking affects processing
  - Retrieval cue in dependency formation (e.g., subject-verb agreements)
    - Avetisyan et al (2020): postnominal relatives
      - The painter(s)$_{NOM}$ [$_{RC}$ that the sculptor$_{NOM}$…**V**…]
      - The painter(s)$_{ACC}$ [$_{RC}$ that the sculptor$_{NOM}$…**V**…]
  - Predictive cue
    - Participants predictively looked at a potentially object-related picture when the first NP was nominative-marked. (Kamide et al. 2003)
    - Predictive processing even before the verb in head-final languages (Henry et al. 2017; Hopp, 2015; Knoeferle et al. 2005)

3. Morphosyntactic information: Case markers

- No case effect (no slowdown for the same case marker)

  → not used to predict upcoming argument structures

  (cf. Double nominative constructions in Experiment 3)

  - Possibility 1: Not employ predictive parsing because of temporary ambiguity
  - Possibility 2: Awareness of structural complexity—not within the same structure!

Implication for general parsing mechanism

- Backward dependency constructions
  - Reactivate previously parsed elements

- Interactive use of syntactic and semantic information, rather than syntax-first modular account (Boland, 1997)

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Thank you!

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