

Development of children's ability to predict and revise during language comprehension and its relation to their inhibitory control

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It has been suggested that executive functions (EFs) play a significant role in language processing (Novick et al., 2014) and that there is large variability in the ability of EFs across different ages, with younger children usually associated with less developed EFs (Lorsback et al., 1998). It is, however, still little known exactly what process during online language comprehension is relevant to EFs. The current study investigated a hypothesis that processing of the sentences that temporarily cause anomalous interpretation requires comprehenders to suppress an initially constructed incorrect interpretation in order to both predict upcoming information and integrate disambiguating information. For this purpose, we examined the online processing of Japanese relative clause (RC) sentences¹⁾ that cause temporary anomalous interpretation using visual world paradigm (VWP) as well as children's inhibitory control ability with a suppression task (Go/No Go task). Forty-four children aged between 5 and 8 participated in the study.

In the VWP study, the participants saw a visual scene such as Figure 1 while listening to a sentence such as (1). Baseline condition (1a) does not cause any anomalous interpretation, while in Accusative-impossible condition (1b) and Nominative-impossible condition (1c), the initial part of the sentence up to the RC verb causes a main clause interpretation that does not make sense for different reasons. In Accusative-impossible condition (1b), the intransitive verb in the RC (*aruiteita* 'was walking') cannot take an accusative noun phrase (NP) (*juusu-o* 'juice-ACC'). In Nominative-impossible condition (1c), the sentence-initial nominative NP is thematically implausible as the RC verb's subject. Go/No Go task was also conducted to measure participants' inhibitory control ability.

The results of comprehension questions (participants answered the correct agent entity in the RC by pointing) for the VWP experiment, showed that the accuracy rate was the highest in Baseline condition and lowest in Nominative-impossible condition (Baseline condition = 94.7%; Accusative-impossible condition = 78.2%; Nominative-impossible condition = 65.4%). The analysis with Generalized Linear Mixed-Effects models including age as a continuous variable revealed that the differences between the three conditions are significant.

For the eye-movement data, we first analyzed the looks to the two animate entities (the RC head and competitor) from the onset of the RC verb to the onset of the RC head to examine the prediction of a RC (head)²⁾ (Figure 2). We analyzed the logit of the looks to the animate entities among all the looks to the visual scene, using LME models. The results showed that, compared to Baseline condition, participants made less anticipatory looks to the animate entities in Accusative-impossible and Nominative-impossible conditions, and there were significantly less looks in Nominative-impossible condition than in Accusative-impossible condition. We next analyzed the looks to the RC head entity among all the looks following the onset of the RC head, to examine the integration process of the RC head (Figure 3). There was no significant difference between Accusative-impossible and Baseline conditions. However, there were significantly more integrative looks to the RC head in Nominative-impossible condition compared to Baseline condition. The finding of fewer integrative looks in Baseline and Accusative-impossible conditions suggests that the more the RC structure was anticipated, the less attention was needed for the RC head entity after it was mentioned.

We conducted a further analysis which examines an influence of participants' suppression ability on the predictive and integrative processing. The analysis with the model including the Go/No Go score (the rate of correct responses in No Go condition) as well as Age revealed that there was a significant interaction between Accusative-impossible condition and the Go/No Go score in the analysis of both predictive and integrative looks, showing that children with higher inhibitory control ability made more predictive and less integrative looks than those with lower inhibitory control ability (Figure 4). The interaction with Nominative-impossible condition was not significant though showing the same trend, which may suggest that the sentences of this condition were often too difficult to process as indicated by the results of comprehension questions.

In sum, this study showed that children's individual difference of inhibitory control ability affects the predictive and integrative processing of certain RC sentences that temporarily cause anomalous interpretation.

Examples

(1) a. Baseline condition

yukkuri aruiteita onnanoko-ga juusu-o koboshita-yo.
[slowly walk-prog-past girl-NOM] juice-ACC spill-past
'The girl who was slowly walking spilled the juice.'

b. Accusative-impossible condition

juusu-o yukkuri aruiteita onnanoko-ni watashita-yo.
juice-ACC [slowly walk-prog-past girl-DAT] pass-past
'(Someone) passed the juice to the girl who was slowly walking.'

c. Nominative-impossible condition

juusu-ga yukkuri aruiteita onnanoko-ni koboreta-yo.
juice-NOM [slowly walk-prog-past girl-DAT] spill-past
'The juice spilled on the girl who was slowly walking.'

Figures

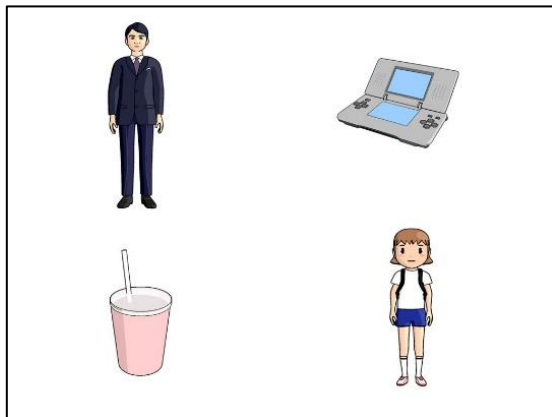


Figure 1. The visual scene for sentences (1)

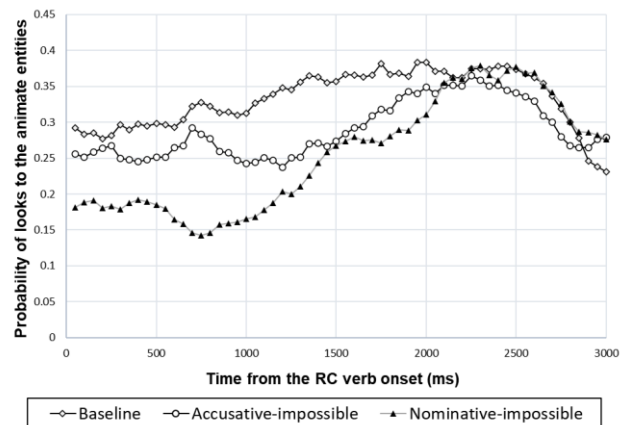


Figure 2. Proportions of the looks to the RC head & competitor entities combined for each condition from the onset of the RC verb

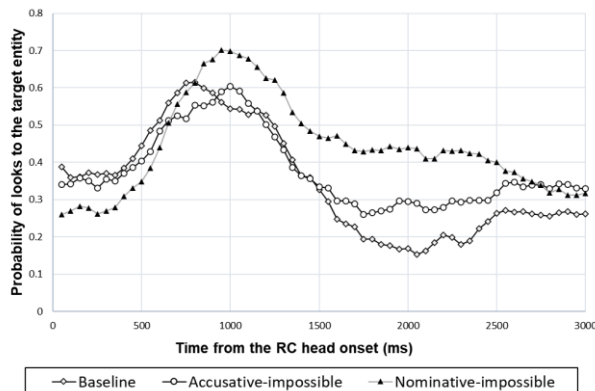


Figure 3. Proportions of the looks to the RC head entity from the onset of the RC head

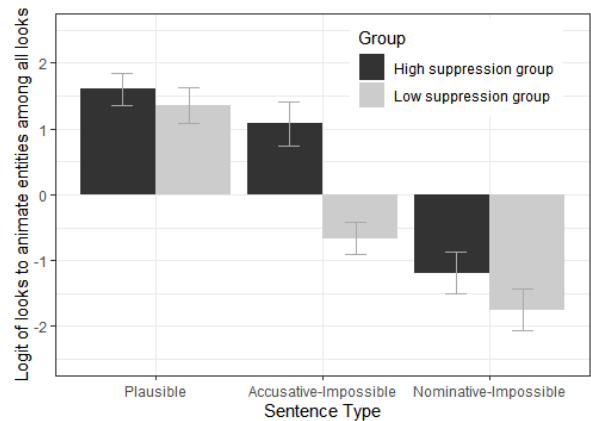


Figure 4. Anticipation looks for High suppression group and Low suppression group for each condition

References

- Novick, J. M., Hussey, E., Teubner-Rhodes, S., Harbison, J. I., & Bunting, M. F. (2014). Clearing the garden-path: improving sentence processing through cognitive control training. *Language, Cognition and Neuroscience*, 29, 186–217.
- Lorsbach, T. C., Katz, G. A., & Cupak, A. J. (1998). Developmental Differences in the Ability to Inhibit the Initial Misinterpretation of Garden Path Passages. *Journal of Experimental Child Psychology*, 71, 275-296.

Notes (Additional Information about Japanese)

- 1) In Japanese, a verb-final language, the canonical word order is SOV, and scrambled sentences (i.e., OSV word order) are allowed. RCs are prenominal (followed by its head) in Japanese. Also, the subject and object can be dropped in some Japanese sentences.
- 2) Previous research showed that in the processing of RC sentences in Japanese, the RC verb triggers the prediction of the RC head.