ERP RESPONSES TO VIOLATIONS IN JAPANESE VERB CONJUGATION PATTERNS

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What’d be the past-tense form?

- **English nonce verbs**
  - skum → skummed [d]
  - slade → slade [id]

- **Japanese nonce verbs**
  - すまぐ (sumagu) → すまいだ (sumai-da)
  - すぬう (sunuu) → すぬった (sunut-ta)
Onbin (音便)

Simple phonologically-conditioned “rule”: Onbin forms are determined by the root-final consonant

/k, g/ → /i/; /m, n, b/ → /N/; /r, t, w/ → /ʔ/

/ʔ/ = glottal stop 「つ」
Experiment by Vance (1991)

- Past tense form of hoku
  - hota 18%
  - hokutta 38%
  - hoita 44%

→ Is the past-tense formation involving “onbin” change a rule in the same sense as English regular inflection (-ed suffixation as in walk/walked) IS a rule?
Introduction

- **Issue:** more than one mechanism in the processing of inflection?
- **Dual Mechanism Model:** Two qualitatively different mechanisms involved in word-level processing (Pinker 1999)
  - Rule-based computation and associative memory
    - Regular (walk/walked) vs. Irregular (sing/sang)
  - What about Japanese verb conjugation?
Roadmap

- Introduction
- ERP components relevant to language processing
- Conjugation of Japanese verbs
- Experiment
  - Method
  - Stimuli & Predictions
  - Results
- Discussion & Conclusion
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ERP (Event-Related Potential)

- Stimulus Onset
  - 0 msec

- Scalp Distribution

- Positivity
- Negativity

- Latency (msec)

- Condition A
- Condition B
ERP Components Related to Language Processing

- **N400**
  - Negativity
  - Peaks at around 400 ms after the stimulus onset
  - Wide distribution, often posterior-centered
  - Reflects semantic or pragmatic anomaly, costs related to lexical search

- **LAN (Left Anterior Negativity)**
  - Negativity
  - Observed around 300-500 ms after the stimulus onset
  - Distribution limited to the left anterior region
  - Reflects morpho-syntactic anomalies like agreement errors.
ERP Components Related to Language Processing

- P600

  Positivity
  Observed at around 600 ms after the stimulus onset
  Both anterior & posterior distribution observed
  Reflects the process of reanalysis or repair in face of morpho-syntactic or syntactic violations of various types
Inappropriately attached or omitted regular inflectional affixes tend to elicit a LAN.

  e.g. *bringed*, *wip* in the past context

- Modifications of irregular inflection tend to yield an N400-like component.
  
  e.g. *pept* as the past form of *peep*

Newman et al. (2007)
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Conjugation of Japanese Verbs

- Two different types of verb roots in terms of their conjugation patterns:
  - Vowel-ending roots (1-dan katsuyo)
  - Consonant-ending roots (5-dan katsuyo)

- Phonological changes in inflection with consonant-ending roots:
  (a) various vowels (-a-, -i-, -u-) are inserted according to the following inflectional endings
  (b) the final consonant undergoes morpho-phonological changes ("onbin")
Phonological Changes in Japanese Verb Conjugation

- **Consonant-ending root**: shaber ‘chat’
  
  <Vowel Insertion>
  
  a. non-past: shaber-\text{-}u (root + TENSE)
  b. negation: shaber-a-nai (root + stem vowel + NEG)
  c. infinitive: shaber-\text{-}i (root + stem vowel, e.g. -tai 'want to')

  <Onbin Change>
  
  d. past: shabe?\text{-}ta
  e. continuative: shabe?\text{-}te

?ː glottal stop (「つ」)
Rule vs Memory in Verb Conjugation?

- Vowel Insertion (-a) before NEG
  Applies to all consonant-ending verb roots with no exception → rule-governed?

- Onbin change
  Phonologically conditioned by root-final consonant
  /k, g/ → /i/; /m, n, b/ → /N/; /r, t, w/ → ?/
  Some exceptions: ik ‘go’ → i?-ta, tow ‘ask’ → tow-ta
  → Lexically memorized? (Vance 1991)
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Stimuli and Predictions 1
(Vowel Insertion (-a) before NEG)

a. shaber-a-nai (Neg-form + -nai)

b. *shaber-i-nai (infinitive form + -nai)

c. *shaber-u-nai (non-past form + -nai)

(b) Involves a purely morpho-phonological rule violation (i.e., insertion of a wrong vowel)

c) involves a phrase-structure violation (-u: non-past tense form)

[[[ shaber ]_V -u ]_T -nai ]_NEG

(the correct configuration would be: [[[ ]_V ]_NEG ]_T )

→ Both (b, c) will elicit computation-related components, with (c) exhibiting a more complicated response
Stimuli and Predictions 2
(Onbin Form before Past -ta)

d. shabeʔ-ta / ka-i-ta / ton-da (‘chat’/ ‘write’/ ‘fly’)
e. *shaber-i-ta / *kak-i-ta / *tob-i-ta

(infinitive form + PAST)

“Onbin” forms are likely to be lexically memorized

† The illicit forms (e) can be predicted to elicit a memory-related ERP component N400.
Negation conjugation errors

Zyuumin-wa danti-de otiba-o
residents-TOP housing.complex-in fallen.leaves-ACC

\[
\begin{align*}
(a) & \text{ moyas-a-nai (Neg-form+nai)} \\
& \text{ burn-NEG} \\
(b) & \text{ *moyas-i-nai (infinitive form+nai)} \\
(c) & \text{ *moyas-u-nai (non-past form+nai)}
\end{align*}
\]

kisoku-da.
rule-COP
‘Residents are not allowed to burn fallen leaves in the site of the housing complex’
Stimuli (Onbin Errors)

Onbin errors in the past-tense form

Kazoku-wa ima-de syasin-o
family-TOP living.room-in pictures-ACC

\[
\begin{align*}
\text{(d) to}^?\text{-ta} & \quad (\text{onbin form + past}) \\
\text{take-PAST} & \\
\text{(e) *tor-i-ta} & \quad (\text{infinitive form + past}) \\
\end{align*}
\]

rasii.
seem

‘It seems that the family took pictures in the living room.’
Method

Participants

21 Japanese right-handed undergraduate students
(15 males and 6 females)

Stimulus Sentences

- Negative conjugation error
  30 sentences with Neg-form+nai
  30 sentences with infinitive form+nai
  30 sentences with non-past form+nai

- Onbin form error
  36 sentences with onbin form +past
  36 sentences with infinitive form+past

162 target + 90 filler sentences
Method

Procedure

• Each phrase appeared on the screen for 600 ms with a 200 ms blank between each phrase.
• Participants were instructed to make a grammaticality judgment (yes/no decision) by clicking a computer mouse.

ERP Recording

64 Ag/AgCl electrodes  Impedance: $\leq 10k\Omega$
Sampling rate: 250Hz  Baseline: -100-0ms
Bandpass: DC-70Hz  Artifact rejection criterion: $\pm 70 \mu V$
Results

- Negation conjugation errors

![EEG schematic with waveforms showing LAN-like negativity and P600](chart紧缺.png)
Results

- Onbin-errors

F3 F4
P3 P4

F3
F4
P3

N400
P600
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Discussion: N400

- The negativity elicited by the illicit infinitive form without onbin (tori-ta compared to toʔ-ta): N400

N400: known to be related to lexical search

Onbin does not involve computation by rule;

The onbin form for each verb root is memorized in the lexicon.
Discussion: LAN-like Component

- The negativity elicited by the non-past illicit forms (moyasu-nai compared to moyasa-nai) : a LAN-like component.

→ can be interpreted as reflecting the parser’s detection of a phrase-structure violation (i.e., NEG outside the TP).
Discussion:
the Distribution of LAN-like Component

- Different from a typical LAN in distribution (temporal, not anterior)

- A similar component observed in Catalan stem formation: overapplication of rule-based stem formation \((\text{root}+ \ -\alpha-\) to a root which requires an irregular form \((\text{root}+ \ -\i-/\-u-\)

  Rodriguez-Fornells et al. (2001)
Discussion: Lack of the Lan-Like Component

- Negation Conjugation Errors:
  (b) Infinitive form + nai (moyasi-nai): P600
  (c) Non-past form + nai (moyasu-nai): LAN-like component + P600

- WHY the difference?
  (b): violation of a simple morpho-phonological rule (vowel insertion)
  (c): phrase-structure violation (NEG outside TP)

→ Both are computation-related violation, but differ in complexity
Discussion: P600

- P600: Observed in all the error types
  - Reflects the cost of dealing with conjugation errors, irrespective of its nature (rule-based or memory-based).
Concluding Remarks

- Conjugation of Japanese roots with a specific vowel for each ending involves rule-based computation.
- The morpho-phonological change (onbin) requires lexical memory.

→ support for the Dual Mechanism Model
For Future Study

- Rule-based phonological change (vowel insertion) and memory-based phonological change (onbin) in the inflection of one and the same verb different from well-studies regular/irregular dichotomy in inflectional patterns in English, German, etc.

- What about the conjugation of verbs with vowel-ending roots?

- Or of adjectives?


THANK YOU

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