Natural Language Processing, Acquisition, and Processing of **VP-ellipsis** and **Gapping**

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5 June 2021
2021 KASELL Spring Conference on English Linguistics

Goal of this dissertation

- Natural Language Processing (NLP), L1 acquisition, early and late L1-Korean L2ers' acquisition, L1 processing, and adult L1-Korean L2ers' processing of contrasts between two seemingly similar phenomena in English

VP-Ellipsis (VPE)
↓ (e.g., Chomsky, 1995; Fiengo & May, 1994; Hankamer & Sag, 1976)

(1) Sara made pizza, and Kelly did [e] too.

(2) Sara made pizza, and Kelly [e] pasta.

↑
Gapping (e.g., Johnson, 2000, 2009)

Grammaticality contrast

VPE and **Gapping** in English differ in terms of whether they are grammatical in **adjunct** clauses

- **VPE** in a conjunct clause
  (3) Sara made pizza [and Kelly did **[e]** too].
- **VPE** in an adjunct clause
  (4) Sara made pizza [because Kelly did **[e]**].
- **Gapping** in a conjunct clause
  (5) Sara made pizza [and Kelly **[e]** pasta].
- ***Gapping** in an adjunct clause
  (6) *Sara made pizza [because Kelly **[e]** pasta].

(paradigm adapted from Schwartz, 1999, p. 638, (6a)–(6d))

Interpretation contrast

VPE and **Gapping** in English differ in terms of whether they permit the argument following the conjunction to be interpreted as the missing verb's subject or object

Interpretation contrast: Gapping

(7) Mom hugged the boy at home and
Dad **[e]** in the park / and **[e]** Dad in the park.

a. Subject reading (SR):
'Mom hugged the boy at home and **Dad** hugged the boy in the park.'

b. Object reading (OR):
'Mom hugged the boy at home and Mom hugged **Dad** in the park.'

→ **ambiguous**

Interpretation contrast: VPE

(8) Mom hugged the boy at home and Dad did **[e]** too.

a. SR:
'Mom hugged the boy at home and **Dad** hugged the boy at home.'

b. OR:
*'Mom hugged the boy at home and Mom hugged **Dad** at home.'

→ **unambiguous**

Previous acquisition research

- Availability of both sloppy and strict interpretations of elided pronouns in **VPE** (L1 acquisition research only)

  (Foley, Núñez del Prado, Barbier, & Lust, 2003; Thornton & Wexler, 1999; for Korean, see J. Kim, 2012; for Chinese, see Su, 2013)

- Parallelism constraint in **VPE** (L1/L2 acquisition research)

  (for L1 acquisition, see Matsuo, 2007; Matsuo & Duffield, 2001; for L2 acquisition, see Al-Thubaiti, 2019; Duffield & Matsuo, 2009; Hawkins, 2012)

- Direction of **Gapping** (L2 acquisition research only)

  (for English, see O'Grady, 1999; for Japanese, see Kanno, 1999; O'Grady, 1999)

Learnability problems

- The contrasts at issue constitute **learnability problems** both in L1 acquisition and in L2 acquisition by L1-Korean L2ers:

  (a) The contrasts cannot be learned from TL input
  (b) They cannot be acquired via analogy between the two phenomena
  (c) For the L2ers, they are not present in the L1
  (d) For the L2ers, they are not explicitly taught in the L2 classroom

  (Crain, 1991; Schwartz & Sprouse, 2000, 2013)

Study 1

NLP analysis

of VPE and Gapping

- How (in)frequent are **VPE** and **Gapping** in input to L1-English children?
- How (in)frequent are **VPE** and **Gapping** in input to L1-Korean L2ers of English?

Data collection: Native English input data

- The data in CHILDES were selected based on the age of children: 3;0–5;11 (e.g., Sarah, Adam, Laura, Ross)
  - 3-year-old sub-corpus: 44,111 utterances
  - 4-year-old sub-corpus: 28,447 utterances
  - 5-year-old sub-corpus: 13,262 utterances

  → **Native English input corpus: 85,820 utterances**

Data collection: EFL input data

- The EFL (English as a foreign language) input that students from elementary school to high school receive in the L1-Korean context
- 4 types of data
  - L1-Korean EFL teacher speech: 3,311 utterances
  - L1-English EFL teacher speech: 2,037 utterances
  - Spoken input from EFL textbooks: 13,900 utterances
  - Written input from EFL textbooks: 25,398 utterances

  → **EFL input corpus: 44,646 utterances**

Data analysis

- The data were analyzed in 3 stages in Python
  1. Data were parsed with spaCy and Benepar

     (Honnibal & Montani, to appear; Kitaev & Klein, 2018)

  2. (a) **VPE**: A sentence was split into clauses and then a clause containing any auxiliary verb (e.g., *be*, *do*, *have*), modal verb, negation (*not*), or *to*-infinitive was identified; if such a trigger was not followed by another verb or an NP in the clause, that clause was extracted as a **VPE** candidate

     (b) **Gapping**: Clauses that lack a verb were identified

  3. The extracted clauses were manually checked for instances of **VPE** and **Gapping**

Results: Native English input

- VPE appeared 1,992 times (2.32%)
- VPE occurred mostly as a separate utterance in a dialogue (1,659 cases, 1.93%)

(9) Child: *Let's go to California now.*
Father: *No, you can't.*

(from the CHILDES data: Ross_031114)

- VPE did not occur frequently in a conjunct clause (35 cases, 0.04%) or in an adjunct clause (55 cases, 0.06%)
- Gapping was extremely rare (4 cases, 0.005%): One case had a SR and three cases had an OR

Results: EFL input

- VPE appeared 602 times (1.35%)
- VPE occurred mostly as a separate utterance in a dialogue (561 cases, 1.26%)
- There was no VPE at all in a conjunct clause and only 1 instance of VPE in an adjunct clause
- Gapping was extremely rare (2 cases, 0.005%): All cases had a SR

Findings

In both the native English input and the EFL input, there were:

- Very few VPE instances in adjunct clauses
- Very few occurrences of Gapping

→ Input alone cannot lead L1-English children and L1-Korean L2ers of English to acquire the grammaticality and interpretation contrasts between VPE and Gapping

Study 2

L1/L2 acquisition of grammaticality contrast between VPE and Gapping

- How early do L1-English-acquiring children know the contrast between licit vs. illicit VPE and Gapping in English?
- Do early and late L1-Korean L2ers of English come to know the contrast between licit vs. illicit VPE and Gapping in English? What role does L2 proficiency play?

Method: Participants

	Age at testing	Age of English onset
L1 Adults (*n* = 70)	23.27 (*SD* = 5.19; range = 18–49)	NA
L1 Children (*n* = 33)	5.76 (*SD* = 1.03; range = 3–7)	NA
Early L2ers (*n* = 27)	8.52 (*SD* = 1.63; range = 5–12)	4.96 (*SD* = 0.76; range = 4–6)
Late L2ers (*n* = 30)	23.03 (*SD* = 2.92; range = 18–30)	8.83 (*SD* = 1.09; range = 8–12)

Proficiency: Late L2ers > Early L2ers ($p < .001$)

Method: Procedure

1. Language background questionnaire
2. Acceptability judgment task (AJT)
3. Picture-sentence matching task (PSMT; Study 3)
4. Picture narration proficiency task

(K.-S. Park, 2014)

Method: AJT

- Participants were presented with an audio stimulus as well as its corresponding written sentence; they then judged acceptability of sentences by pressing one of five buttons

- 2 × 2 Latin-square design
  - *Construction*: VPE vs. Gapping
  - *Clause*: Conjunct vs. Adjunct

Method: Sample target stimuli

- VPE in a conjunct clause (*k* = 6)
  (3) Sara made pizza and Kelly did **[e]** too.
- VPE in an adjunct clause (*k* = 6)
  (4) Sara made pizza because Kelly did **[e]**.
- Gapping in a conjunct clause (*k* = 6)
  (5) Sara made pizza and Kelly **[e]** pasta.
- *Gapping in an adjunct clause (*k* = 6)
  (6) *Sara made pizza because Kelly **[e]** pasta.

(paradigm adapted from Schwartz, 1999, p. 638, (6a)–(6d))

cf. *Backward Gapping (*k* = 3)
(10) *Ryan **[e]** the chair, and I liked the desk.

Results: By group

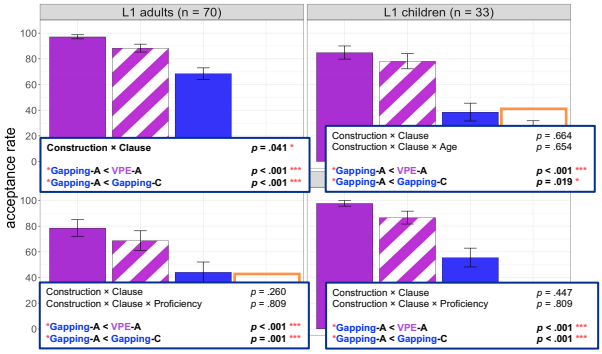

Figure 1. Acceptance rate (in %) in the acceptability judgment task per condition and group. Error bars indicate 95% CIs.

Data analysis: Age/Proficiency effect

- A simple linear regression analysis on the sensitivity to the *grammaticality contrast between* VPE and Gapping with *Age* (for L1 children) or *Proficiency scores* (for early L2ers) as an independent variable
- Procedure for calculating the sensitivity scores

  ([Mean acceptance rate for VPE-C]
  + [Mean acceptance rate for VPE-A]
  + [Mean acceptance rate for Gapping-C]) / 3
  − [Mean acceptance rate for *Gapping-A]

Results: Age effect in L1 children

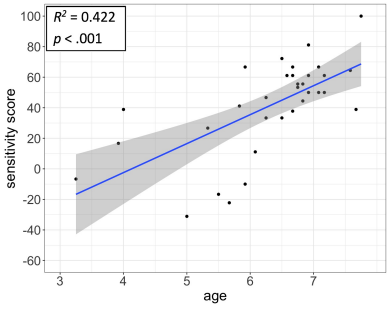

Figure 2. Relation between the L1 children' age and sensitivity scores on the acceptability judgment task. The shaded region shows the 95% CIs.

Results: Proficiency effect in Early L2ers

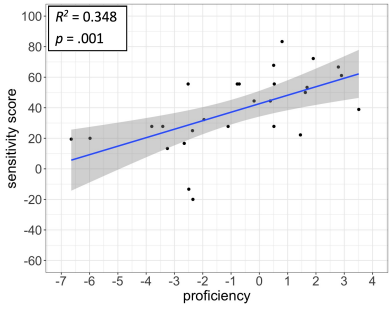

Figure 3. Relation between the early L2ers' proficiency and sensitivity scores on the acceptability judgment task. The shaded region shows the 95% CIs.

Data analysis: By individual

- *Age* served as a guideline for the L1 children and *Proficiency scores* served as a guideline for L2ers
- Criteria
  - (a) Knowledge of VPE (8–12 correct out of 12)
  - (b) Knowledge of the ungrammaticality of *backward Gapping (3 correct out of 3)
  - (c) Knowledge of the ungrammaticality of *Gapping-A (5–6 correct out of 6)
  - (d) Knowledge of the contrast between Gapping-C and *Gapping-A (number of accepted items for Gapping-C > *Gapping-A)

Results: By individual

- L1 children mastered the grammaticality contrast between VPE and Gapping as early as age 5;11
- 4 (out of 27) early L2ers and 20 (out of 30) late L2ers showed clear evidence of having acquired the grammaticality contrast

Finding

- Older L1 children and (early and late) L2ers with higher proficiency are able to overcome the learnability problems involved in the grammaticality contrast at issue

Study 3

L1/L2 acquisition of the interpretation contrast between VPE and Gapping

- How early do L1-English-acquiring children know the contrast between possible vs. impossible interpretations of VPE and Gapping in English?
- Do early and late L1-Korean L2ers of English come to know the contrast between possible vs. impossible interpretations of VPE and Gapping in English? What role does L2 proficiency play?

Method: Participants

	Age at testing	Age of English onset
L1 Adults (*n* = 32)	23.78 (*SD* = 5.76; range = 19–49)	NA
L1 Children (*n* = 24)	5.92 (*SD* = 0.65; range = 5–7)	NA
Early L2ers (*n* = 27)	8.52 (*SD* = 1.63; range = 5–12)	4.96 (*SD* = 0.76; range = 4–6)
Late L2ers (*n* = 30)	23.03 (*SD* = 2.92; range = 18–30)	8.83 (*SD* = 1.09; range = 8–12)

Method: PSMT

- Participants were presented with a pair of pictures along with a monoclausal description of each picture; they then judged whether the subsequent target sentence matched the pair of pictures by pressing one of three buttons

- 2 × 2 Latin-square design
  - *Construction*: VPE vs. Gapping
  - *Interpretation*: SR vs. OR

Method: Sample target stimuli

VPE-SR (MATCH; κ = 4)	
Context: Mom hugged the boy at home.	Dad hugged the boy at home too.
	
Target: Mom hugged the boy at home and Dad did too.	

*VPE-OR (MISMATCH; κ = 4)	
Context: Mom hugged the boy at home.	Mom hugged Dad at home too.
	
Target: Mom hugged the boy at home and Dad did too.	

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Method: Sample target stimuli

Gapping-SR (MATCH; κ = 4)	
Context: Mom hugged the boy at home.	Dad hugged the boy in the park.
	
Target: Mom hugged the boy at home and Dad in the park.	

Gapping-OR (MATCH; κ = 4)	
Context: Mom hugged the boy at home.	Mom hugged Dad in the park.
	
Target: Mom hugged the boy at home and Dad in the park.	

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Results: By group

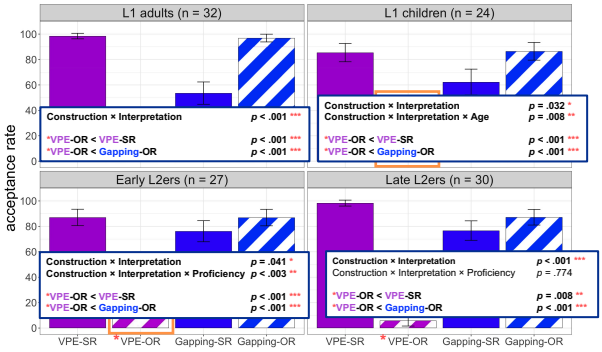

Figure 4. Acceptance rate in the picture-sentence matching task per condition and group. Error bars indicate 95% CIs.

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Data analysis: Age/Proficiency effect

- A simple linear regression analysis on the sensitivity to the *interpretation contrast between* VPE and Gapping with *Age* (for L1 children) or *Proficiency scores* (for early L2ers) as an independent variable
- Procedure for calculating the sensitivity scores

  ([Mean acceptance rate for VPE-SR]
  + [Mean acceptance rate for Gapping-SR]
  + [Mean acceptance rate for Gapping-OR]) / 3
  − [Mean acceptance rate for *VPE-OR]

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Results: Age effect in L1 children

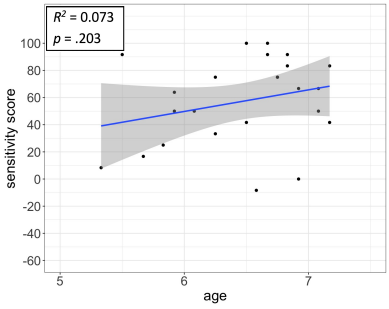

Figure 5. Relation between the L1 children's ages and sensitivity scores on the picture-sentence matching task. The shaded region shows the 95% CIs.

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Results: Proficiency effect in Early L2ers

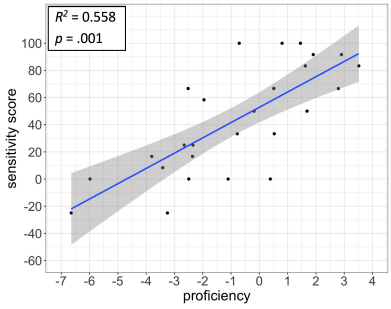

Figure 6. Relation between the early L2ers' proficiency and sensitivity scores on the picture-sentence matching task. The shaded region shows the 95% CIs.

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Data analysis: By individual

- *Age* served as a guideline for the L1 children and *Proficiency scores* served as a guideline for L2ers
- Criteria
  - (a) Knowledge of the grammaticality of VPE-SR (3–4 correct out of 4)
  - (b) Knowledge of the grammaticality of Gapping-OR (3–4 correct out of 4)
  - (c) Knowledge of the the contrast between VPE-SR and *VPE-OR (number of the correct items for VPE-SR > *VPE-OR)
  - (d) Knowledge of the ungrammaticality of *VPE-OR (3–4 correct out of 4)

Results: By individual

- L1 children mastered the interpretation contrast between VPE and Gapping as early as age 5;6
- 12 (out of 27) early L2ers and 26 (out of 30) late L2ers showed clear evidence of having acquired the target contrast

Finding

- Older L1 children and (early and late) L2ers with higher proficiency are able to overcome the learnability problems involved in the interpretation contrast at issue

Study 4

L1/L2 processing of Gapping

- Can English native speakers and adult L1-Korean L2ers of English recognize and resolve a verb gap in Gapping sentences in real time?
- For the L2ers, what role does L2 proficiency play?

Method: Participants

	Age at testing	Age of English Onset	Cloze proficiency test score (Brown, 1980)
English native speakers (L1-English; *n* = 53)	21.58 (*SD* = 4.72; range = 18–46)	NA	38.89 (*SD* = 5.88; range = 22–50)
L1-Korean L2ers of English (L2-English; *n* = 48)	22.71 (*SD* = 2.95; range = 18–29)	7.85 (*SD* = 1.96; range = 4–13)	30.71 (*SD* = 8.84; range = 11–47)

Method: Procedure

1. Language background questionnaire
2. Self-paced reading task (SPRT)
3. Cloze proficiency test

(Brown, 1980)

Method: SPRT

Prediction at Segment 8 and/or Segment 9
- Gapping-P < *Gapping-I
- VPE-P ≈ VPE-I

- Critical sentences (k = 5 per condition)

Segment / Condition	1	2	3	4	5	6	7	8 critical region	9 spill-over region	10
Gapping-P	Bill	ordered	coffee	and tea	at the cafe,	and	Jane	**[e]** sandwiches	and cake	at the bakery.
*Gapping-I	Bill	drank	coffee	and tea	at the cafe,	and	Jane	**[e]** sandwiches	and cake	at the bakery.
VPE-P (baseline)	Bill	ordered	coffee	and tea	at the cafe,	and	Jane	did **[e]**	too	with his brother.
VPE-I (baseline)	Bill	drank	coffee	and tea	at the cafe,	and	Jane	did **[e]**	too	with his brother.

Notes. The Gapping condition sentences were modeled on those from Kaan, Wijnen, & Swaab (2004). The VPE conditions were included as a baseline; the so-called VPE-I condition sentences were not themselves 'implausible' but made use of the same verbs as the *Gapping-I condition sentences as a control.

Results: By group

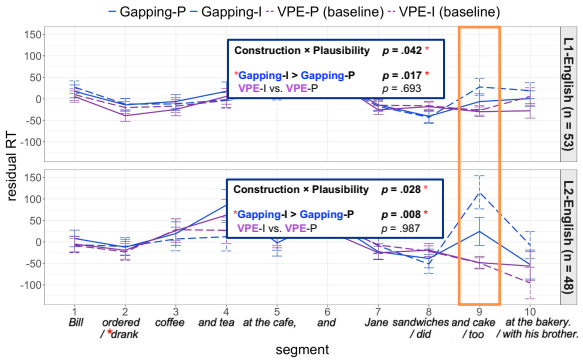

Figure 7. Mean residual RTs (in ms) per segment, condition, and group. The error bars indicate 95% CIs.

Finding

- Both native speakers and L2ers with relatively high proficiency posit a verb gap and reconstruct the verb information at the gap position when reading Gapping sentences

Conclusion

Conclusion: Acquisition studies

- L1-English children succeeded in acquiring the grammaticality contrast between VPE and Gapping as early as age 5;11 and the interpretation contrast between VPE and Gapping as early as age 5;6
- Higher-proficiency early L2ers and most of the late L2ers had also mastered both contrasts

Conclusion: Acquisition studies

- Note that the contrasts at issue constitute learnability problems both for L1 children and for L1-Korean L2ers of English:
  - (a) The contrasts cannot be learned from TL input alone
  - (b) They cannot be acquired via analogy between the two phenomena
  - (c) For the L2ers, they are not present in the L1
  - (d) For the L2ers, they are not explicitly taught in the L2 classroom

(Schwartz & Sprouse, 2000, 2013)

→ **The findings from the two acquisition studies provide evidence that the domain-specific cognitive system that constrains L1 acquisition also constrains L2 acquisition**

Conclusion: Processing study

- L2ers, like native speakers, can posit a verb gap and reconstruct the verb information at the gap position in **Gapping**

  → This suggests that L2ers can represent and process verb gaps in a target-like way

  → **L2ers can make use of syntactic information during real-time sentence processing**

  → **L2ers' parsing mechanisms are not qualitatively different from those of native speakers**

REFERENCES (1/2)

Al-Thubaiti, K. A. (2019). Selective vulnerability in very advanced L2 grammars: Evidence from VPE constraints. *Second Language Research*, *35*, 225–252.

Brown, J. D. (1980). Relative merits of four methods for scoring cloze tests. *The Modern Language Journal*, *64*, 311–317.

Chomsky, N. (1995). *The minimalist program*. Cambridge, MA: MIT Press.

Crain, S. (1991). Language acquisition in the absence of experience. *Behavioral and Brain Sciences*, *14*, 597–650.

Duffield, N. G., & Matsuo, A. (2009). Native speakers' versus L2 learners' sensitivity to parallelism. *Studies in Second Language Acquisition*, *31*, 93–123.

Fiengo, R., & May, R. (1994). *Indices and identity*. Cambridge, MA: MIT Press.

Foley, C., Núñez del Prado, Z., Barbier, I., & Lust, B. (2003). Knowledge of variable binding in VP-ellipsis: Language acquisition research and theory converge. *Syntax*, *6*, 52–83.

Hankamer, J., & Sag, I. (1976). Deep and surface anaphora. *Linguistic Inquiry, 7*, 391–428.

Hawkins, R. (2012). Knowledge of English verb phrase ellipsis by speakers of Arabic and Chinese. *Linguistic Approaches to Bilingualism*, *2*, 404–438.

Honnibal, M., &, Montani, I. (to appear). spaCy 2: Natural language understanding with bloom embeddings, convolutional neural networks and incremental parsing. Available from https://spacy.io/

Johnson, K. (2000). Gapping determiners. In K. Schwabe & N. Zhang (Eds.), *Ellipsis in conjunction* (pp. 95–115). Tübingen, Germany: Niemeyer.

Johnson, K. (2009). Gapping is not (VP-) ellipsis. *Linguistic Inquiry*, *40*, 289–328.

Kaan, E., Wijnen, F., & Swaab, T. Y. (2004). Gapping: Electrophysiological evidence for immediate processing of "missing" verbs in sentence comprehension. *Brain and Language*, *89*, 584–592.

Kanno, K. (1999). Acquisition of verb gapping in Japanese by Mandarin and English speakers. In K. Kanno (Ed.), *The acquisition of Japanese as a second language* (pp. 159–173). Amsterdam: John Benjamins.

REFERENCES (2/2)

Kim, J. (2012). *Comprehension of elided phrases in Korean and English: VP-ellipsis, null object constructions, and one-substitution* (Unpublished doctoral dissertation). University of Hawai'i at Mānoa, Honolulu, HI.

Kitaev, N., & Klein, D. (2018). Constituency parsing with a self-attentive encoder. In I. Gurevych & Y. Miyao (Eds.), *Proceedings of the 56th Annual Meeting of the Association for Computational Linguistics* (Vol. 1, pp. 2676–2686). Melbourne, Australia: Association for Computational Linguistics.

Matsuo, A. (2007). Differing interpretations of empty categories in English and Japanese VP ellipsis contexts. *Language Acquisition*, *14*, 3–29.

Matsuo, A., & Duffield, N. (2001). VP-ellipsis and anaphora in child language acquisition. *Language Acquisition*, *9*, 301–327.

O'Grady, W. (1999). Gapping and coordination in second language acquisition. In K. Kanno (Ed.), *The acquisition of Japanese as a second language* (pp. 141–157). Amsterdam: John Benjamins.

Park, K.-S. (2014). *Information structure and dative word-order alternations in English and Korean: L1 children, L2 children, and L2 adults* (Unpublished doctoral dissertation). University of Hawai'i at Mānoa, Honolulu, HI.

Schwartz, B. D. (1999). Let's make up your mind: "Special nativist" perspectives on language, modularity of mind, and nonnative language acquisition. *Studies in Second Language Acquisition*, *21*, 635–655.

Schwartz, B. D., & Sprouse, R. A. (2000). When syntactic theories evolve: Consequences for L2 acquisition research. In J. Archibald (Ed.), *Second language acquisition and linguistic theory* (pp. 156–186). Malden, MA: Blackwell.

Schwartz, B. D., & Sprouse, R. A. (2013). Generative approaches and the poverty of the stimulus. In J. Herschensohn & M. Young-Scholten (Eds.), *Handbook of second language acquisition* (pp. 137–158). Cambridge, UK: Cambridge University Press.

Su, Yi-Ching. (2013). Interpretations of VP-ellipsis sentences in Mandarin. In S. Stavrakaki, P. Konstantinopoulou & M. Lalioti (Eds.), *Advances in language acquisition* (pp. 200–206). New Castle, UK: Cambridge Scholars Publishing.

Thornton, R., & Wexler, K. (1999). *Principle B, VP ellipsis, and interpretation in child grammar*. Cambridge, MA: MIT Press.

THANK YOU!

Special thanks to:

Leilani Au, Les Black, Robert Bley-Vroman, Jeffrey Bock, Amber Camp, Dustin Crowther, Kamil Deen, Micha Elsner, Bonnie Fox, Shin Fukuda, Theres Grüter, Sanghyun Han, Holger Hopp, Haeji Hwang, Chae Kamikawa, Hyunwoo Kim, Jihyun Kim, Rakhun Kim, Heejeong Ko, Kristopher Kyle, Eunsun Lee, Jeff Lidz, Ju Young Min, William O'Grady, Akari Ohba, Alison Onishi, Yangon Rah, Jeffrey Runner, Amy Schafer, Bonnie D. Schwartz, Fukuda Shin, Rex A. Sprouse, Katherine Strong, Kristen Syrett, Nozomi Tanaka, Kristen Urada, Hyunkwon Yang, Fred Zenker