Neurolinguistic Differences between Evidentiality and Modality

Yurie Hara, Naho Orita, Ying Deng, Takeshi Koshizuka and Hiromu Sakai

INTRO: Many of the prominent studies on inferential evidentials (Izvorski, 1997; Matthewson et al., 2006; McCready & Ogata, 2007) have argued that evidentiality is a kind of modality. Davis & Hara (2014) and Hara (2017) (henceforth, D&H) argue against this evidential-as-modal approach and make two claims: 1. The Japanese sentence-final auxiliary *yooda* 'it seems' as in (1) is a morpheme of evidentiality which is distinct from canonical modal auxiliaries like *daroo* 'I bet' in (2). 2. The semantics of *yooda* relies on the notion of causality.

(1) Ame-ga futta yooda.
    rain-NOM fell EVID
    'It seems that it rained.'

(2) Michi-ga nureteiru daroo.
    streets-NOM wet I-bet
    'It rained, I bet.'

Given D&H's observation, we propose that *daroo* is a necessity modal (Kratzer, 2005):

(3) **Interpretation of *daroo*:** $\text{Daroo}(p)$ is true at $\mathbf{f}, \mathbf{g}, w$ iff $\text{Must}(p)$ is true at $\mathbf{f}, \mathbf{g}, w$.

Turning to the evidential *yooda*, the interpretation of *yooda* is defined as in (4): $\text{Yooda}(p)$ presupposes that there is some state q such that q is a necessity relative to causal premise background $\mathbf{f}_c$, (Kaufmann, 2014) and asserts that the speaker perceives q at w.

(4) **Interpretation of *yooda*:**
    $\text{Yooda}(p)$ is defined at $\mathbf{f}_c, \mathbf{g}, w$ iff $\exists q$ such that $\text{Must}_p(q)$ is true at $\mathbf{f}_c, \mathbf{g}, w$.   (presupposition)
    If defined, $\text{Yooda}(p)$ is true at w iff the speaker perceives q at w.   (assertion)

RESEARCH QUESTIONS: The goal of this study is to answer the following research questions: **Q1-1**. Can we justify D&H's theoretical claims by way of corpus and neurolinguistic studies? **Q1-2**. Can the experimental result provide data that cannot be obtained solely by introspection? **Q2**. Is there a neurological difference between processing of modals and evidentials? **Q3**. In online processing of a sentence, does the parser predict what will be the final auxiliary of the sentence based on the content of the partially processed sentence?

CORPUS: We conducted a corpus study to test whether the distribution of *yooda* is dependent on the causal relation. Since the corpus does not contain information on whether a predicate denotes a cause or effect, we made the assumptions in (5) and the predictions in (6):

(5) a. Causes are events while effects are states.
    b. The cause event temporally precedes the effect state.

(6) a. *Yooda* tends to be attached to past-tensed and eventive predicates.
    b. *Daroo* tends to be attached to non-past and stative predicates.

To test the predictions in (6), we use Balanced Corpus of Contemporary Written Japanese (Maekawa et al., 2014) containing approximately 100 million words collected from various kinds of Japanese texts. We extract sentences ending with *daroo* and *yooda*, resulting in 30686 *yooda* sentences and 47538 *daroo* sentences. We measured Normalized Pointwise Mutual Information (NPMI): The higher positive values of NPMI indicate stronger associations or positive correlations between kinds of predicates and final auxiliaries *yooda/daroo*. Tab. 1 summarizes

Tab. 1: NPMI

	yooda		daroo
past	0.22	>	0.057
non-past	0.177	<	0.214
verb	0.204	>	0.188
verb-positive	0.196	>	0.17
verb-negative	0.209	<	0.253
adjective	0.116	<	0.135

the result. As predicted, *yooda* has better associations with past-tensed predicates and positive verbs, which tend to denote events, while *daroo* has better associations with non-past predicates and negative verbs and adjectives, which tend to denote states (Krifka, 1990).

EEG: An EEG experiment was conducted to address the research questions laid out above in Section 2. ***Procedure:*** The stimuli had two fully-crossed factors—CONTEXT (Effect-Cause/Cause-Effect) and AUX (*yooda/daroo*)—which resulted in four conditions:

(7) a. EC*y*: Effect-Cause-*yooda* (Expected): The streets are wet. It rained-*yooda*.
    b. #CE*y*: #Cause-Effect-*yooda* (Unexpected): #It rained. The streets are wet-*yooda*.
    c. #EC*d*: #Effect-Cause-*daroo* (Unexpected): #The streets are wet. It rained-*daroo*.

    d.   CE*d*: Cause-Effect-*daroo* (Expected): It rained. The streets are wet-*daroo*.

Each condition had 78 items. 78 fillers were included. The experiment was counterbalanced so that one participant will not see the same context twice (234 trials in each experiment). Data obtained from 31 Japanese native speakers were analyzed. The procedure of a trial is depicted in 1(a). ***Result:*** Statistical analyses were preformed in the 500-700ms time window. A $2 \times 2 \times 6$ repeated measures ANOVA with the factors CONTEXT (CE/EC), AUX (*y/d*) and ROI (left-anterior (LA; F3 ,F7, FC5); right-anterior (RA; F4, F8, FC6); left-central (LC; FC1,CP1,CP5); right-central (RC; FC2,CP2,CP6); left-posterior (LP; P3, P7, O1); right-posterior (RP; P4, P8, O2)) revealed a three-way interaction ($p < 0.01$). Compared to EC*y*, the #CE*y* condition elicited a significantly more negative-deflection at RP ($p < 0.05$) as in Fig. 1(b) and a significantly more positive deflection at LA ($p < 0.01$) as in Fig. 1(c). There was also a significant AUX $\times$ ROI interaction ($p < 0.001$). *Daroo* elicited a significantly more negative-deflection at LP ($p < 0.01$) and RP ($p < 0.01$) compared to *yooda*. There was no significant difference between #EC*d* and CE*d* conditions. ***Discussion:*** We interpret the posterior negativity and frontal positivity elicited by #CE*y* condition as N400/P600 effect of semantic anomaly and reanalysis (Kuperberg, 2007; Kulakova et al., 2014). The negativity observed as AUX $\times$ ROI interaction for *daroo* shows that processing of modality which involves processing of multiple possible worlds poses increased processing demands. This accords well with the findings in the previous studies: Processing of English and German counterfactuals and modals elicit negativity, which is analyzed as an indication of increased processing costs (Dwivedi et al., 2006; Kulakova et al., 2014; Kulakova & Nieuwland, 2016).

ANSWERING THE RESEARCH QUESTIONS: **A1-1**. The corpus and EEG studies support the theoretical claim that *yooda* belongs to a category of evidential, which is different from modals like *daroo* and its interpretation is dependent on causal relations. **A1-2&A2**. The EEG result revealed that compared to evidentials, processing of modals increases processing load, which cannot be predicted by the introspection-based data. **A3**. The unexpected #Cause-Effect-*yooda* condition elicited an N400/P600 effect which is an indication of semantic anomaly and reanalysis. Thus, the parser does predict what will be the final auxiliary of the sentence based on the content of the partially processed sentence.

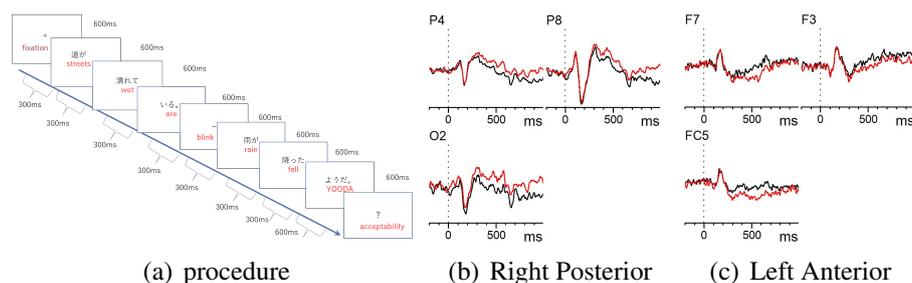(a) procedure   (b) Right Posterior   (c) Left Anterior

Fig. 1: (b-c): Grand Average waveforms time locked to the final auxiliary: #Cause-Effect-*yooda* (red line) and Effect-Cause-*yooda* (black line)

SELECTED REFERENCES: **Davis & Hara.** 2014. Evidentiality as a causal relation: A case study from Japanese *youda*. **Dwivedi, Phillips, Laguë-Beauvais & Baum.** 2006 An electrophysiological study of mood, modal context, and anaphora. **Hara**. 2017. Causality and evidentiality. **Kaufmann**. 2013. Causal premise semantics. **Kratzer**. 2005. Constraining premise sets for counterfactuals. **Krifka**. 1990. Boolean and non-boolean 'and'. **Kulakova, Freunberger & Roehm.** 2014. Marking the counterfactual: ERP evidence for pragmatic processing of German subjunctives. **Kulakova, Eugenia & Nieuwland.** 2016. Pragmatic skills predict online counterfactual comprehension: Evidence from the N400. **Kuperberg**. 2007. Neural mechanisms of language comprehension: Challenges to syntax. **Maekawa et al.** 2014. Balanced corpus of contemporary written Japanese.