Unveiling the Parallel Function Hypothesis on Personal Pronouns: A Corpus Analysis Utilizing Eye-Tracking Data

The 11th Conference on Language, Discourse, and Cognition (CLDC11)

Yue Chen

University of California, Los Angeles

May 4th 2024

Background

UCLA

- This study investigates the influence of the Parallel Functioning Hypothesis on first fixation duration, number of fixations, and number of skips during sentence processing by using the LARC-ID eye-tracking dataset [7]

Parallel Functioning Hypothesis (PFH)

UCLA

- In complex sentences, the presence of the pronoun and its referential noun phrases (NPs) within the same grammatical functional category leads to Parallel Function Pronoun Resolution (PFR) [11][6]
- PFR results in easier and quicker processing when the pronouns and their referents fall into the same grammatical function category (Parallel Function), compared to Non-Parallel Function Pronoun Resolution (NPFR) [4][11][6]
- This phenomenon has been observed in both adults and children, indicating that participants of all ages benefit from the Parallel Functioning Hypothesis by experiencing reduced processing time for pronoun resolution [1][3]

Grammatical Function Type (Parallel and Nonparallel Function)

UCLA

Pronoun Grammatical Function	Antecedent NP Function	Sentence Label	Sentence Example
Subject	Subject	Parallel	**Nathan** disliked Aron and similarly, **he** hated Nicole for a while and in the end, they all avoided each other
Subject	Object	Non-Parallel	**Fiona** defeated in the court and so James congratulated **her** after the match but nobody took any notice.

Table: Examples of Parallel and Non-Parallel Sentences

Pronoun Interpretation

UCLA

- Pronoun interpretation is influenced by both linguistic contexts, such as syntactic structures, social cues, eye gaze, and physical gestures [1] [3]
- People employ previous linguistic experiences, context, linguistic cues, gender, number, pragmatics, and semantics to disambiguate pronoun understanding [12][10]
- People experience significantly increasing processing time of an intar-sentential sentence compared to an inter-sentential sentence [2]

Sentence Type (Intrasentential and Intersentential)

UCLA

Sentence Label	Sentence Example
Intra	**Lemuel** knew most of their faces by now, and even some of their names. They didn't let on that they noticed **him**, and maybe they didn't see **him** at all.
Inter	**Lemuel** sat down just out of her reach and tried to say **he** was sorry, but nothing would come.

Table: Examples of Intra and Inter Sentences

Sentence Type (SO, SS, OS)

UCLA

Antecedent NP Function	Pronoun Grammatical Function	Sentence Label	Sentence Example
Subject	Object	SO	**Lemuel** pondered the dots for some time, avoiding the extreme right-hand edge of the map, thinking that perhaps he would like to visit a place where everyone was very small. But in the photographs the people looking back at **him** seemed to be the same size as anyone else.
Subject	Subject	SS	**Lemuel** knew that if he was with her she'd have to slow down for him
Object	Subject	OS	If a thing like that touched him at all, Lemuel thought - but he could not imagine what would happen then.

Table: Examples of SO, SS, OS Sentence

Research Question

UCLA

- From a naturalistic reading perspective will the personal pronoun regulation obey the Parallel Functioning Hypothesis?
- Will the different grammatical functions of personal pronouns (SS, SO, OS) influence how people process referents?
- Will different sentence structures (inter and intar) influence how people process referents?
- How do previous knowledge and experiences influence an individual's pronoun resolution?

Data Set

UCLA

- This study utilized the LARC-ID eye-tracking dataset [7]
- 15 participants (10 females, 5 males) were recruited for the LARC-ID dataset
- All participants were native English speakers with a mean age of 19 years (SD = 1.13 years), ranging from 18 to 22 years
- All participants had some college experience, with an average of 2 years (range: 1-4 years)

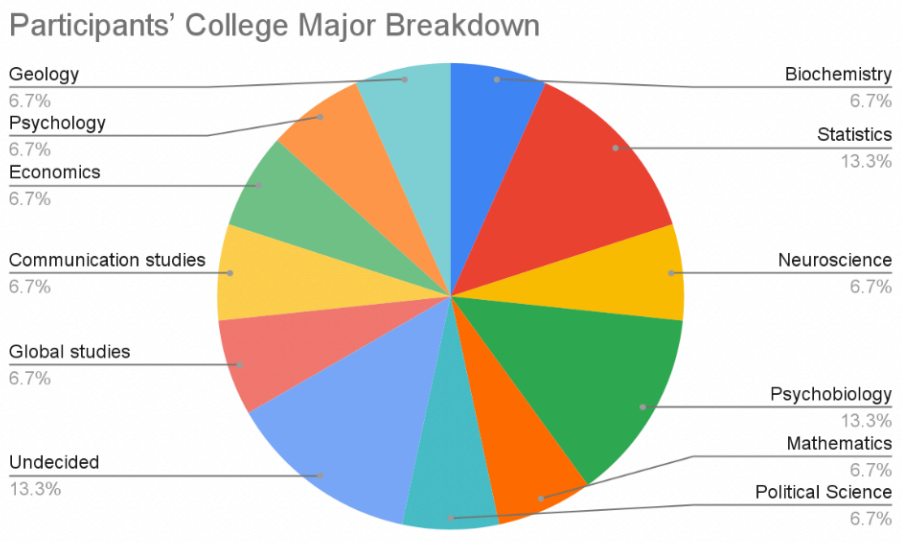

Figure: Participants Demographics

Data Annotation

UCLA

- In total, 12 sentences were selected
  - 6 PF sentence and 6 NPF sentences
  - 6 PF sentence and 6 NPF sentences
- Four main areas of a sentence
  - Target subject (the referent of the pronoun)
  - Target pronoun
  - Pronoun Region A (two words before the target pronoun)
  - Pronoun Region B (two words after the target pronoun)

Example From the Corpus

If a thing like **that touched** (Pronoun Region A) **him** (Target Pronoun) at all, **and sometimes** (Pronoun Region B) **Lemuel** (Target Subject) thought - but he could not imagine what would happen then.

Result

UCLA

- PF vs. NPF Sentences:
  - Slight differences in first fixation duration were observed between Parallel Function (PF) and Non-Parallel Function (NPF) sentences.
  - More skips are seen in PF sentences compared to NPF sentences.

Measurements	First Fixation Mean (ms)		Number of Fixations		Number of Skips		Total Count	
Group	PF	NPF	PF	NPF	PF	NPF	PF	NPF
Target Subject (SUB)	218.23	216.59	71	75	19	15	90	90
Target Pronoun (PRO)	195.13	198.95	41	43	49	47	90	90
Pronoun Region A	212	211	101	120	19	5	120	125
Pronoun Region B	217	218	119	96	6	7	125	103

Figure: PF and NPF Comparison

Result

UCLA

- SS, SO, and OS Structures:
  - Subject-subject (SS) structures were most common, followed by subject-object (SO), and least common was object-subject (OS)
  - In SO structures, the subject had the longest first fixation duration, while the target pronoun had the shortest
  - Pronoun region B in SO structures had the longest first fixation duration

Measurements	First Fixation Mean (ms)			Number of Fixations			Number of Skips			Total Count		
Group	SO	SS	OS	SO	SS	OS	SO	SS	OS	SO	SS	OS
Target Subject (SUB)	219.34	218.23	200.55	64	71	11	11	19	4	75	90	15
Target Pronoun (PRO)	194.48	217.07	213.7	33	41	10	42	49	5	75	90	15
Pronoun Region A	211.19	212.07	209.75	104	101	16	4	19	2	108	120	18
Pronoun Region B	220.77	217.58	204	81	119	15	6	6	2	87	125	17

Notes: SO $N = 5$, SS $N = 6$, OS $N = 1$

Figure: SO SS and OS Comparison

Result

UCLA

- Intra vs. Inter-sentential Sentences:
  - Intra-sentential structures had longer first fixation duration compared to inter-sentential structures.
  - More skips occurred in inter-sentential structures.

Measurements	First Fixation Mean (ms)		Number of Fixations		Number of Skips		Total Count	
Group	Intra	Inter	Intra	Inter	Intra	Inter	Intra	Inter
Target Subject (SUB)	224.21	214.14	47	99	13	21	60	120
Target Pronoun (PRO)	195.13	212.87	24	60	36	60	60	120
Pronoun Region A	214.58	210.43	56	165	3	21	59	186
Pronoun Region B	225.12	214.4	69	146	5	8	74	154

Notes: Intra $N = 4$, Inter $N = 8$

Figure: Inter and Intra Sentence Comparison

Discussion

UCLA

- The findings suggest that participants might use the grammatical positions of the target subject and pronouns as cognitive strategies for allocating processing resources based on the position of pronouns and their referents, which align with previous research on pronoun resolution, highlighting the role of salience and contextual cues in guiding participants' processing and interpretation [1][2][5]
- The salience and position of the referent impact the processing dynamics of pronouns within a sentence [8]
- The frequency of specific sentence structures in natural languages may also influence participants' processing time. More frequent structures are processed more efficiently due to participants' linguistic experience [9][13]

Conclusion

UCLA

- There are minimal differences between Parallel Function and Non-Parallel Function sentences, failing to provide positive support in favor of this hypothesis.
- The intrasentential structures lead to longer first fixation duration for the target subject, target pronoun, and both pronoun regions compared to intersentential structures.
- The grammatical positions of the subjects and the pronouns indicate that when the subject and pronoun are in the subject-object position, participants exhibit longer first fixation duration at the subject and shorter first fixation duration at the target pronoun.

References

[1] Jennifer E Arnold and Shin-Yi C Lao. "Effects of psychological attention on pronoun comprehension". In: *Language, cognition and neuroscience* 30.7 (2015), pp. 832–852.

[2] Susan E Brennan, Marilyn W Friedman, and Carl Pollard. "A centering approach to pronouns". In: *25th annual meeting of the association for computational linguistics*. 1987, pp. 155–162.

[3] Yu-Chin Chien and Kenneth Wexler. "Children's knowledge of locality conditions in binding as evidence for the modularity of syntax and pragmatics". In: *Language acquisition* 1.3 (1990), pp. 225–295.

[4] Emrah Cinkara and Neşe Cabaroğlu. "Parallel functioning hypothesis to explain pronoun resolution and processing load: Evidence from eye-tracking". In: *Journal of Quantitative Linguistics* 22.2 (2015), pp. 119–134.

[5] Alan Garnham. *Mental models and the interpretation of anaphora*. Psychology Press, 2013.

[6] Ellen H Grober, William Beardsley, and Alfonso Caramazza. "Parallel function strategy in pronoun assignment". In: *Cognition* 6.2 (1978), pp. 117–133.

[7] Jesse Harris and Stephanie Rich. "Los Angeles Reading Corpus of Individual Differences: Pilot distribution and analysis". In: *Proceedings of the Annual Meeting of the Cognitive Science Society*. Vol. 43. 43. 2021.

[8] Maryellen C MacDonald. "How language production shapes language form and comprehension". In: *Frontiers in psychology* 4 (2013), p. 40296.

[9] Jessica L Montag and Maryellen C MacDonald. "Text exposure predicts spoken production of complex sentences in 8-and 12-year-old children and adults.". In: *Journal of Experimental Psychology: General* 144.2 (2015), p. 447.

[10] Yuriko Oshima-Takane. "Children learn from speech not addressed to them: The case of personal pronouns". In: *Journal of Child language* 15.1 (1988), pp. 95–108.

[11] Amy Sheldon. "The role of parallel function in the acquisition of relative clauses in English". In: *Journal of verbal learning and verbal behavior* 13.3 (1974), pp. 272–281.

[12] Sandrine Sorlin and Laure Gardelle. "The Pragmatics of Personal Pronouns". In: (2015).

[13] Michael K Tanenhaus and John C Trueswell. "Sentence comprehension.". In: (1995).

Acknowledgement

I am deeply grateful to my undergraduate thesis supervisor Dr. Jesse Harris from UCLA for his guidance and help throughout this project; Dr. Stephanie Rich for her help with data collection; the UCLA linguistics department for providing financial support for this project; all members of the UCLA language processing lab for their comments and suggestions and the participants who participated in this study.