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## **On the Processing of Japanese *Wh*-Questions: Relating Grammar and Brain**

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### **1. Introduction**

The question we address in this paper is whether there is any discernible relationship between theoretical claims made with regard to *wh*-in-situ languages such as Japanese and particular brain responses. Recent advances in neural imaging technologies allow the testing of linguistic theories using real-time sentence processing. For instance, event-related brain potentials (ERPs) show electrical activity in the brain that is time locked to an external event, such as the onset of a word presented visually or auditorily (cf. Kutas and Van Petten 1994). ERPs offer electrophysiological indices of neural activities with resolutions on the order of tens of milliseconds, without the need for an additional task such as a button press to a grammaticality judgment during on-line language comprehension.

This paper introduces a subpart of the data from our ERP study on the processing of Japanese *wh*-questions (Ueno and Kluender in prep.). We discuss an ERP component, right anterior negativity (RAN), that seems to index a dependency between an in-situ *wh*-element and its corresponding Q[uestion]-particle, and argue that RAN thus reflects the relationship between *wh*-in-situ and COMP as discussed in linguistic theory.

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(3) a. Embedded clause *wh*-question

[Hobbes-wa [Calvin-ga **nani-o** mottekita-ka] itta-ndesu-ka].  
 Hobbes-T Calvin-N **what-A** brought-Q said-POLITE-Q  
 ‘Did Hobbes say what Calvin brought?’

b. Matrix clause *wh*-question

[Hobbes-wa [Calvin-ga **nani-o** mottekita-to] itta-ndesu-ka].  
 Hobbes-T Calvin-N **what-A** brought-that said-POLITE-Q  
 ‘What did Hobbes say Calvin brought?’

For matrix clause *wh*-questions like (3b), a non-question particle *to* ‘that’ is attached to the embedded verb.

Given the above syntactic differences, theoretical claims have been made regarding *wh*-in-situ. These claims can be roughly classified into two categories, namely, movement and Q-coindexing. Both claims are based on the assumption that a *wh*-element is a variable that needs to have its interrogative scope licensed.

The movement analyses argue that although *wh*-movement and *wh*-in-situ languages yield different surface word orders, they occur in the same order at LF. They argue that *wh*-elements in *wh*-in-situ languages are displaced to their clausal scope positions, just as in *wh*-movement languages (Huang 1982; Lasnik and Saito 1984; Nishigauchi 1990).

On the other hand, the Q-coindexing analyses focus on the relationship between *wh* and Q. Nishigauchi (1990) and Cheng (1991) argue that *wh*-in-situ languages require Q-particles that determine the quantificational (i.e., interrogative, existential, or universal) force of *wh*-elements. Further, several linguists (Baker 1970; Pesetsky 1987; Watanabe 1992; Aoun and Li 1993; Cole and Hermon 1994) propose the mechanism of binding by a Q-operator. In this mechanism, the scope of a *wh*-element is represented by a coindexing Q-operator rather than by the moved *wh*-element. As shown in Figure 1, a covert Q-operator is postulated in the spec of CP, with an overt/covert Q-particle in C linked by spec-head agreement. Then the operator, either base-generated (Baker, Pesetsky; Cole and Hermon) or moved (Watanabe; Aoun and Li), is said to bind the *wh*-element.

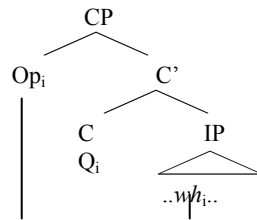


Figure 1 Q-operator binding mechanism.

These two types of analyses appear different at first glance, yet they share a common property: the scope of a *wh*-in-situ needs to be licensed by something in its interrogative clausal CP. This “something” can be either the moved *wh*-element itself or a moved/base-generated operator that is linked with its Q-particle.<sup>2</sup>

There has been experimental evidence suggesting some type of relationship between Japanese *wh*-elements and Q-particles. In their ERP study, Nakagome et al. (2001) examined the processing of mono-clausal *wh*-questions with and without Q-particles at the sentence-final verb position. The results showed a P600 effect (more positivity around 600ms post-stimulus onset) in response to *wh*-questions in which the sentence-final Q-particle was missing. Nakagome et al. attributed the P600 effect to syntactic processes related to the operation of movement.

In a self-paced reading experiment, Miyamoto and Takahashi (2002) reported that matrix clause *wh*-questions were read more slowly than embedded clause *wh*-questions at the embedded verb position when there was no Q-particle attached to the embedded verb. Miyamoto and Takahashi argued that just like the dependency between a displaced *wh*-filler and its gap position in *wh*-movement languages, there is a dependency between a *wh*-word and a related Q-particle in *wh*-in-situ languages. Due to this dependency, Japanese readers expect a Q-particle as soon as they see a *wh*-word. Matrix clause *wh*-questions were read more slowly than embedded clause *wh*-questions because they violated this expectation (Typing Mismatch Effect, henceforth, TME). Similarly, Aoshima, Phillips, and Weinberg (this volume) observed TME slowdown even when a *wh*-element was scrambled out of the embedded clause.

The above studies suggest that there is some psychologically real relationship between Japanese *wh*-elements and Q-particles. Although their interpretations differ, the focus of these studies was on the Q-particle itself. This goes along with the theoretical claims that *wh*-in-situ has to have its scope licensed by something in its interrogative clausal CP (either moved *wh*, Q-operator, or Q-particle).

Given the above, we wanted to test if there was any detectable neural relationship between Japanese *wh*-elements and corresponding Q-particles in the on-line ERP processing of Japanese *wh*-questions. We predicted that if such a relationship exists, it may be similar to filler-gap dependencies in *wh*-movement languages and elicit LAN. Further, we wanted to see if there was any relationship between the experimental data and linguistic theory.

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2. Pesetsky (2000) argues that all *wh*-phrases require overt movement and that the in-situ versus fronted contrast is a question of whether to pronounce the foot or the head of the chain. This analysis can also be subsumed under the generalization that something in [Spec, CP] binds *wh*-in-situ.

### 3. ERP experiments on Japanese *wh*-questions

This section presents the results of two ERP experiments on the processing of mono-clausal and bi-clausal Japanese *wh*-questions respectively. Note that ERPs consist of positive and negative voltage peaks distributed over time. ERP effects are examined in terms of differences between waveforms compared to control conditions in polarity (e.g., N for negative or P for positive), latency, amplitude, morphology (shape of the waveforms), and distribution over the scalp. In the present study our focus is on anterior (frontal) negativities in both slow potential (ERP differences lasting several seconds) and phasic (ERP differences a few 100 msec in duration) forms. Negativity is conventionally plotted up.

#### 3.1. Mono-clausal *wh*-questions

As a first step, we investigated the processing of mono-clausal *wh*-questions. 20 native speakers of Japanese participated in the study. Stimuli included (4a) scrambled object *wh*-questions and (4b) yes/no-questions with scrambled demonstrative objects.

##### (4) a. Scrambled *wh*-questions

Ano jimotono shinbun-ni        yoruto  
 the local newspaper-to according  
**nani-o** sono yukanna bokenka-ga toto \_\_ mitsuketa-ndesu-ka.  
**what-A** the brave adventurer-N finally discovered-POL-Q

‘According to the local newspaper, what did the brave adventurer finally discover?’

##### b. Scrambled yes/no-questions

Ano jimotono shinbun-ni        yoruto  
 the local newspaper-to according  
**sore-o** sono yukanna bokenka-ga toto \_\_ mitsuketa-ndesu-ka.  
**that-A** the brave adventurer-N finally discovered-POL-Q

‘According to the local newspaper, did the brave adventurer finally discover that?’

200 sets of experimental sentences were placed in a Latin square design to create four parallel lists, such that no one subject saw more than one sentence from each set. 200 filler sentences were added to each list, and lists were pseudorandomized and divided into 20 sets of 20 sentences each.

Stimuli were presented on a computer screen in Japanese characters one word at a time with 650 ms stimulus onset asynchrony. In order to

maintain subjects' attention, comprehension questions were inserted in the stimuli every five sentences on average. The electroencephalogram (EEG) was recorded from 19 positions with a sampling rate of 250 Hz. Recordings were referenced to the left mastoid, and re-referenced to the average of both mastoid electrodes off-line.

Single-word averages consisted of 1000 ms epochs including a 100 ms prestimulus baseline, and two-word averages consisted of 2000 ms epochs including a 200 ms prestimulus baseline. Four-word averages consisted of 3000 ms epochs (4 x 650 ms SOA plus a 400 ms prestimulus baseline). The statistical analyses were done separately on midline (Fz, Cz, Pz), parasagittal (Fp1/2, F3/4, C3/4, P3/4, O1/2), and temporal (F7/8, T3/4, T5/6) electrodes, using condition, anteriority, and hemisphere as factors. Original degrees of freedom are reported with the corrected probability level using the Huynh-Feldt method.

Figure 2 shows the comparison of words following displaced *wh*- and demonstrative pronouns up to and including the verb-Q complex ('brave adventurer-NOM finally discovered-Q' in (4)). ANOVAs performed in the latency window of 500-800 ms poststimulus onset of 'finally' (1800 to 2100 ms from the onset of 'brave') revealed a significant or marginal main effect of condition [*midline*:  $F(1, 19)=6.34$ ,  $p=.021$ ; *parasagittal*:  $F(1, 19)=6.21$ ,  $p=.022$ ; *temporal*:  $F(1, 19)=3.97$ ,  $p=.061$ ], indicating scrambled *wh*-questions were more negative than scrambled yes/no-questions. In addition, there was a significant interaction between condition and hemisphere in the parasagittal array [ $F(1, 19)=10.84$ ,  $p=.004$ ], with the ERPs to scrambled *wh*-questions more negative over the right hemisphere. Separate ANOVAs performed in the 300-600 ms region of 'discovered-Q' (2250 and 2550 ms from the onset of 'brave') also showed a significant main effect of condition in all three arrays [*midline*:  $F(1, 19)=5.46$ ,  $p=.031$ ; *parasagittal*:  $F(1, 19)=5.58$ ,  $p=.029$ ; *temporal*:  $F(1, 19)=5.75$ ,  $p=.027$ ]. In addition, there were significant interactions between condition and anteriority in the midline array [ $F(2, 38)=4.66$ ,  $p=.042$ ] and between condition and hemisphere in the parasagittal array [ $F(1, 19)=8.06$ ,  $p=.011$ ]. These interactions were due to greater negativity over right anterior regions in response to scrambled *wh*-sentences.

To summarize, scrambled *wh*-questions in comparison to scrambled yes/no-questions elicited greater negativity, especially at right anterior electrodes, both at the adverbial and at the verb-Q complex positions. We termed this effect the RAN (right anterior negativity) effect. The RAN effect seems to indicate some type of relationship between Japanese *wh*-words and question particles. This is consistent with both theoretical and experimental claims previously made about Japanese *wh*-questions, as discussed in Section 2. Thus, our preliminary conclusion at this point is that the brain is sensitive to the relationship between a *wh*-word and a

following Q-particle. However, since the effect was more phasic than long-lasting, there could be two possible interpretations. It could be interpreted as an index of the parser's expectation for a Q-particle as argued by Miyamoto and Takahashi (2002) (termed "wh-Q expectation hypothesis" hereafter), or as more of a local mental operation associated with the verb-Q position. We suspected that this might be an index of *wh*-scope integration at the Q-particle position that disambiguates the scope of the *wh*-element (termed "*wh*-scope calculation hypothesis" hereafter). We investigated the processing of bi-clausal Japanese *wh*-questions to tease apart these two possibilities.

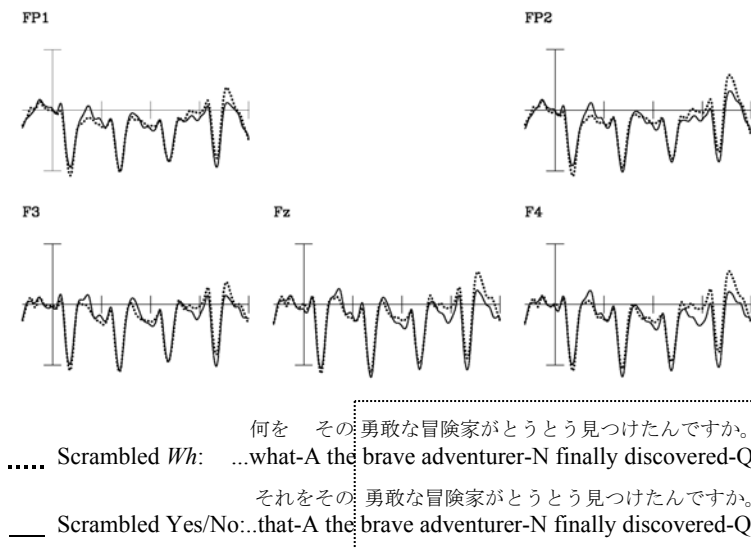


Figure 2 ERPs ( $n = 20$ ) at frontal (Fp1/2, F3/4, Fz) electrodes relative to a 400 ms prestimulus baseline. Shown are the ERPs covering the adjective, subject noun, adverbial, and verb-Q positions of scrambled *wh*- vs. yes/no-questions. Negativity is plotted up, on a scale of  $\pm 5 \mu\text{v}$ .

### 3.2. Bi-clausal *wh*-questions

We essentially used the same ERP procedure as in the previous experiments with a different group of 20 native speakers of Japanese. Stimuli were a modified version of Miyamoto and Takahashi (2002) and included bi-clausal *wh*-questions (with embedded and matrix clause scope *wh*, and with a scrambled embedded clause) and their structurally equivalent yes/no-question counterparts, as shown in (5).

(5) a. Embedded clause *wh*-questions

[senmu-ga **donna** pasokon-o katta-**ka**] keiri-no kacho-ga\_\_kikimasita-**ka**.  
 director-N **what** PC-A bought-**Q** acc.-of manager-N asked-**Q**

‘Did the accounting manager ask what kind of PC the director bought?’

b. Matrix clause *wh*-questions

[senmu-ga **donna** pasokon-o katta-**to**] keiri-no kacho-ga\_\_iimasita-**ka**.  
 director-N **what** PC-A bought-**that** acc.-of manager-N said-**Q**

‘What kind of PC did the accounting manager say the director bought?’

## c. Embedded clause yes/no-questions

[senmu-ga **atarasii** pasokon-o katta-**ka**] keiri-no kacho-ga\_\_kikimasita-**ka**.  
 director-N **new** PC-A bought-**Q** acc.-of manager-N asked-**Q**

‘Did the accounting manager ask if the director bought a new PC?’

## d. Matrix clause yes/no-questions

[senmu-ga **atarasii** pasokon-o katta-**to**] keiri-no kacho-ga\_\_iimasita-**ka**.  
 director-N **new** PC-A bought-**that** acc.-of manager-N said-**Q**

‘Did the accounting manager say the director bought a new PC?’

Comparisons were made between all *wh*- and all yes/no- questions in the embedded clause region, and between matrix and embedded clause *wh*-questions at the embedded verb position and in the matrix clause region.

Figure 3 shows ERPs to all *wh*-questions in comparison to all yes/no-questions at the embedded object position. Visual inspection showed a sustained anterior negativity in response to all *wh*-questions. ANOVAs run in the window of 300-1300 ms revealed a significant or marginal main effect of condition in all three arrays [*midline*:  $F(1, 19)=3.28$ ,  $p=.086$ ; *parasagittal*:  $F(1, 19)=5.83$ ,  $p=.026$ ; *temporal*:  $F(1, 19)=4.81$ ,  $p=.041$ ], as well as a marginal condition x anteriority interaction in the temporal array [ $F(2, 38)=3.75$ ,  $p=.063$ ]. These results indicated that *wh*-questions were more negative than yes/no-questions especially over anterior regions of the scalp. This effect of anterior negativity cannot be an effect of *wh*-scope calculation (i.e., in support of the *wh*-scope calculation hypothesis), as, at this point in the sentence, subjects would not have seen any Q-particle that would disambiguate the scope of the *wh*-element they had seen. On the other hand, an effect of this type is entirely consistent with the *wh*-Q expectation hypothesis, in so far as the introduction of a *wh*-word triggers the parser’s expectation for a Q-particle.

The *wh*-Q expectation hypothesis was also supported over the *wh*-scope calculation hypothesis by the following comparison. The *wh*-scope

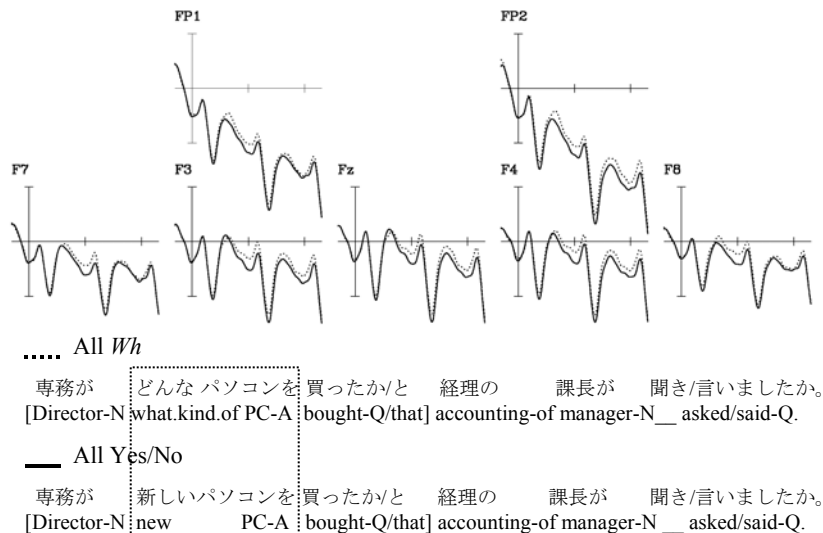
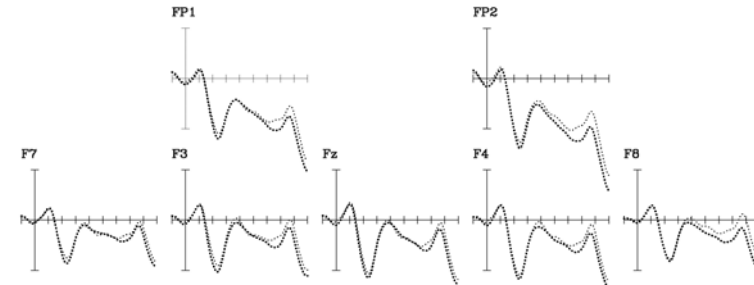


Figure 3 ERPs ( $n=20$ ) at frontal (Fp1/2, F7/8, F3/4, Fz) electrodes relative to a 200 ms prestimulus baseline. Shown are the ERPs to the embedded object position of all *wh*- vs. yes/no-questions.

calculation hypothesis predicts that we should see the RAN effect at the verb-Q position that disambiguates *wh*-scope, namely, at the embedded verb-Q position of embedded clause *wh*-questions, and at the matrix verb-Q position of matrix clause *wh*-questions. On the other hand, the *wh*-Q expectation hypothesis predicts that we should see a RAN effect at the embedded verb position of matrix clause *wh*-questions, as subjects' expectation for a Q-particle would not yet have been met in this condition. Consistent with the prediction by the *wh*-Q expectation hypothesis, a RAN effect was seen in response to matrix clause *wh*-questions at the embedded verb position, rather than to embedded clause *wh*-questions (see Figure 4). ANOVAs in the 300-900 ms window revealed a marginal condition  $\times$  anteriority  $\times$  hemisphere interaction in the temporal array [ $F(2, 38)=2.88$ ,  $p=.071$ ], indicating that matrix clause *wh*-questions in comparison to embedded clause *wh*-questions were more negative especially over the right anterior regions of scalp. In order to re-examine the validity of the *wh*-scope calculation hypothesis, matrix clause *wh*-questions were compared both to embedded clause *wh*-questions and to matrix clause yes/no-questions at the matrix verb-Q position, but no RAN effect or other apparent ERP effects were found (cf. Ueno and Kluender in prep.).

Returning now to the comparison between matrix vs. embedded clause *wh*-questions, we extended the latency window to the end of the sentence in



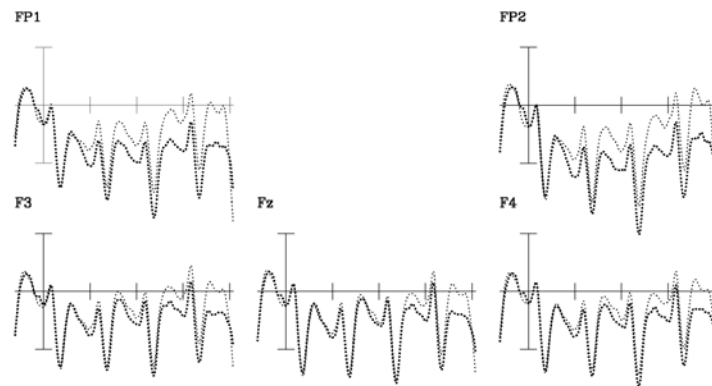
..... Embedded *Wh*

専務が どのような パソコンを 買ったか 經理の 課長が 聞きましたか。  
 [Director-N what.kind.of PC-A bought-Q] accounting-of manager-N \_\_ asked-Q.

..... Matrix *Wh*

専務が どのような パソコンを 買ったと 經理の 課長が 言いましたか。  
 [Director-N what.kind.of PC-A bought-that] accounting-of manager-N \_\_ said-Q.

Figure 4 ERPs (n=20) at frontal (Fp1/2, F7/8, F3/4, Fz) electrodes relative to a 100 ms prestimulus baseline. Shown are the ERPs to the embedded verb position of embedded vs. matrix *wh*-questions.



..... Embedded *Wh*

専務が どのような パソコンを 買ったか 經理の 課長が 聞きましたか。  
 [Director-N what.kind.of PC-A bought-Q] accounting-of manager-N \_\_ asked-Q.

..... Matrix *Wh*

専務が どのような パソコンを 買ったと 經理の 課長が 言いましたか。  
 [Director-N what.kind.of PC-A bought-that] accounting-of manager-N \_\_ said-Q.

Figure 5 ERPs (n=20) at frontal (Fp1/2, F3/4, Fz) electrodes relative to a 400 ms prestimulus baseline. Shown are the ERPs to the region from embedded to matrix verb position of embedded vs. matrix *wh*-questions.

order to look for slow potentials effects (long-lasting ERP differences) between the presentation of a *wh*-word and its associated Q-particle that would lend further support to the *wh*-Q expectation hypothesis. Figure 5 shows ERPs to the region between the embedded and matrix verbs (as in ‘bought-Q/that accounting-of manager-N asked/said-Q’) for embedded vs. matrix clause *wh*-questions. The trend of anterior negativity continued. ANOVAs run in the 300-2600 ms window revealed a significant main effect of condition in the parasagittal [ $F(1, 19)=4.95, p=.038$ ] and temporal [ $F(1, 19)=5.41, p=.031$ ] arrays, as well as a significant or marginal condition x anteriority interaction in the parasagittal [ $F(4, 76)=3.72, p=.066$ ] and temporal [ $F(2, 38) = 4.44, p = .047$ ] arrays. These results indicated that matrix clause *wh*-questions were more negative than embedded clause *wh*-questions especially over anterior regions of the scalp.

#### 4. Discussion

To summarize, we have seen effects of anterior negativity in response to *wh*-questions in multiple comparisons, some of them not reported here. In the majority of cases, the effects were lateralized to the right side of the head. While they were sometimes bilateral in distribution, they were never left-lateralized. This pattern of results was consistent only with the *wh*-Q expectation hypothesis: (R)AN seems to be a reliable neural processing correlate of the dependency between *wh*-elements and Q-particles.

This effect seems similar to the effect indexing the dependency between *wh*-elements and their gaps in *wh*-movement languages. We have seen that both filler-gap dependencies and *wh*-Q dependencies elicit anterior negativity, often in the form of slow potentials. Slow anterior negative potentials have been generally associated with a working memory load caused by both sentential (King and Kutas 1995; Müller, King, and Kutas 1997; Münte, Schiltz, and Kutas 1998; Fiebach et al. 2001) and non-sentential (Ruchkin, Johnson, Canoue, and Ritter 1990) linguistic stimuli. Therefore, it seems feasible to interpret the anterior negative slow potentials found in our study as an index of working memory load due to a dependency between a *wh*-element and its corresponding Q-particle in Japanese, as the parser would have to actively maintain a *wh*-element until its scope is licensed by the Q-particle. This may well be similar to the working memory load for associating a *wh*-filler with its gap in *wh*-movement languages. However, the question remains: why RAN instead of LAN?

First, it should be kept in mind that ours is not the first or the only study to report bilateral and/or right-lateralized slow negative potentials in response to syntactic dependencies (King and Kutas 1995; Müller et al. 1997). However, to account for the lateralization difference, it might be a

good idea to review the underlying cognitive process involved in the processing of *wh*-movement and *wh*-in-situ. With respect to *wh*-movement languages, it has been argued that holding a *wh*-filler without a grammatical function and a thematic role, until it is associated with its gap, taxes working memory (Kluender and Kutas 1993; King and Kutas 1995).<sup>3</sup> On the other hand, what is ambiguous about Japanese *wh*-elements is their interrogative scope, until they are linked with their corresponding Q-particles. For both *wh*-movement and *wh*-in-situ languages, the parser has to hold something in anticipation of missing syntactic and semantic information for some extent of time, yet the type of missing information is different, and this may be the factor that causes the difference between left- and right-lateralization.

In terms of the relationship between linguistic theory and brain responses, recall from Section 2 that linguistic theories argue that the scope of a *wh*-in-situ needs to be licensed by something in the Spec or head of its interrogative clausal CP. The Q-coindexing analyses focus on the relationship between *wh*-elements and Q-particles, in that *wh*-in-situ either requires a Q-particle in [C, CP] (Nishigauchi 1990; Cheng 1991) or needs to be bound by a Q-operator by spec-head agreement with the Q-particle in CP (Baker 1970; Pesetsky 1987; Watanabe 1992; Aoun and Li 1993; Cole and Hermon 1994) in order to have its scope licensed. If we assume rightward movement of *wh*-in-situ and rightward projection of Spec, as shown in Figure 6, these claims basically entail a relationship between a *wh*-element and its Q-particle at the end of the clause. The LF-movement analyses (Huang 1982; Lasnik and Saito 1984; Nishigauchi 1990) can also be fit into this model, in that a *wh*-element moves to the Spec of CP and binds its trace at LF, again in spec-head agreement with a Q-particle in C.

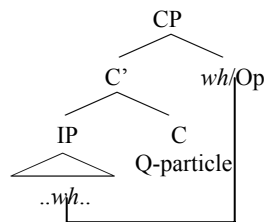


Figure 6 Relationship between *wh*-in-situ and CP.

3. Fiebach et al. (2001) take a more syntactic approach and claim that LAN is linked to “a syntactic working memory process that maintains the filler actively available until the gap is licensed and the syntactic chain between filler and gap can be established (p. 327).” In essence, these researchers all claim that the process of holding a filler that is temporarily unlicensed (in terms of either grammatical function, thematic role, or syntactic chain) taxes working memory.

This seems to be quite relevant to the (R)AN effects found between Japanese *wh*-elements and Q-particles in the present study. The parser actively expects a Q-particle after seeing a *wh*-element, and this is probably due to the need to determine its scope. We have abandoned the “RAN as an index of local *wh*-scope calculation at the verb-Q position” hypothesis, yet we could still say that the scope of a *wh*-element is licensed by the long-distance relationship between a *wh*-element and its corresponding Q-particle, as indexed by (R)AN.

In this sense, our result is compatible with both Q-coindexation and LF-movement analyses. This is plausible since (as pointed out in Section 2) in both analyses the scope of a *wh*-in-situ needs to be licensed by something in the CP that marks its scope (or COMP, to use a term that covers both Spec and C). Therefore, we can say that there is in general a dependency between *wh*-in-situ and COMP, and the *wh*-Q dependency observed in processing studies mirrors in a more or less direct way the *wh*-COMP dependency posited by linguistic theory.

## 5. Conclusion

In conclusion, the present study on the processing of mono-clausal and bi-clausal Japanese *wh*-questions suggests a reliable neural processing correlate (as indexed by (R)AN) of the dependency between *wh*-elements and Q-particles. Theoretical claims about *wh*-in-situ argue for a mechanism inside COMP that licenses the scope of a corresponding *wh*-element, either by a Q-particle, a Q-operator, or the moved *wh*-element itself. This is consistent with our data showing that the brain actively seeks a Q-particle in COMP. From all of the above, we can say that the brain responses we measured reflect the complex relationship between a *wh*-in-situ and its licensing COMP as proposed in various linguistic theories.

## References

- Aoshima, Sachiko, Colin Phillips, and Amy Weinberg. this volume. Theoretical implications of the parsing of Japanese *wh*-scrambling constructions, pp. 29-42.
- Aoun, Joseph, and Yen-hui A. Lee. 1993. *Wh*-elements in situ: Syntax or LF? *Linguistic Inquiry*, 24, 199-238.
- Baker, C.L. 1970. Notes on the description of English questions: The role of an abstract question morpheme. *Foundations of Language*, 6, 197-219.
- Cole, Peter, and Gabriella Hermon. 1994. Is there LF *wh*-movement? *Linguistic Inquiry*, 25(2), 239-262.
- Cheng, Lisa L-S. 1991. *On the typology of wh-questions*. Ph.D. dissertation, MIT.
- Fiebach, Christian J., Matthias Schlesewsky, and Angela D. Friederici. 2001. Syntactic working memory and the establishment of filler-gap dependencies:

- Insights from ERPs and fMRI. *Journal of Psycholinguistic Research*, 30, 321-338.
- Fodor, Janet D. 1989. Empty categories in sentence processing. *Language and Cognitive Processes*, 4(3/4), 155-209.
- Huang, C.-T. James. 1982. Logical relations in Chinese and the theory of grammar. Ph.D. dissertation, MIT.
- King, Jonathan W., and Marta Kutas. 1995. Who did what to when?: Using word- and clause-level ERPs to monitor working memory usage in reading. *Journal of Cognitive Neuroscience*, 7(3), 376-395.
- Kluender, Robert, and Marta Kutas. 1993. Bridging the gap: Evidence from ERPs on the processing of unbounded dependencies. *Journal of Cognitive Neuroscience*, 5(2), 196-214.
- Kutas, Marta, and Cyma K. Van Petten. 1994. Psycholinguistics electrified: Event-related brain potential investigations. In M. A. Gernsbacher (Ed.), *Handbook of psycholinguistics*. (pp. 83-143). San Diego: Academic Press.
- Lasnik, Howard, and Mamoru Saito. 1984. On the nature of proper government. *Linguistic Inquiry*, 15, 235-89.
- Miyamoto, Edson T., and Shoichi Takahashi. 2002. The processing of *wh*-phrases and interrogative complementizers in Japanese. In N. Akatsuka and S. Strauss (Eds.), *Japanese/Korean Linguistics*, 10 (pp. 62-75). Stanford: CSLI.
- Müller, Horst, Jonathan W. King, and Marta Kutas. 1997. Event related potentials elicited by spoken relative clauses. *Cognitive Brain Research*, 5, 193-203.
- Münste, Thomas F., Koiija Schiltz, and Marta Kutas. 1998. When temporal terms belie conceptual order. *Nature*, 395, 71-73.
- Nakagome, Kazuyuki, Satoru Takazawa, Osamu Kanno, Hiroko Hagiwara, Heizo Nakajima, Kenji Ito, and Ichiro Koshida. 2001. A topographical study of ERP correlates of semantic and syntactic violations in the Japanese language using the multichannel EEG system. *Psychophysiology* 38, 304-315.
- Nishigauchi, Taisuke. 1990. *Quantification in the theory of grammar*. Dordrecht: Kluwer Academic Publishers.
- Pesetsky, David. 1987. *Wh-in-situ: Movement and unselectable binding*. In E. Reuland and A.G.B. ter Meulen (Eds.), *The representation of indefiniteness*. Cambridge: MIT Press.
- Pesetsky, David. 2000. *Phrasal movement and its kin*. Cambridge, MA: MIT Press.
- Ruchkin, Daniel S., Ray Johnson Jr., Howard Canoune, and Walter Ritter. 1990. Short-term memory storage and retention: An event-related brain potential study. *Electroencephalography and Clinical Neurophysiology*, 76, 419-439.
- Ueno, Mieko, and Robert Kluender. in prep. *On the processing of Japanese wh-questions: An ERP study*.
- Watanabe, Akira. 1992. Subjacency and S-structure movement of *wh*-in-situ. *Journal of East Asian Linguistics*, 1, 255-292.