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論 文 審 査 の 結 果 の 要 旨 お よ び 担 当 者

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論 文 題 目　Ambiguity in the Processing of Japanese, Korean and Mandarin Chinese Relative Clauses

日本語，韓国語，中国官話の関係節の処理における曖昧性

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Significance of Findings

The significance of this research is that it provides evidence that processing models of memory and expectation are interconnected during reading by using relative clauses (RC). While arguments for hybrid-models of processing have been proposed and evidence observed in languages such as English and Russian RCs, both post-nominal RC languages, the current study adds evidence for hybrid-models within the three prenominal RC languages of Japanese, Korean and Mandarin Chinese (three languages which have similar yet different typological features). Another important component of this study was that it investigated the influence of ambiguity in these three languages. In these languages, since there are no relative pronouns or relativizers at the left edge of the clause, they can be confused with simple clauses. This study revealed that while reading time speeds quickened if the disambiguating cues were used prior to the relative clause, the first indication of relative clause difficulty appeared at the same position of the sentence. Consequently, this study revealed that there are necessary cues within the sentence which are required for the human parser to extract structural frequencies from our prior experiences. However, while the findings were constrained to the same positions, reading behavior altered at these positions depending on the level of ambiguity. This finding revealed that when the relative clause became less ambiguous, the factor of expectation (i.e., frequencies) became more prominent. When it was more ambiguous, factors of working memory were more prominent. However, the findings suggest that working memory, specifically the process of retrieval/integration, may be a parametric mechanism between languages as a factor of specific typological features of a language. Yet, one feature of working memory, similarity-interference, was observed to prevalent in all three languages. In all, this study demonstrates that the activation level of a clause structure stored in memory fluctuates depending on working memory constraints (i.e., locality during retrieval and interference between similar nouns) and the structure's frequency in a language which is accessible via a cue to retrieve said frequencies.

Dissertation Summary

Chapter 1: Numerous models of sentence processing have been constructed through the lens of the processing of relative clauses (RC). In RC processing, there is a near universal phenomenon demonstrating that subject-extracted relative clauses (SRCs) are easier to process and comprehend compared to their object-extracted relative clause (ORC) counterparts. Following this, many researchers have crafted hypotheses of processing in order to explain the processing asymmetry between SRCs and ORCs. Considering the amount of models to explain this effect, it is difficult to reconcile which models are valid accounts of processing as well as formulating a unified sentence processing theory.

A key method to empirically test models is to investigate them within a large amount of languages with varying typological features to determine if a model can accurately predict processing in each language. In terms of RC processing, studies had classically investigated

processing within European languages which are typically post-nominal (i.e., the RC follows the head noun it modifies). Accordingly, there has recently been a surge in studies investigating processing within prenominal languages (i.e., the RC precedes the head noun it modifies). In the current study, RC processing was investigated in three East Asian languages, all of which have prenominal RC structures: Japanese, Korean, and Mandarin Chinese. However, all three of these languages have a confounding factor inherent to each language and their respective structure. Specifically, this factor is an initial clause-type ambiguity. In other words, since these languages lack relative pronouns or markers at the left edge (i.e., the start or boundary of the clause), a simple sentence (i.e., matrix clause) interpretation will likely be taken instead of an RC one. This misparse will continue until a viable cue to disambiguate the ambiguity of clause-type: The head noun in Japanese, the adnominal marker in Korean, and the relativizer in Mandarin. While recent studies have begun to use unambiguous RCs in these languages, there are a relatively few addressing it as an actual processing factor. Consequently, it is of empirical importance to investigate the manner in which ambiguity influences the processing of RCs in each language to better explain how processing unfolds. As such, the main aim of this study was to investigate RC processing in each language as a factor of ambiguity to explain how processing mechanisms interact with one another.

In terms of processing factors, this study limited the discussion to three prominent factors which have already been integrated into cue-based retrieval models. The purpose of this was to detail the interrelatedness of these three factors: Integration of filler-gap dependencies, expectation-based processing (i.e., frequency effects) and similarity-interference. Also, a fourth factor, outside the scope of cue-based retrieval, was introduced since it is a more recent theory for Japanese and Korean RCs: The object-before-subject-bias (OBSB).

The current study utilized eye-tracking methods on native speakers of each of these languages. Chapters 2-4 detailed the processing of RCs in each language. This study asked three basic questions: (1) Are ORCs more difficult to process than SRCs for each of the three languages? (2) Does (1) change as a factor of ambiguity? (3) Which processing models account for the data? Are they influenced by ambiguity and how are they related?

Chapter 2: This chapter detailed the processing of relative clauses in Mandarin Chinese. Mandarin Chinese is a relatively unique language with an exceptionally rare language typology in regards to relative clauses. Mandarin is an SVO language with prenominal relative clauses (i.e., the RC precedes the head noun). Because of this pattern, ORCs in Mandarin follow the canonical SVO word order of Mandarin while SRCs instead follow a non-canonical VOS order. In terms of other languages, SRCs typically follow the canonical word order while ORCs do not. Even though this typological feature is divergent, Mandarin SRCs are still more frequent than ORCs in corpora similar to that of most other languages.

While Mandarin has a relativizer particle (i.e., not a relative pronoun), it appears frequently at the right edge or boundary of the clause. Consequently, since there are no cues to encode an RC

interpretation at the ledge edge or boundary, the mental parser will instead likely interpret the clause as a simple matrix clause. In other words, RCs in Mandarin are initially ambiguous. This would cause a strong garden path effect that would likely facilitate the processing of ORCs, despite their increased structural complexity, processing difficulties surrounding them, and being the less frequent structure.

Previous experimental studies on Mandarin RCs have revealed mixed results. Sometimes ORCs were found to be easier to process and comprehend and other times SRCs were easier. However, these past studies had the ambiguity as a confounding factor. Those who found ORC advantages claimed that due to a linear integration/retrieval metric for filler-gap dependencies, ORCs are easier since the gap is more local to the filler (i.e., the head noun) in terms of linear distance, compared to SRCs. On the other hand, those who found SRC advantages instead claimed that structural accessibility of the subject position and increased frequency of the RC structure should make SRCs easier than ORCs. Furthermore, some researchers contend that those ORC advantages found were mere reflections of the garden path effect. More recently, however, researchers began exploring RCs in Mandarin using less ambiguous sentence designs. While the relativizer cannot be fronted, other syntactic cues that can create clause boundaries and increase the RC interpretation were used. These studies found that when Mandarin RCs were unambiguous, ORCs were more difficult to process and comprehend in comparison to SRCs as a result of their lower frequency. However, there were still marginal indications that ORCs were initially easier to process.

The current study on Mandarin RCs, explored processing in terms of ambiguity. Two separate eye-tracking studies were conducted using native speakers of Mandarin from Mainland China, opposed to Taiwan or other countries. Experiment 1 used a strictly ambiguous design while Experiment 2 introduced ambiguity as an experimental factor. This study showed that both ORCs and SRCs have different processing requirements depending on the locus and time course during reading. The results revealed that ORC reading was possibly facilitated by linear/temporal integration and canonicity. On the other hand, similarity-based interference made ORCs more difficult, and expectation-based processing were more prominent for unambiguous ORCs. Overall, RC processing in Mandarin should not be broken down to a single ORC (dis)advantage, but understood as multiple interdependent factors influencing whether ORCs are either more difficult or easier to parse depending on the task and context at hand.

Chapter 3: This chapter detailed the processing of Korean relative clauses. Korean is an SOV language with prenominal RCs. In Korean, SRCs are more frequent than ORCs. While Korean has an adnominal marker suffixed to the embedded RC verb (i.e., the right edge), there are no RC cues at the left edge of the clause. Therefore, there is initial clause type ambiguity for Korean.

Previous studies on Korean RCs show that, with respect to processing, ORCs are more

difficult to process at the head noun than SRC within temporarily ambiguous contexts. ORCs, however, are predicted by expectation-based processing models for surprisal to incur a greater processing cost during early processing stages at the RC verb, since it is a likely locus of disambiguation for RCs in Korean, and because ORCs are a less frequent structure compared to SRCs. Consequently, the current study investigated whether processing difficulty for ORCs manifests itself at the RC verb using eye-tracking methods, both ambiguous and unambiguous RCs, and both a sentential-decision task and comprehension task. The results revealed significantly increased go-past reading times for ORCs at the RC verb and head noun for both ambiguous and unambiguous RCs. I believe this is a result of a less frequent structure being more difficult to parse during disambiguation. Additionally, the findings at the head noun support an integration metric based on structural-phrase integration rather than linear/temporal metrics. Ambiguity, however, had little effect on the overall processing pattern for Korean RCs. The lack of influence from ambiguity may be attributed to Korean having distinct loci for disambiguation and integration. Consequently, expectation-based models of processing accurately predicted difficulty for ORCs at the locus of disambiguation in Korean.

Chapter 4: This chapter detailed the processing of Japanese relative clauses. Japanese is an SOV language with prenominal RCs. In Japanese, SRCs are more frequent than ORCs. Japanese RCs have no RC markers or cues within typical externally-headed relative clauses. Therefore, the head noun itself acts as the cue to provide the RC interpretation. Because of this clause-type ambiguity, a garden path effect would occur up to the head noun. Since embedded noun-modifying structures lack overt marking at the left boundary or edge of the clause, it can be initially difficult to distinguish matrix clauses from RCs and complement clauses (e.g., *-koto*, *-to iu*, *-jijitsu*). Accordingly, the parser only becomes aware of the RC structure at a locus of disambiguation which happens to be the head noun.

While there are previous studies which have eliminated this ambiguity resulting in an attenuated difficulty at the head noun, these studies, however, have not effectively investigated the classical processing asymmetry between subject- and object-relatives during reading comprehension. In the current study, eye-tracking was employed on native Japanese speakers to determine how RC processing is influenced by ambiguity. The results revealed different processing patterns for each ambiguity context. Specifically, for the ambiguous RC context, ORC difficulties were observed during overall measures of processing at the head noun and RC verb which can be attributed to a variety of processing factors such as structural-integration, similarity-interference, expectation and the object-before-subject-bias. In contrast, when the clause structure was unambiguous, ORC difficulty was mainly observed during early processing measures at the head noun. This shift in processing behavior is indicative of effects of expectation-based processing, i.e., since ORCs are less frequent than SRCs, they are more difficult to process. Thus, when the clause becomes less ambiguous, expectations become a more salient processing feature. Overall, RC processing in Japanese is influenced by the level

of ambiguity.

Chapter 5: This chapter detailed the relationship of the findings from Chapters 2-4. In this study, several language independent and dependent findings were observed. Notably, for all three languages, the chief processing difficulties were centered at the locus of disambiguation as predicted by expectation-based processing. For Mandarin and Japanese, but not Korean, ambiguity was observed to be a factor influencing the processing of RCs. When RCs were unambiguous, the effects from expectation-based processing became more pronounced. Integration effects were also observed for all three languages at the predicted locus of integration; however, if the clause became less ambiguous, these effects became less observable for Japanese and Mandarin. For both Japanese and Korean, the results supported a structural-integration metric while a linear metric was supported in Mandarin. This may suggest that these metrics are parametric between languages or that the head noun retrieves the *wh*-operator instead of the gap in these two languages. For all three languages, some level of similarity-interference was observed at the head noun making ORCs more difficult. For Mandarin in particular, ORC advantages were observed regardless of ambiguity which suggests that the regularities of the language may support processing despite parsing a less frequent structure. While, the above findings fit within the framework of cue-based retrieval, the model needs to be updated to account for regularities facilitating processing.

OBSB only had little support for ambiguous RCs in Japanese and unambiguous RCs in Korean, which should not be subject to OBSB effects. As such, OBSB may likely only contribute little to the overall ORC processing difficulties for Japanese and Korean.

Chapter 6: In conclusion, the combined findings from all three studies revealed that multiple factors contribute to the overall processing of RCs in these languages. Specifically, memory-constraints (i.e., integration/retrieval decay, similarity-based interference) and expectation-based processing were shown to be interrelated factors. These factors caused fluctuation in the activation of the RC structures and lexical dependencies that either facilitated processing or increased processing difficulties. Furthermore, ambiguity was largely seen as a factor for both Japanese and Mandarin, but not Korean. The reasoning for this is that in the former two, the locus of disambiguation also serves as the locus of integration, but in Korean, in contrast, these two are at separate loci. These findings fit nicely into the framework of cue-based retrieval models. Also, cue-based parsing was also supported since unambiguous RCs were not shown to reveal expectation effects until the locus of disambiguation (i.e., the principal cue for the RC interpretation). However, there was one additional finding that was counter to normal cue-based parsing effects. That is canonical order facilitation in Mandarin for unambiguous RCs. Thus, canonical order facilitation should be included in the framework of cue-based parsing in contexts which are (i) unambiguous, but (ii) have principal cues responsible for extracting frequency expectation at the right edge of the clause. This factor may

be unique for languages like Mandarin however. Overall, RC processing should be viewed as an interrelated model of various processing mechanisms.

Major Comments

The following four major points were discussed during the oral defense:

(1) A critical comment was proposed that it could be possible that for the native speakers of Korean and Mandarin Chinese living/being in Japan and likely being bilingual speakers of Japanese could have influenced Michael's findings. In other words, there could have been an influence from Japanese on the processing of their respective first language. Michael was questioned about potential influences and how he accounted for it. He responded that there could have been influences of the Japanese language for the processing of Korean and Mandarin Chinese. However, he claimed that there was no evidence of this. He replied that the results in each language replicated results found in other studies which used native speakers in Korean, Taiwan and Mainland China. Also, he mentioned that this issue was mostly problematic for the Mandarin Chinese group as the differences in word orders between the languages could have altered the processing of Mandarin. Again, he claimed that there was no evidence for this and the opposite was true.

(2) Another important comment reflected the first language acquisition of relative clauses in Korean by children. This comment indicated that children acquiring Korean as a first language have the tendency to produce the *-kes* complementizer marker for relative clauses in Korean. He was asked if they did this to make relative clauses more salient since the structure is ambiguous. Michael replied that yes, Korean children have this tendency. He also mentioned that children learning Japanese as a first language have a similar phenomenon of producing an ungrammatical *–no* complementizer/genitive for relative clauses as well. In all, he argued that this was likely an overgeneralization of grammatical rules in each language instead of issues in ambiguity. However, Korean in particular, the use of *–kes* in adult speech is still being debated, so it is not known if it is ungrammatical as *–no* is for Japanese.

(3) A point was mentioned that Michael discussed the temporal integration metric (Lewis & Vasishth, 2006) and the linear integration metric (Gibson, 2000) together. Yet, the comment suggested that Michael claimed that the linear metric is a memory-based metric while the temporal metric was not. Michael responded that their comment was incorrect and clarified the statement. He mentioned that both metrics operate within memory. Specifically, he mentioned that for both metrics, items are initially activated and stored in memory and their activation level then decays in a similar fashion. He stated that the difference between the two metrics is that the linear metric allows reactivation in memory (i.e., activation, decay, and reactivation) while the other does not reactivate (i.e., activation and decay).

(4) An important question was brought forward about the statistical analysis methods Michael's used in his dissertation. In particular, why he used *linear mixed effects* (LME) models for his analyses? (i) He was questioned about the advantages of LME over previous traditional

analyses such as *Analysis of Variance* (ANOVA). Michael responded that the main advantages of LME over ANOVA were that LME includes random factors such as item and subject variance which allows the dataset to become more generalizable. He said that without the inclusion of random effects in a model, the model more directly reflects the dataset of the experiment. (ii) He was also provided a comment that the majority of the published papers report only significant results (i.e., significance in data analysis) and there is a likelihood that significant results are obtained by chance (i.e., Type II errors). He was ultimately questioned about which methods he used to conclude his findings were valid. Michael responded that yes, there is always the chance that Type II errors (i.e., false positives) can be obtained. To avoid this, an important method is to replicate finding and results to ensure that there is replicability in the findings. Also, he mentioned to avoid researchers from choosing models which support their claims, strict protocol must be followed by testing models in order to determine which model best fit the data, not the researcher's claim. (iii) He was also questioned why he decided to code his variables using sum contrasts (i.e., -0.5 & +0.5) rather than (0) and (1) and whether he believed if his results would change if he adopted differently methods. Michael responded that he followed the advice given to him by his reviewers of his published papers and that he followed the analysis procedures used by other researchers on the subject, namely, Shraven Vasishth. He also mentioned that he had actually analyzed the results using several different styles (to learn more about LME) and found that the results did not alter drastically. He concluded that he believed that the overall pattern of results would not change if he used a different method.

There were several other comments and questions during Michael's defense. Michael properly responded to each promptly and thoroughly.

Judgment by the Dissertation Committee

Michael P. Mansbridge not only completed an outstanding doctoral dissertation but also gave an excellent oral presentation. He adequately responded to multiple comments by the members of his doctoral evaluation committee. Throughout his dissertation, he also demonstrated the abilities and knowledge needed to conduct independent activities as a researcher in the future. The evaluation committee, therefore, judged that the doctoral dissertation presented by Michael P. Mansbridge exceeded the standards for candidates of The Doctor of Philosophy, and passed his doctoral evaluation.