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Psycholinguistic Study on Japanese Sentence Processing

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Language
Lingua
Linguistic Inquiry
Journal of Japanese Linguistics
Journal of Quantitative Linguistics
言語研究

言語学
linguistics

心理言語学
(psycholinguistics)

Psychonomic Bulletin and Review
Journal of Experimental Psychology: Learning, Memory and Cognition
Psychological Research
PLoS ONE
心理学研究

Journal of Neurolinguistics
Applied Psycholinguistics
Language and Speech
Journal of Psycholinguistic Research

心理学
psychology

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Movement

Ruth met Tim.

Who did Ruth meet *Trace (gap)* ?

Wh-movement

do
do-support

4

Who did Ruth meet ?

Who did Ruth meet *gap* ?

gap–filling parsing

e.g., Frazier & Clifton, 1989

5

ルースが 誰 に 会いましたか。

Ruth-*ga* Tim-*ni* ai-ma-sita.
S O V

Ruth met Tim.
S V O

***wh*-in-situ**

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Kenji ate a cake .

a cake Kenji ate.

ケーキを ケンジが *gap* 食べた。

移動操作

movement operation

scrambling

7

ケーキを ケンジが *gap* 食べた。

空所補充解析

gap-filling parsing

8

scrambling

is not obligatory.

is optional.

Scrambling in Japanese is widely regarded as an optional rule (e.g., Fukui, 1993; Saitō, 1985; Saitō and Fukui, 1985; Takano, 1998).

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My brother ate a cake.

IP (inflectional phrase)

[弟がケーキを食べる]た。 *ta*

TP (tense phrase)

NP我哥哥 VP吃了 NP蛋糕。

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Flexible Word Order

Hanko-ga *Taro-o* *nagutta.*

Hanako-NOM Taro-ACC hit-PAST

Hanako hit Taro.

Taro-o *Hanako-ga* *nagutta.*

Taro-ACC Hanako-NOM hit-PAST

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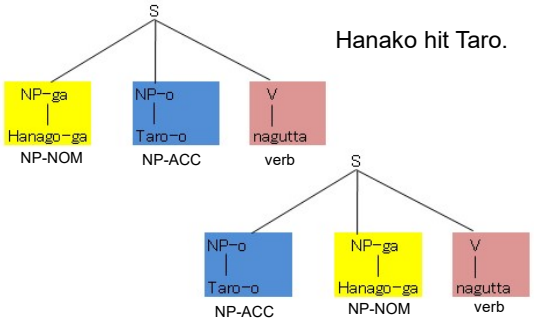
Flat structure by Nakayama (1995) and Yamashita (1997)



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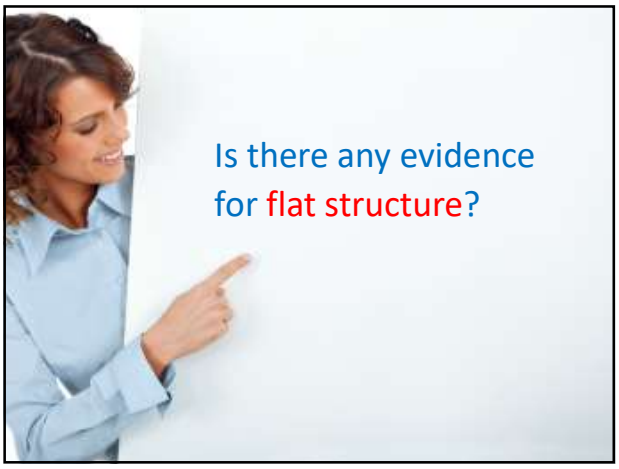

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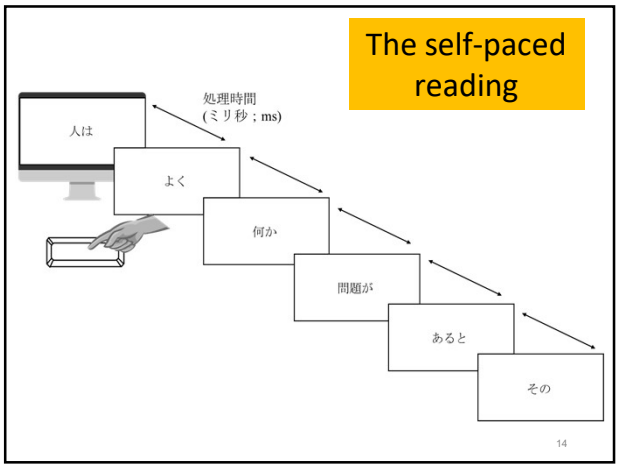

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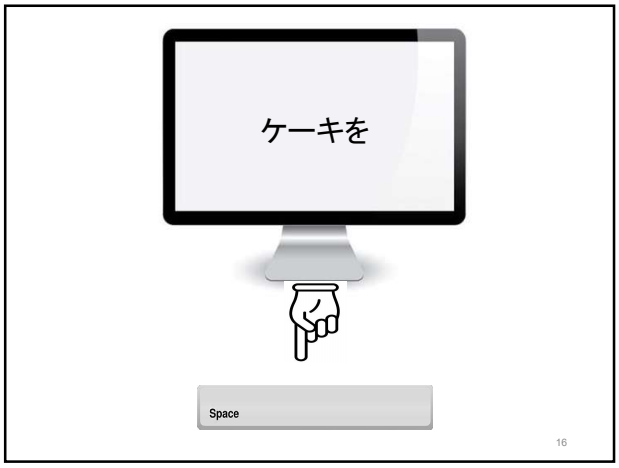

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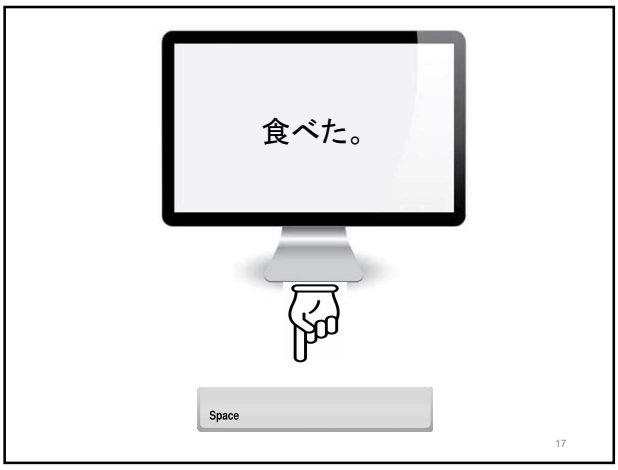

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My brother a cake eat.

弟が ケーキを 食べた。

reading time (RT_1) reading time (RT_2) reading time (RT_3)

The self-paced reading

A participant is required to read a sentence one part at a time. When the participant is finished reading a cue part, they press a key (Just, Carpenter and Woolley 1982). The duration between key presses is interpreted as the reading time for each part.

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The self-paced reading

- This method is illuminates how **complex and/or ambiguous sentences** are processed (e.g., Ferreira and Henderson 1991, MacDonald, Just and Carpenter 1992). For instance, Ferreira and Henderson (1991) used self-paced reading to show **the process of recovery from misanalysed garden-path sentences**

The complex houses married and single soldiers and their families.

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Flat structure

Nakayama (1995) and Yamashita (1997) conducted on-line sentence processing experiments using the self-paced reading method, which did not find differences in reading times between canonical and scrambled sentences.

Nakayama (1995) and Yamashita (1997) used this evidence to argue for a flat structure in nominative NP-*ga* and accusative NP-*o* construction.

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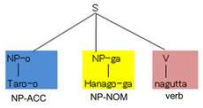
Flat strucuter = no *gap-filling parsing*



Sakamoto (2001) further elaborated on the results of Nakayama (1995) and Yamashita (1997), noting that since case particles are attached to all nouns in Japanese, clear identifications are given to functions of nouns.

Consequently, scrambled word order does not require an extra cognitive load for sentence parsing. Given this argument, the assumption of flat structure does not initiate the ***gap-filling parsing***.

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Is that true that Japanese language does not have ***a configurational syntactic structure***?

?

What is a ***gap-filling parsing***?

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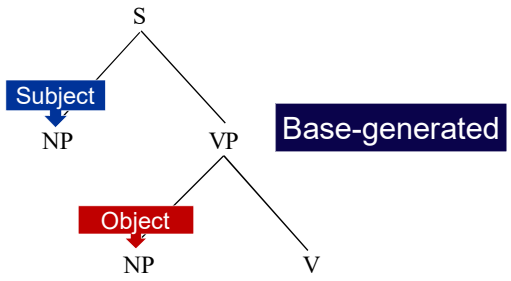
Base Structure
Japanese SOV



(1) base-structure of SOV

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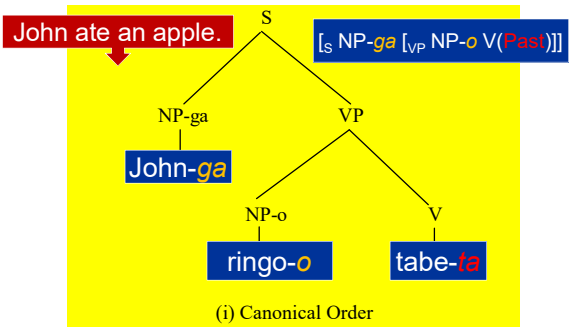
Canonical Sentence Structure
(transitive verb, no scrambling)

John ate an apple.



(i) Canonical Order

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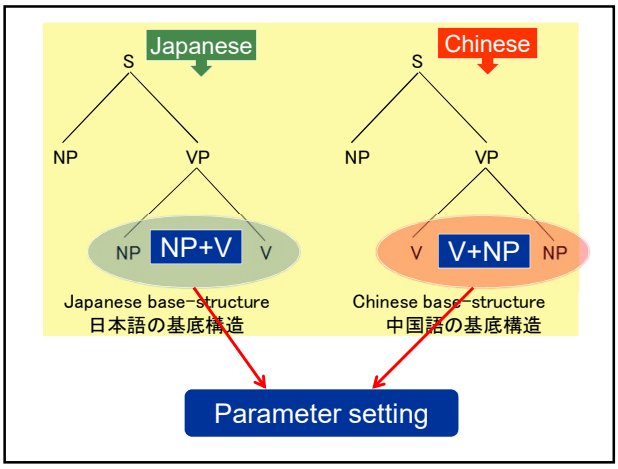

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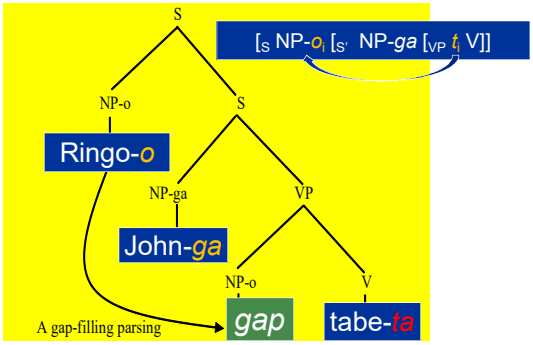
A gap filling paring



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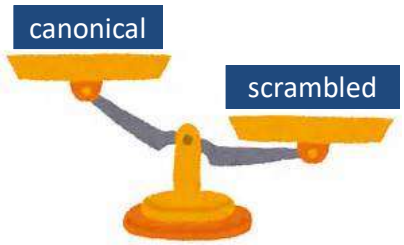

If scrambling is the result of phrasal movement based on canonical order, sentences with a scrambled order should require extra resources for sentence processing (heavier cognitive loading).

（e.g., Miyamoto & Takahashi, 2004; Tamaoka et al., 2005, 2013）

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scrambling effect(s)

The scrambling effect is manifested as a delay in processing time, in comparison with the (assumed) canonical order baseline.

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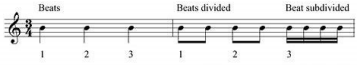
Problems of the self-paced reading

- Consider the sentence 'Michael ate sushi.' First, 'Michael' appears on the screen, and the participant reads it and press the key. Then, the past-tense verb 'ate' appears, and again, the participant presses the key, and 'sushi'. This three-beat action is all that is required for processing a simple three-phrase sentence. Native speaker can read this sentence much faster than they can press keys on a keyboard. This produces three equal reading times – each one as long as it takes the participant to press a keyboard. Thus, self-paced reading is not ideal for measuring simple sentences, like a transitive sentence containing only three phrases.



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- Self-paced reading predominately locks participants' reading to a certain region. It does **not allow a participant to read backwards** to check previously read phrases. As a result, participants must store all the previous information about a sentence in their memory before processing each part.
- Some studies (e.g., Ferreira and Henderson 1991, Koornneef and Van Berkum 2006) show on assumed effect on the word just after the critical word. This tendency is called **spill-over**.
- The motion of pressing the key to read forward phrase by phrase cannot be easily stopped, because a short-term memory is fully occupied by accumulated information withdrawn from the on-going processing of a sentence. This tendency is also likely to **flatten reading times** of phrases measured by self-paced reading.

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Because we are investigating simple transitive sentences, the self-paced reading method was not suitable for investigating the scrambling effect in Japanese.

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Processing Japanese scrambling

Tamaoka, K., Sakai, H., Kawahara, J., Miyaoka, Y., Lim, H., & Koizumi, M. (2005). Priority information used for the processing of Japanese sentences: Thematic roles, case particles or grammatical functions? *Journal of Psycholinguistic Research*, *34*, 273-324.

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Reaction time paradigm

Processing Japanese
canonical and scrambled sentences

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Processing active sentences with transitive verbs

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Stimulus sentences in **Experiment 1**

(1) Canonical active sentence (SOV)
Ototoo-*ga* keeki-*o* tabe-*ta*.
Brother-NOM a cake-ACC eat-PAST
'My brother ate a cake.'

(2) Scrambled active sentence (OSV)
Keeki-*o* ototoo-*ga* tabe-*ta*.
A cake-ACC brother-NOM eat-PAST

Sentence correctness decision task

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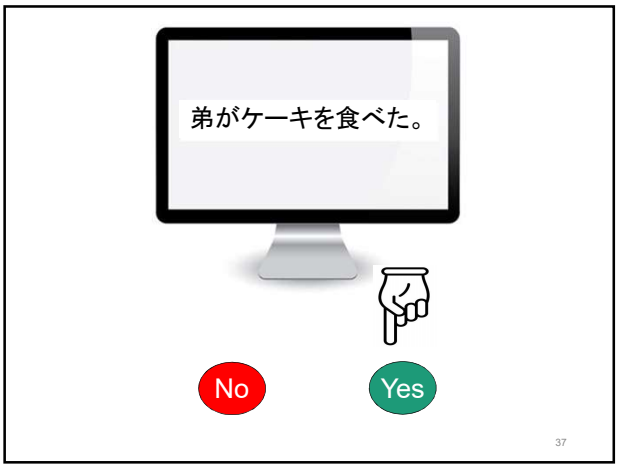

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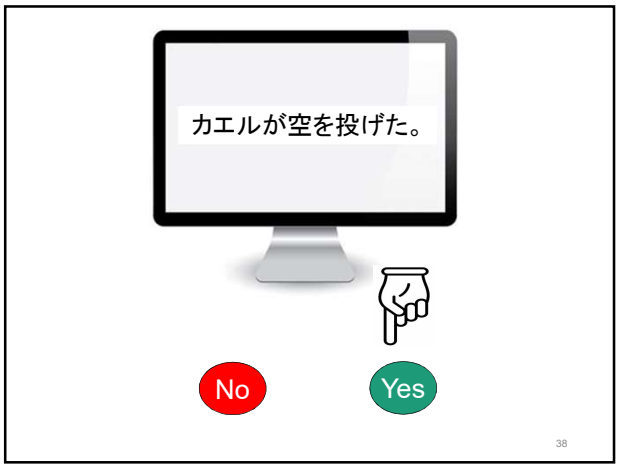

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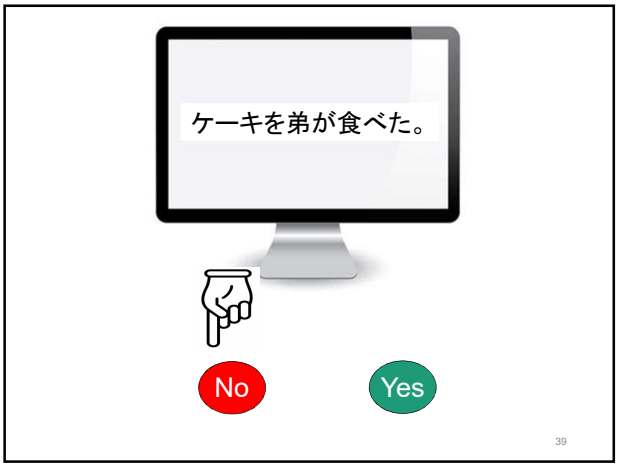

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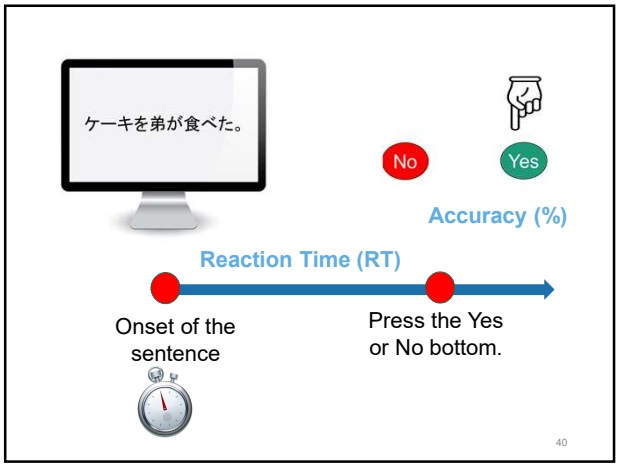

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Results of Experiment 1

Table 1 Correctness decision for Japanese sentences with two-argument verbs

Response Type	Sentence Type	Reaction Time (ms) M	Reaction Time (ms) SD	Error Rate (%) M	Error Rate (%) SD
'Yes' Responses	SOV	1209	238	3.02%	3.37%
	OSV	1432	308	9.07%	6.96%
OSV–SOV		⊿ 223	F_1 ***, F_2 ***	⊿ 6.04%	F_1 ***, F_2 ***
'No' Responses	SOV	1297	224	4.91%	6.96%
	OSV	1388	216	9.38%	9.95%
OSV–SOV		⊿ 91	F_1 ***, F_2 *n.s.*	⊿ 4.47%	F_1 *n.s.*, F_2 *n.s.*

Note: 28 subjects and 52 items for 'Yes' responses while 28 subjects and 32 items for 'No' responses.

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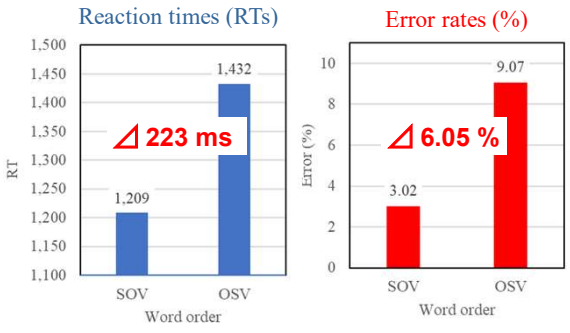
Results of Experiment 1 in the bar-graph



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Findings of Experiment 1

- Experiment 1 found a scrambling effect for active transitive sentences (for correct 'Yes' responses).
- The Gap-filling parsing might lead to longer reaction times for scrambled sentences versus canonical sentences.
- The parsing process for scrambled sentences resulted in higher error rates for scrambled sentences than canonical ones.

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Experiment 2

Processing active sentences with ditransitive verbs

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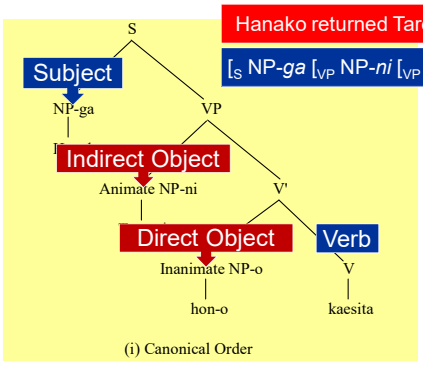
Canonical Active Sentences with Ditransitive Verbs

Hanako returned Taro a book.

[$_S$ NP-*ga* [$_{VP}$ NP-*ni* [$_{VP}$ NP-*o* V]]]



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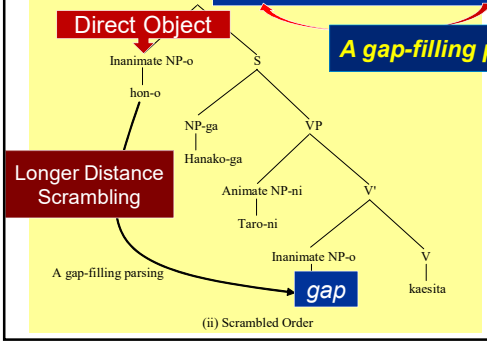
Scrambled Active Sentences with Ditransitive Verbs

[$_S$ NP-o_i [$_{S'}$ NP-*ga* [$_{VP}$ NP-*ni* [$_{V'}$ t_i NP-*o* V]]]]

A gap-filling parsing



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Results of Experiment 2

Table 3 Correctness decision for Japanese sentences with three-argument verbs

Response Type	Sentence Type	Reaction Time (ms) M	Reaction Time (ms) SD	Error Rate (%) M	Error Rate (%) SD
'Yes' Responses	SOOV	1359	320	1.79%	3.90%
	OOSV	1963	643	11.79%	17.44%
OOSV–SOOV		⊿ 604	F_1 ***, F_2 ***	⊿ 10.00%	F_1 **, F_2 ***
'No' Responses	SOOV	1436	265	1.79%	4.76%
	OOSV	1597	398	4.29%	10.34%
OOSV–SOOV		⊿ 161	F_1 ***, F_2 **	⊿ 2.50%	F_1 n.s., F_2 n.s.

Note: 28 subjects and 20 items for both 'Yes' and 'No' responses.

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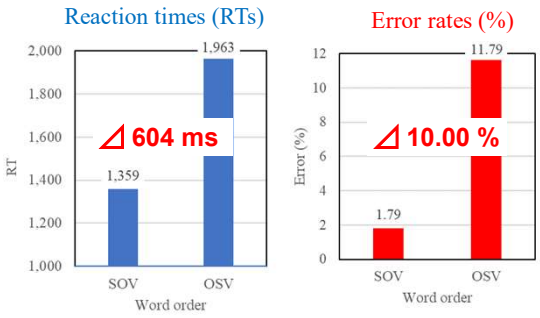
Results of Experiment 2 in the bar-graph



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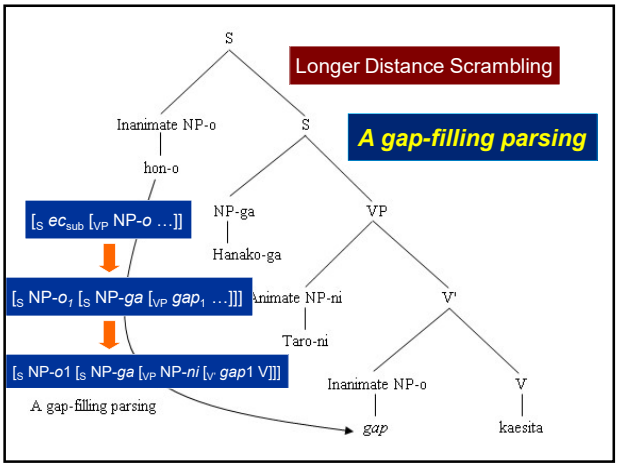

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Difference between Experiment 1 and 2

- Processing time: A difference between canonical and scrambled order in ditransitive verbs had the mean of **604 milliseconds**, much longer than the mean of **223 milliseconds** for transitive verbs.
- This difference in processing time was produced by differences in the **distance of the scrambling**: Ditransitive sentences involved longer distance scrambling; transitive sentence involved shorter distance scrambling.

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Configurational syntactic structure

- Experiments 1 and 2 supported the existence of scrambling effects in Japanese: consequently, Japanese does not have flat structure.
- Several linguists (e.g., Hoji, 1985; Miyagawa, 1989; Saito, 1985; Saito and Hoji, 1983 for Japanese; Mahajan, 1990; Muller and Wolfgang, 1994; Webelhuth, 1989) have suggested that an instance of phrasal movement can result in free noun phrase order phenomena.
- This is called a configurational syntactic structure.

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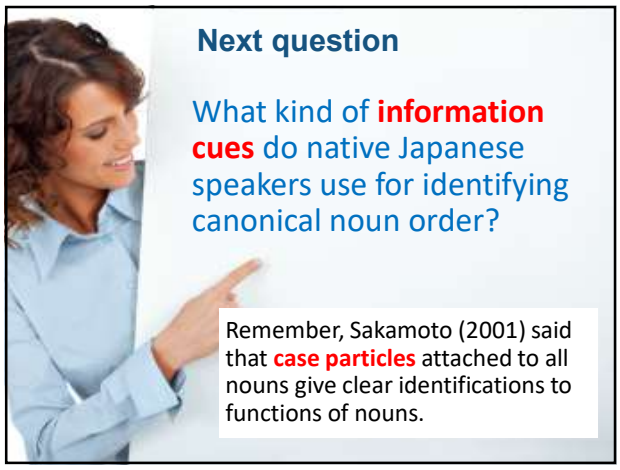

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(1) thematic roles

An agent precedes a theme.

弟がケーキを食べた。
（My brother ate a cake.）
An **agent** 弟が (my brother) precedes a **theme** ケーキを (a cake) in this active sentence.

agent　theme

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(2) case particles

Case particles in a noun phrase provide relations between a predicate (verb) and noun phrases.

In Japanese, the particle *–ga* assigns a noun phrase nominative while *–o* assigns an accusative.

An 弟が (my brother) with the nominative case *–ga* precedes a ケーキを (a cake) with the accusative case *-o*. This is also true for the dative case *–ni*.

-ga が　*–ni* に　*–o* を

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(3) grammatical functions

The subject precedes the object.

We assume that grammatical functions are not primitive notions, rather they are defined in terms of syntactic configurations (see Chomsky, 1981). The subject is the spec of the sentence.

The subject 弟 (my brother) precedes the object ケーキ.

subject　object

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弟がケーキを食べた。
（My brother ate a cake.）

Three are three cues for identifying Japanese canonical word order in active sentences:

(1) **thematic roles**,
(2) **case particles**,
(3) **grammatical functions**.
i.e., My brother proceeds a cake.

The next experiments will determine **priority information** used for native Japanese speakers.

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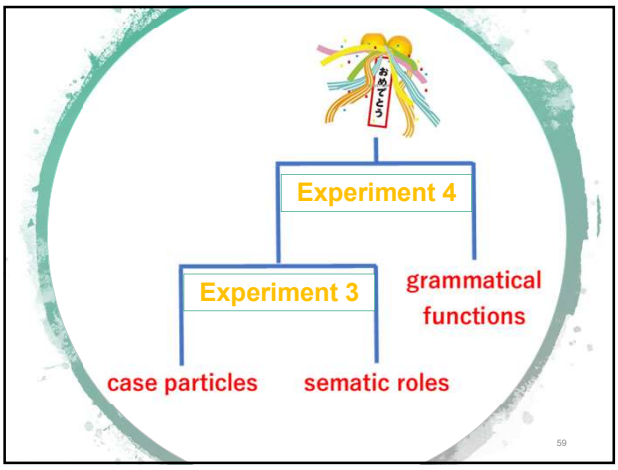

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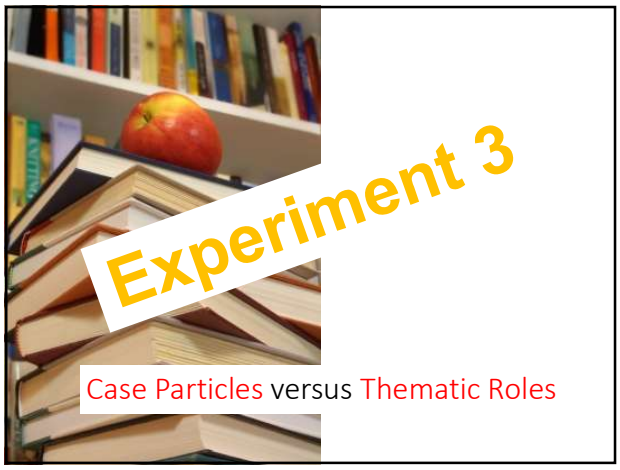

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Passive sentences

'Taro was hit by Keiko.' Prediction of canonical order

Thematic roles:

Keiko-*ni* Taro-*ga* nagurare-*ta*.

NP(Keiko)-DAT NP(Taro)-NOM V-Past (was hit)

agent theme (patient)

Case particles:

Taro-*ga* Keiko-*ni* nagurare-*ta*.

NP(Taro)-NOM NP(Keiko)-DAT V-Past (was hit)

-ga (nominative) *-ni* (dative)

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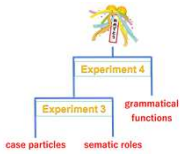
Case Particles versus **Thematic Roles**



In passive sentences with transitive verbs, thematic roles and case markers provided a conflicting word order.

In passive sentences, the nominative case particle *-ga* comes before the dative case particle *-ni* (i.e., **case particles**) while the agent comes after the theme (i.e., **thematic roles**).

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Results of Experiment 3

Table 5 Correctness decision for Japanese passive sentences with two-argument verbs

Response Type	Sentence Type	Reaction Time (ms) M	Reaction Time (ms) SD	Error Rate (%) M	Error Rate (%) SD
'Yes' Responces	SOV	1521	359	1.85%	3.54%
	OSV	1722	497	6.25%	8.08%
OSV–SOV		201	F_1 ***, F_2 ***	4.40%	F_1 **, F_2 **
'No' Responces	SOV	1484	309	10.83%	9.74%
	OSV	1582	366	9.17%	10.60%
OSV–SOV		98	F_1 n.s., F_2 n.s.	−1.67%	F_1 n.s., F_2 n.s.

Note: 24 subjects and 36 items for 'Yes' responses while 24 subjects and 20 items for 'No' responses.

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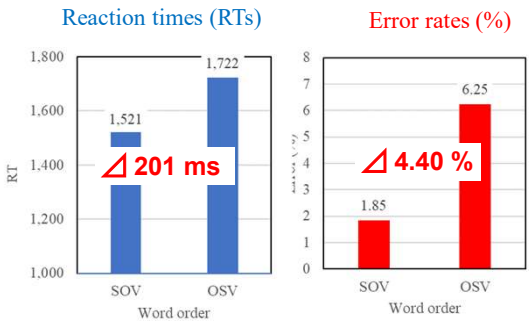
Results of Experiment 3 in the bar-graph



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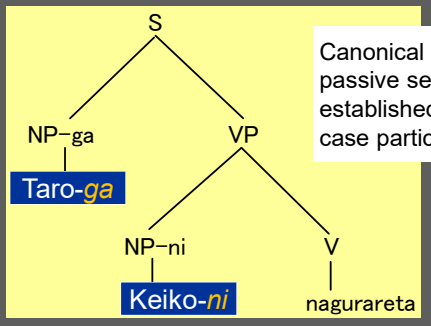
The results of Experiment 3 indicated that canonical orders established by **case particles** were more quickly and accurately identified than scrambled order.



Canonical order of passive sentences established by case particles

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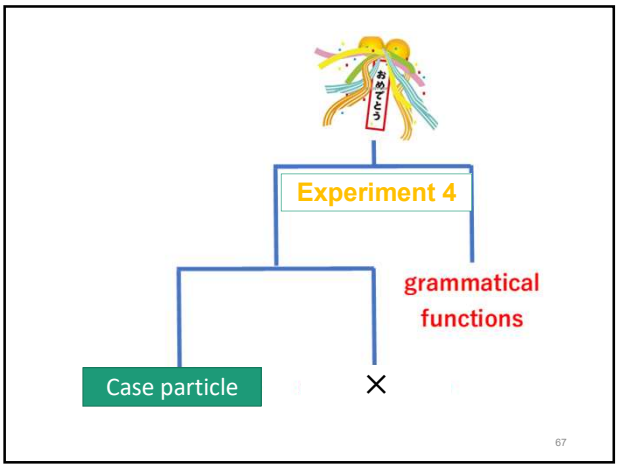

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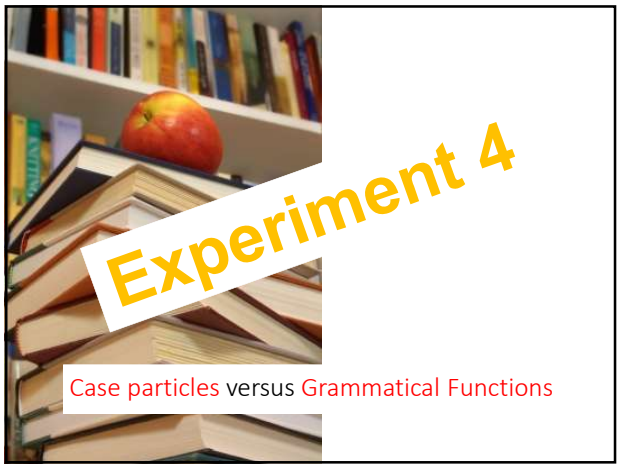

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Potential sentences

- There are a specific kind of sentences that take dative (DAT) subject.
- A noun with the dative case particle *–ni* is the subject in potential sentences (Harada, 1977; Shibatani, 1978; Ura, 1999).
- An example of a potential sentence is *Hanako-ni eigo-ga hanaseru-daroo-ka*? ('Can Hanako speak English?').

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Prediction of canonical order

Grammatical functions:

Hanako-ni Eigo-ga hanaseru(+darou-ka).
NP(Hanako)-DAT NP(English)-NOM (can speak +?)
'Can Hanako speak English?'
subject object

Case Particles:

Eigo-ga Hanako-ni hanaseru(+darouka).
NP(English)-NOM NP(Hanako)-DAT (can speak +?)
nominative detive

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Results of Experiment 4

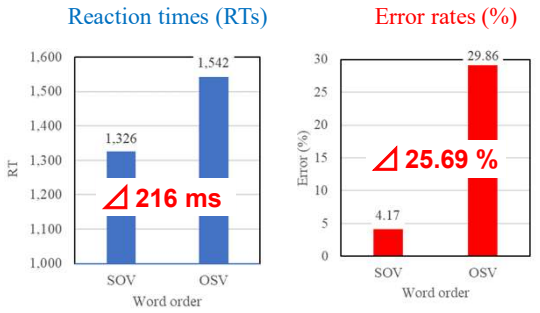
Table 6 Correctness decision for Japanese possible sentence with two-argument verbs

Response Type	Sentence Type	Reaction Time (ms) M	Reaction Time (ms) SD	Error Rate (%) M	Error Rate (%) SD
'Yes' Responces	SOV	1326	299	4.17%	7.37%
	OSV	1542	366	29.86%	24.93%
OSV-SOV		216	F_1 ***, F_2 ***	25.69%	F_1 ***, F_2 ***
'No' Responces	SOV	1586	349	5.90%	6.72%
	OSV	1602	318	7.99%	8.33%
OSV-SOV		16	F_1 n.s., F_2 n.s.	2.08%	F_1 n.s., F_2 n.s.

Note: 24 subjects and 36 items for 'Yes' responses while 24 subjects and 20 items for 'No' responses.

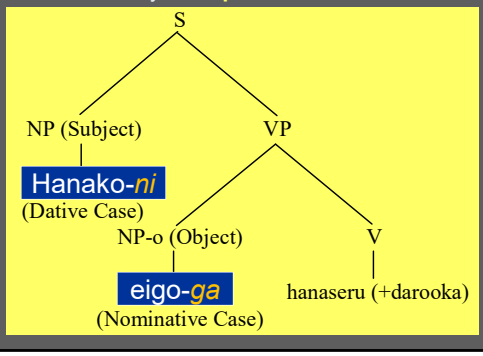
72

Results of Experiment 4 in the bar-graph



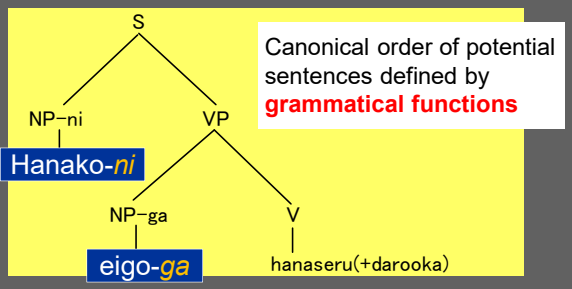
73

Potential sentences with word order established by **grammatical functions** had shorter reading times and lower error rates than potential sentences with word order established by **case particles**.



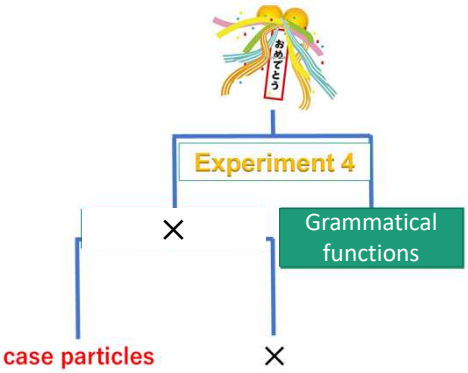
74

Potential sentences with word order established by **grammatical functions** had shorter reading times and lower error rates than potential sentences with word order established by **case particles**.



Canonical order of potential sentences defined by **grammatical functions**

75



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Grammatical functions

Table Possible Explanations for Scrambling Effects through Five Experiments

Purpose of Experiments	Exp. #	Sentence Types	Thematic Roles	Case Particles	Grammatical Functions
Scrambling Effects	Exp. 1	Active Sentences with Transitive Verbs	X	X	X
	Exp. 2	Active Sentences with Ditransitive Verbs	X	X	X
Priority Information	Exp. 3	Passive Sentences with Transitive Verbs	Excluded	X	X
	Exp. 4	Potential Sentences		Excluded	X

Note: **X** refers to a possible explanation for the sentence processing.

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Sunning up the Exp 1-4

Neither thematic roles nor case particles can provide fully satisfactory information for canonical order, and only grammatical functions offer plausible information in all active, passive and potential sentences.

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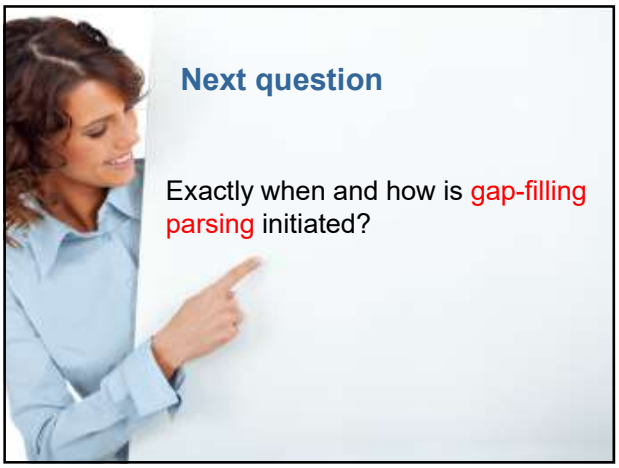
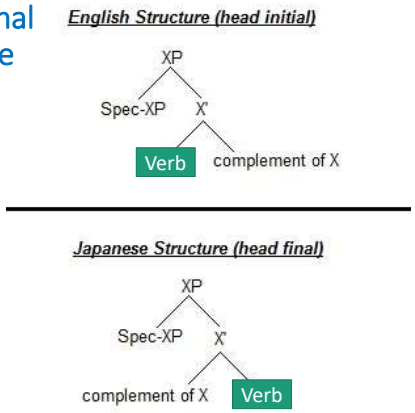


79

A head-final language



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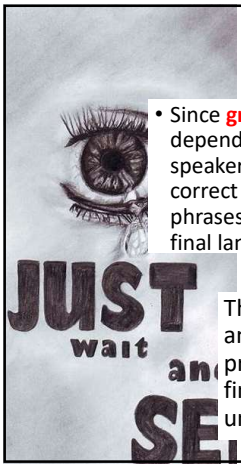


Wait-and-see model

- Since **grammatical function** is usually dependent on the type of predicates, native speakers sometime cannot determine the correct grammatical function of noun phrases until the end of sentence in a head-final language like Japanese.

The **wait-and-see model** provides an explanation for the sentence processing mechanism of head-final languages: that is simply wait until seeing the ending verb.

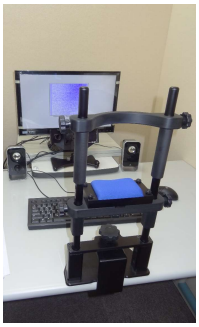
81

81

Since the sentence-correctness decision paradigm does not give decisive information about the timing of gap-filling operations, we will investigate this possibility as an avenue for the next **eye-tracking technique**.

82

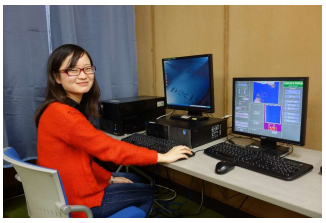
Eye-tracking



EyeLink 1000
(1 millisecond of measurement)

83

Eye-tracking



84

Eye Tracking

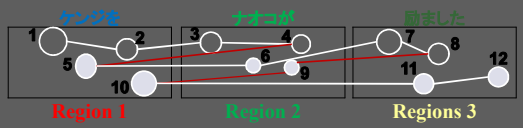
ケンジをナオコが励ました。

fixation saccade

85

Eye Tracking

ケンジをナオコが励ました。



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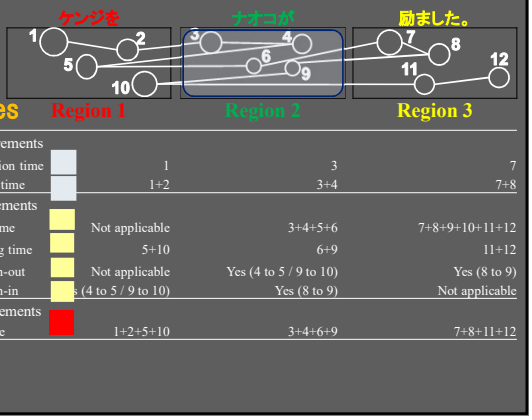

	Region 1	Region 2	Region 3
Early measurements			
(1) First-fixation time	1	3	7
(2) First-pass time	1+2	3+4	7+8
Late measurements			
(3) Go-past time	Not applicable	3+4+5+6	7+8+9+10+11+12
(4) Re-reading time	5+10	6+9	11+12
(5) Regression-out	Not applicable	Yes (4 to 5 / 9 to 10)	Yes (8 to 9)
(6) Regression-in	(4 to 5 / 9 to 10)	Yes (8 to 9)	Not applicable
Total measurements			
(7) Dwell time	1+2+5+10	3+4+6+9	7+8+11+12

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言語研究 (*Gengo Kenkyu*) 155: 35–63 (2019) doi: 10.11435/gengo.155.0_35

An Eye-tracking Investigation of *Pre-head* and *Head-driven* Processing for Scrambled Japanese Sentences

KATSUO TAMAOKA *Nagoya University*
MICHAEL P. MANSBRIDGE *Nagoya University*

Abstract: The syntactic movement of scrambled Japanese sentences is often attributed to *pre-head anticipatory processing* prior to reading the head verb. However, previous studies have not compared nouns within the same sentence position; furthermore, studies have compared different noun types, influencing processing via semantic activation. Thus, this study only presented highly frequent first names and maintained each noun in the same position by only

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Nagoya University

MANSBRIDGE, P. Michael
Nagoya University

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Experiment 5

Eye tracking of scrambled active sentences

90

弟が ✕ ケーキを　ケーキを ✕ 弟が　食べた。

食べた。

You cannot directly compare two phrases in the same region.

91

Kenji -o/-ga　Naoko-o/-ga　encouraged

ケンジが　ナオコを　励ました。

ケンジを　ナオコが　励ました。

OK

92

Experiment 5 used simple SOV and OSV active sentences with two high-frequency first name proper nouns (e.g., Kenta, Naoko) and a verb.

Although some degree of the pre-head processing is involved in the processing of scrambled sentences in Japanese, the agreement information from the head verb will play an important role in forming the final syntactic structure.

93

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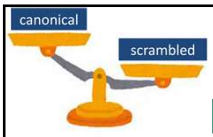

Pre-head processing

The *o*-and-*ga* order

Go-past time

NP-ACC$_1$	NP-NOM	*gap* $_1$	V

Re-reading time

Regression-in

Head-driven processing

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Experiment 6

Eye tracking of scrambled order in complex sentences

95

canonical

a. [S[SOV]V] complex canonical ordered sentence

Region 1	Region 2	Region 3	Region 4	Region 5	
Kenji-ga	*Masato-ga*	*Keiko-o*	*tasuketa*	*to*	*kii-ta*
NP-NOM	NP-NOM	NP-ACC	V(help)-PAST	Comp	V(hear)-PAST

'Kenji heard that Masoto helped Keiko.'

short-distance

b. [S[O$_1$S*gap*$_1$V]V] short-distance scrambling ordered sentence

Region 1	Region 2	Region 3	Region 4	Region 5	
Kenji-ga	*Masato-o*	*Keiko-ga*	*tasuketa*	*to*	*kii-ta*
NP-NOM	NP-ACC$_1$	NP-NOM	*gap*$_1$ V(help)-PAST	Comp	V(hear)-PAST

'Kenji heard that Keiko helped Masoto.'

long-distance

c. [O$_1$[S[S*gap*$_1$V]V]] long-distance scrambling ordered complex sentence

Region 1	Region 2	Region 3	Region 4	Region 5	
Kenji-o	*Masato-ga*	*Keiko-ga*	*tasuketa*	*to*	*kii-ta*
NP-ACC$_1$	NP-NOM	NP-NOM	*gap*$_1$ V(help)-PAST	Comp	V(hear)-PAST

'Masato heard that Keiko helped Kenji.'

96

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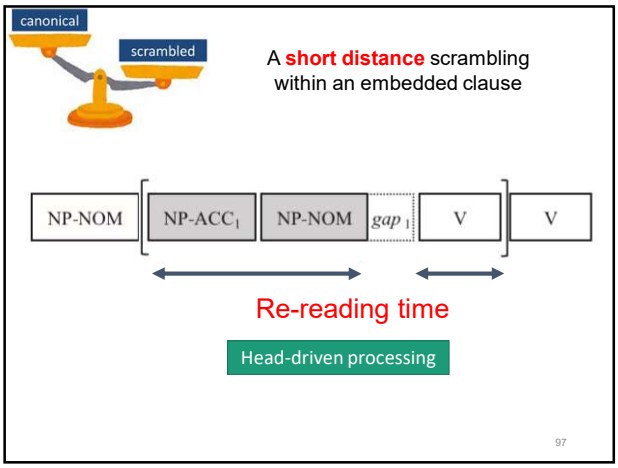

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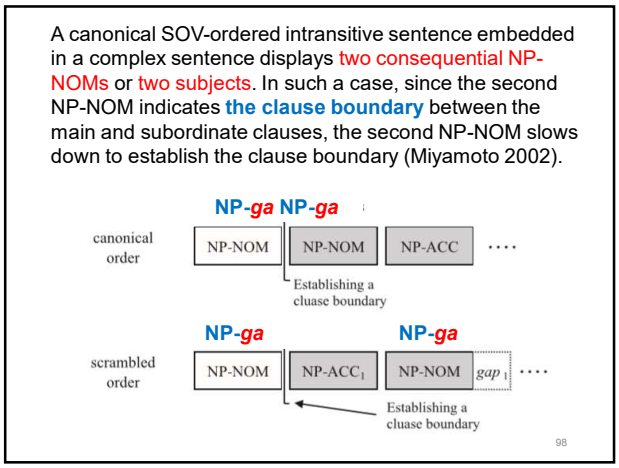

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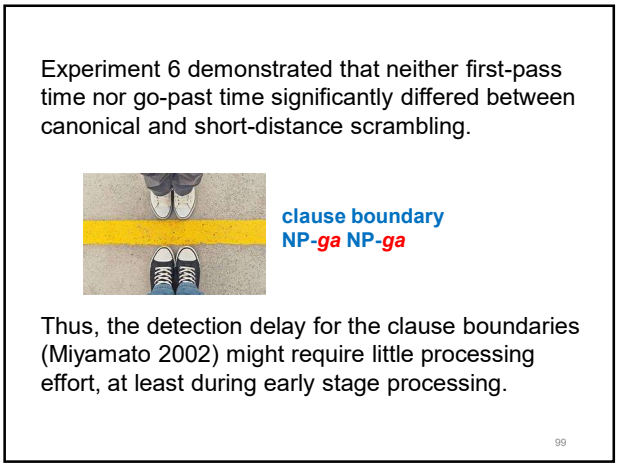

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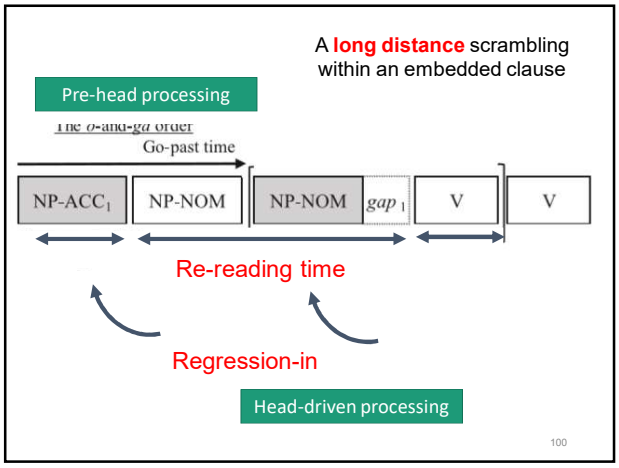

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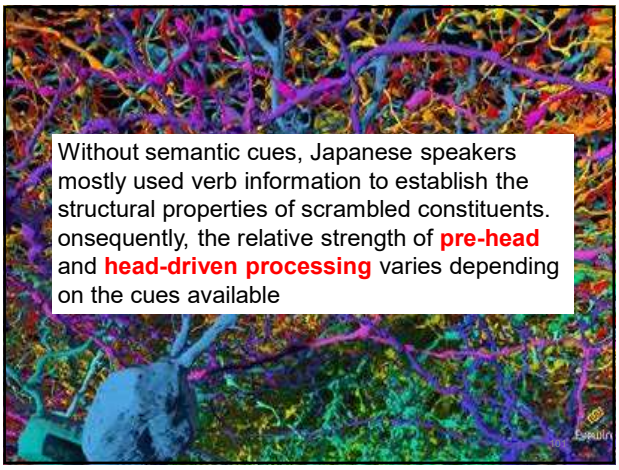

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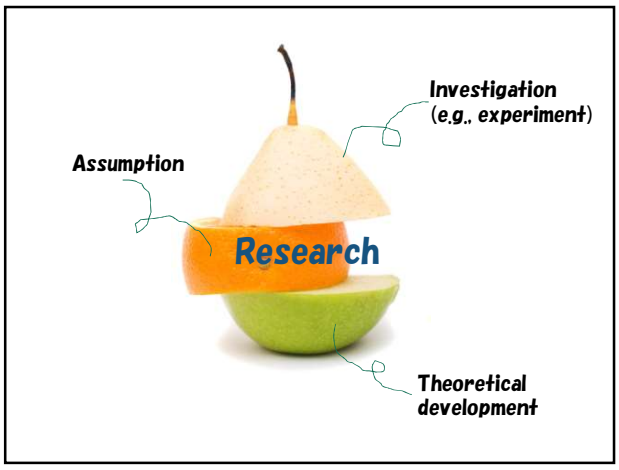

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Thank you for listening to my talk.
ご清聴ありがとうございました
謝謝收聽!
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NAGOYA UNIVERSITY
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