

# Inferential Evidential\*

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## 1 Introduction

Evidentials are morphemes that signal the source of information a speaker possesses to make the claim (Aikhenvald, 2004; Willett, 1988). Evidential morphemes are distinguished depending on their evidence types. For instance, Willett (1988) provides the following typology of evidence types.

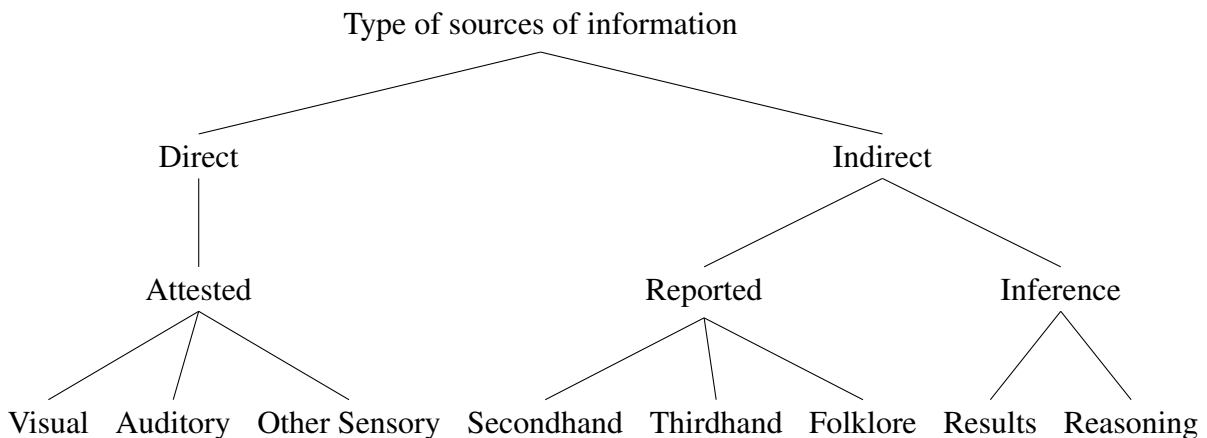


Figure 1: Willett’s (1988, 57) typology of evidence types

Japanese has a rich paradigm of inferential/indirect evidential markers such as *yooda/mitaida/rasii* ‘it seems/appears’, *TP+sooda* ‘I hear’, and *V+sooda* ‘looks like’ (Aoki, 1986; McCready & Ogata, 2007; Hara, 2020). To my knowledge, the work by McCready & Ogata (2007) is the first to give a formal analysis to the Japanese indirect evidentials. According to McCready & Ogata (2007), evidential markers should be treated as a kind of epistemic modal. Many of the leading literature on evidentiality in other languages (Izvorski, 1997; Matthewson et al., 2006) also classifies evidentiality under the general category of epistemic modality. On the other

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hand, canonical modals like English *must* are argued to belong to the inferential evidentials (von Fintel & Gillies, 2010; Degen et al., 2019) blurring the boundary between evidentiality and modality. By examining the semantics of Japanese inferential evidential *yooda* as in (1), Davis & Hara (2014) show that evidentials constitute a category distinct from epistemic modality like *daroo* ‘I bet/probably’ as in (2). That is, unlike *daroo*, which denotes quantification over possible worlds, *yooda* asserts that the speaker perceived some event which is usually *caused* by the event denoted in the prejacent proposition.

- (1) Ame-ga futta yooda.  
rain-NOM fell EVID  
‘It seems that it rained.’
- (2) Michi-ga nureteiru daroo.  
streets-NOM wet I-bet  
‘The streets are wet, I bet/probably.’

Thus, as argued by Davis & Hara (2014) and Hara (2017), the semantics of *yooda* relies on the notion of causality. That is, the proposition to which *yooda* attaches must denote a cause event in a cause-effect relation. For example, in (3), *yooda* attaches to the cause event of a causal relation, ‘if it rains, the streets are wet’.

- (3) Michi-ga nureteiru. Ame-ga futta yooda.  
streets-NOM wet rain-NOM fell EVID  
‘The streets are wet. It seems that it rained.’

If *yooda* attaches to the effect state of the same causal relation, the construction becomes infelicitous as in (4).

- (4) #Ame-ga futta. Michi-ga nureteiru yooda.  
rain-NOM fell streets-NOM wet EVID  
‘#It rained. It seems that the streets are wet.’

Based on these observations, Hara (2017) provides a formal semantic analysis of *yooda* using Kaufmann’s (2013) causal premise semantics. The goal of the current chapter is to introduce the EEG experiment conducted by Hara et al. (2020) that supports Hara’s (2017) proposal on the semantics of *yooda*.<sup>1</sup>

The current chapter first presents semi-formal semantics of *yooda* and *daroo* given in Davis & Hara (2014); Hara (2017); Hara et al. (2020). Then, Section 3 reviews previous studies on EEG processing of modality and causal inference. Finally, Section 4 introduces the EEG study of evidentiality by Hara et al. (2020).

## 2 Semantics of *daroo* and *yooda*

Hara et al. (2020) adopt the analysis of *yooda* in Hara (2017) and propose the semantics of *daroo* and *yooda* in Kaufmann’s (2013) Causal Premise Semantics, which incorporates causal networks to Kratzer’s (2005) premise semantics. Let **f** and **g** be premise background and ordering source respectively and *w* a possible world.<sup>2</sup> In a nutshell, *daroo* is a canonical necessity

<sup>1</sup>Hara et al. (2020) also conduct a corpus study. Interested readers are referred to Hara et al. (2020).

<sup>2</sup>Many of the definitions are omitted for space reasons. See Hara (2017) and Kaufmann (2013).

modal.<sup>3</sup> Let  $\text{Must}(p)$  universal quantification over possible worlds that are compatible with  $\mathbf{f}$  and  $\mathbf{g}$  at  $w$ .<sup>4</sup>

(5)  $\text{Daroo}(p)$  is true at  $\mathbf{f}, \mathbf{g}, w$  iff  $\text{Must}(p)$  is true at  $\mathbf{f}, \mathbf{g}, w$ .

In contrast, the interpretation of *yooda* is defined as in (6). Let  $\mathbf{f}_c$  be a causal premise background (see Hara, 2017, Kaufmann2013). First, ‘ $p$  causes  $q$ ’ is formulated as  $\text{Must}_p(q)$ .<sup>5</sup>

$\text{Yooda}(p)$  presupposes that  $\text{Must}_p(q)$  is true, that is, there is a state  $q$  such that if  $p$  is true,  $q$  must be true at  $\mathbf{f}_c, \mathbf{g}, w$ . More intuitively, there is an effect state  $q$  such that  $p$  causes  $q$ . If it is defined,  $\text{Yooda}(p)$  asserts that the speaker perceives  $q$  at  $w$ :

(6)  $\text{Yooda}(p)$  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)

As can be seen in (6), the assertion of *p-yooda* is evaluated only at the single actual/utterance world  $w$ .

As discussed by Davis & Hara (2014); Hara (2017); Hara et al. (2020), the current semantics of *yooda* and *daroo* explain a wide range of empirical data that previous analyses on evidentiality such as McCready & Ogata (2007); Izvorski (1997); Matthewson et al. (2006) could not. First, a bare assertion of  $p$  and a modalized assertion, *p-daroo* commit the speaker to  $p$  as attempts to cancel  $p$  in the subsequent clause lead to infelicity as in (7) and (8):

- (7) #Ame-ga futta kedo jitsu-wa futtenai.  
 rain-NOM fell but actually fall-NEG  
 ‘#It rained but in fact it didn’t.’
- (8) #Ame-ga futta daroo kedo jitsu-wa futtenai.  
 rain-NOM fell I-bet but actually fall-NEG  
 ‘#Probably, it rained but in fact it didn’t.’

If *yooda* were an epistemic modality as proposed by McCready & Ogata (2007), it should pattern with *daroo*. However,  $p$  in *p-yooda* can be canceled:

- (9) Ame-ga futta yooda kedo, jitsu-wa futte-nai. (Dereka-ga mizu-o maitanda.)  
 rain-NOM fell EVID but actually fall-NEG someone-NOM water-ACC sprayed  
 ‘It seems that it rained, but in fact it didn’t. (Someone sprayed water.)’

Thus, *p-yooda* does not commit the speaker to  $p$ . This naturally follows from the semantics proposed for *yooda* (6). The at-issue content of *p-yooda* only commits the speaker to ‘she perceived  $q$  (which is usually caused by  $p$ )’.

<sup>3</sup>*Daroo* has some other interesting lexical restrictions which are irrelevant to the current purpose of the study. See Hara (2006, 2018).

<sup>4</sup> $\text{Must}(p)$  is formally defined as (i):

- (i) Let  $\text{Prem}((\mathbf{f}^* \mathbf{g})(w))$  a Premise structure obtained by ranking Kratzer premise sets.  $\text{Must}(p)$  is true at  $\mathbf{f}, \mathbf{g}, w$  iff  $p$  is a necessity relative to  $\text{Prem}((\mathbf{f}^* \mathbf{g})(w))$ .

<sup>5</sup>On the basis of *Hypothetical update* defined in (i),  $\text{Must}_p(q)$  is formally defined as (ii).

- (i) **Hypothetical update:** For all  $w$ :  $\mathbf{f}[p](w) := \{\{p\}\}^* \mathbf{f}(w)$ .  
 (ii) **Causal rule:**  $\text{Must}_p(q)$  is true at  $\mathbf{f}_c, \mathbf{g}, w$  iff  $\text{Must}(q)$  is true at  $\mathbf{f}_c[p], \mathbf{g}, w$ .

Furthermore, (6) correctly encodes the asymmetric causal relation in its semantics. In M&O's analysis, what counts as evidence in asserting *p-yooda* is some information *q* such that learning *q* leads *a* to raise her subjective probability of *p*. In both (10a) and (10b), *a* learns something, which should raise *a*'s subjective probability of the prejacent proposition, hence the use of *yooda* is predicted to be acceptable in both.

- (10) a. (Looking at wet streets)  
 Ame-ga futta yooda.  
 rain-NOM fell EVID  
 'It seems that it rained.'
- b. (Looking at falling raindrops)  
 #Michi-ga nureteiru yooda.  
 streets-NOM wet EVID  
 '#It seems that the streets are wet.'

As can be seen, it is the wrong prediction. On the other hand, (6) correctly rules out (10b) because wet streets do not cause rain but the other way around.

Finally, *daroo* appears to be in a complementary distribution with *yooda*. That is, *p-daroo* is unacceptable when the speaker learns information *q* such that *p* causes *q* as in (11a), while it is acceptable when the information *q* is such that *q* causes *p* as in (11b).

- (11) a. (Looking at wet streets)  
 #Ame-ga futta daroo.  
 rain-NOM fell I-bet  
 '#Probably, it rained.'
- b. (Looking at falling raindrops)  
 Michi-ga nureteiru daroo.  
 streets-NOM wet I-bet  
 'Probably, the streets are wet.'

This causal requirement on *daroo* is not directly derived from the semantics of *daroo* given in (5). Rather Hara & Davis (2013); Davis & Hara (2014); Hara et al. (2020) argue that the infelicity of (11a) is a result of pragmatic competition. The semantics of *yooda* is stronger than that of *daroo* since it requires a more specific context. Thus, in the context like (11a), *daroo* loses out in a pragmatic competition with *yooda*. Notice that the current analysis of *yooda* and *daroo* predicts that the unacceptability of (10b) and (11a) are different in their nature: The former is semantic while the latter is pragmatic. The introspection-based data above as well as the corpus result reported in Hara et al. (2020), however, cannot distinguish whether the causal requirements on *yooda* and *daroo* are semantic or pragmatic.

In summary, *yooda* belongs to the category of evidentiality which is distinguished from that of modality such as *daroo*. The semantics of *p-yooda* includes a presupposition that there is a state *q* such that *p* causes *q*. The assertion of *p-yooda* does not commit the speaker to *p* but only entails that the speaker perceives *q*. In contrast, *p-daroo* is an epistemic necessity modal, the semantics of which involves quantification over possible worlds, thus the assertion of it commits the speaker to *p*. Furthermore, *daroo* does not have a causality presupposition like *yooda*.

The goal of EEG experiment reported in Hara et al. (2020) is to empirically support the theoretical claims regarding the semantics of *yooda* and *daroo*. More specifically, *daroo* is a kind of epistemic modality, while *yooda* is not. The semantics of *yooda* encodes the asymmetric

causal relation, while *daroo* pragmatically gives rise to a causal restriction.

### 3 Previous EEG studies on related notions

This section reviews some previous EEG studies on the notions related to evidentiality, namely modality, causal inference and discourse anomaly.

#### 3.1 Modality

Dwivedi et al. (2006) report that hypothetical contexts in English elicit negative trend. That is, in the following conditions, the pronoun (*It*) position in #H-F and H-NF elicited negative-going deflections compared to C-NF and C-F in left posterior regions.

- (12) a. Control-Factual (C-F): John is reading a novel. It ends quite abruptly.
- b. Hypothetical-Factual (#H-F): #John is considering writing a novel. It ends quite abruptly.
- c. Control-Non-factual (C-NF): John is reading a novel. It might end quite abruptly.
- d. Hypothetical-Non-factual (H-NF): John is considering writing a novel. It might end quite abruptly.

Dwivedi et al. (2006) interpret this negativity as an index of extra processing load due to the fact that the hypothetical context complicates the search space for the antecedent of the pronoun.

Kulakova et al. (2014) observe that German subjunctives elicit left-anterior negativity (LAN) compared to indicatives. In (13), the subjunctive auxiliary (*wären*) elicits frontal negativity compared the indicative one.

- (13) a. Subjunctive (counterfactual)  
      Wenn die Würfel gezinkt wären,           dann wäre       das Spiel fair/unfair.  
      If    the dice   rigged were<sub>subjunctive</sub>, then would.be the game fair/unfair.  
      ‘If the dice had been rigged, then the game would have been fair/unfair.’
- b. Indicative  
      Wenn die Würfel gezinkt waren,       dann war das Spiel fair/unfair.  
      If    the dice   rigged were<sub>indicative</sub>, then was the game fair/unfair.  
      ‘If the dice were rigged, then the game was fair/unfair.’

Kulakova et al. (2014) propose that the elicited LAN reflects the dual meaning of subjunctive. That is, the counterfactual meaning marked by subjunctive involves reference to both the background fact and the supposition encoded in the antecedent while the indicative antecedent only involves the supposition.

Similarly, Kulakova & Nieuwland (2016) show that English counterfactual antecedents elicit larger N400 compared to hypothetical (indicative) antecedents at the critical word (*sugar* in (14)).<sup>6</sup>

- (14) a. Counterfactual-true: If sweets were made out of sugar, candy could make people very fat when consumed frequently.

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<sup>6</sup>Kulakova & Nieuwland (2016) state that the elicited N400 effect reflects the lower expectancy for the critical word *sugar* in the counterfactual than in the hypothetical, but does not develop a further discussion on why it is less expected in the counterfactual antecedent.

- b. Counterfactual-false: If words were made out of sugar, sentences could make people very fat when consumed frequently.
- c. Hypothetical-true: If sweets are made out of sugar, candy can make people very fat when consumed frequently.
- d. Hypothetical-false: If words are made out of sugar, sentences can make people very fat when consumed frequently.

In short, processing of English modals and English and German counterfactuals increase processing costs. Processing of modals invokes multiple possible worlds while processing of counterfactuals requires reference to both the background fact and the (counterfactual) supposition. This increase in the processing cost when processing modality and counterfactuals has been argued to elicit negativity.

### 3.2 Causal inference

Baggio et al. (2008) report that when the processor makes a causal inference, sustained anterior negativities are observed. More concretely, in (15b), the processor infers that the event described by the subordinate clause causes to disable the goal state of the accomplishment predicate of the main clause. Baggio et al. (2008) observe that (15b) elicited more negative-deflection in anterior regions at the final verb compared to (15a).

- (15)
- a. Accomplishment–neutral  
 Het meisje was een brief aan het schrijven toen haar vriendin koffie op het  
 The girl was a letter on the to-write when her friend coffee on the  
 tafelkleed morste.  
 tablecloth spilled.  
 ‘The girl was writing a letter when her friend spilled coffee on the tablecloth.’
  - b. Accomplishment-disabled  
 Het meisje was een brief aan het schrijven toen haar vriendin koffie op het  
 The girl was a letter on the to-write when her friend coffee on the  
 papier morste.  
 paper spilled.  
 ‘The girl was writing a letter when her friend spilled coffee on the paper.’

Cohn & Kutas (2015) measure ERPs of the visual narratives and propose that frontal negativity is an index of causal inference. The implicit (Implied & Impoverished) sequences that require the processor to make a causal inference to make the sequences coherent elicited a more negative deflection in anterior regions compared to the explicit (Expected & Explicit) sequences.

### 3.3 Discourse Anomaly

Kaan & Swaab (2003) propose that frontal P600 is an index of ambiguity resolution and processing difficulty in discourse. Compared to the grammatical one NP condition in (16), the two NPs conditions (Preferred, Nonpreferred, Ungrammatical) elicit a larger positivity between 500-900 ms at frontal regions.

- (16)
- a. One NP (Grammatical): The man in the restaurant doesn’t like the hamburgers that are on his plate.
  - b. Two NPs–Preferred (Grammatical): I cut the cake beside the pizzas that were brought by Jill.

- c. Two NPs–Nonpreferred (Grammatical): I cut the cakes beside the pizza that were brought by Jill.
- d. Two NPs–Ungrammatical: I cut the cake beside the pizza that were brought by Jill.

Similarly, Dwivedi et al. (2006) observe left-frontal P600 for anomalous discourse. In (12) above, the anomalous #H-F condition elicited a P600-like effect in the left and frontal sites compared to the C-F condition.

Furthermore, when the experiment involves an acceptability judgment task, it is reported that semantically anomalous constructions tend to yield N400/P600 effect (Kuperberg, 2007; Kulakova et al., 2014). Kuperberg (2007) cites works by Kolk et al. (2003) and Geyer et al. (2006) and states that P600 for semantic violations is elicited when participants made acceptability judgments. For example in Geyer et al. (2006), the semantically anomalous continuation (17b) elicited P600 and N400 only when there was an acceptability judgment task.

- (17) a. Tyler cancelled the subscription ...
- b. \*Tyler cancelled the tongue ...

Similarly, the study by Kulakova et al. (2014) mentioned above also involved an acceptability judgment task and reports that an N400/P600 effect was observed for the final words (*fair/unfair*. in (13)) that manipulate the truth of the target sentences. The subjunctive condition elicited an N400/P600 effect at final words.

## 4 EEG study on evidentiality (Hara et al., 2020)

This section reviews an EEG experiment conducted by Hara et al. (2020). As discussed in Section 2, the goal of Hara et al. (2020) is to provide empirical justifications for the formal analysis of *yooda* and *daroo*: *Yooda* and *daroo* belong to different categories. *Yooda* belongs to the category of evidentiality which is distinct from modality. The utterance of *p-yooda* presupposes that there is a causal relation ‘*p* causes *q*’ and asserts that the speaker observes *q*. In contrast, *daroo* is a canonical modality that expresses universal quantification over possible worlds. Crucially, the causal requirement for *daroo*-sentences only arises as a pragmatic inference. In this respect, the EEG experiment is a telling method. Neither introspection-based nor corpus data can distinguish semantic anomaly from pragmatic one.

### 4.1 Experimental setup

Data obtained from 30 native Japanese speakers were analyzed. The stimuli had two fully-crossed factors—CONTEXT (Effect-Cause/Cause-Effect) and SFA (sentence-final-auxiliary; *yooda/daroo*)—which resulted in four conditions:

- (18) a. ECy: Effect-Cause-*yooda* :  
       Michi-ga nureteiru. Ame-ga futta yooda.  
       streets-NOM wet rain-NOM fell EVID  
       ‘The streets are wet. It seems that it rained.’
- b. CEy: Cause-Effect-*yooda*:  
       #Ame-ga futta. Michi-ga nureteiru yooda.  
       rain-NOM fell streets-NOM wet EVID  
       ‘#It rained. It seems that the streets are wet.’

- c. *CEd*: Cause-Effect-*daroo*:  
 Ame-ga futta. Michi-ga nureteiru daroo.  
 rain-NOM fell streets-NOM wet I-bet  
 ‘It rained. The streets are wet, probably.’
- d. *ECd*: Effect-Cause-*daroo*:  
 #Michi-ga nureteiru. Ame-ga futta daroo.  
 streets-NOM wet rain-NOM fell I-bet  
 ‘The streets are wet. It rained, probably’

ECy is a fit condition where the final auxiliary *yooda*, which semantically presupposes that there is a causal relation and attaches to a proposition that denotes the cause event, matches the Effect-Cause context. CEy is an anomalous condition where *yooda* is attached to the effect state in a causal relation. *CEd* is a fit condition where the final auxiliary *daroo* is attached to a conclusion drawn from premises. *ECd* is an anomalous condition, but unlike CEy, which is semantically anomalous, it is pragmatically anomalous. That is, as discussed in Section 2, unlike *yooda*, *daroo* does not lexically encode a causal relation in its semantics. (18d) is anomalous because *yooda*, which semantically encodes the causal requirement, is more optimal in the Effect-Cause context.

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). The procedure of a trial is depicted in Figure 2. At the end of each filler trial, subjects were asked to give a yes/no response to an acceptability judgment task.

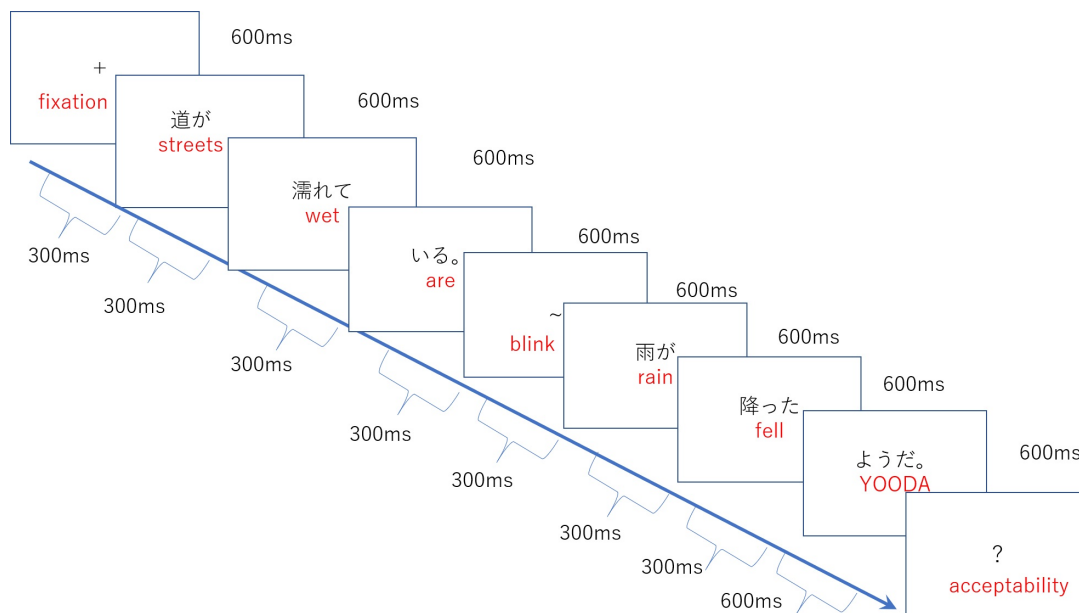


Figure 2: Procedure of a trial

EEG was recorded using AC amplifiers (Brain Products) from 32 electrodes equipped in an elastic cap (EASYCAP) according to the International 10–20 system.

Repeated-measures ANOVA (anovakun 4.8.3<sup>7</sup> implemented in R (R Core Team, 2019)) were performed with the factors CONTEXT (Cause-Effect/Effect-Cause), SFA (sentence-final auxil-

<sup>7</sup><http://riseki.php.xdomain.jp/>



iary; *yooda/daroo*) and ROI (regions of interests). Six ROIs are obtained by calculating the mean of the three electrodes in each region (anterior-left (AL; F3, F7, FC5); anterior-right (AR; F4, F8, FC6); central-left (CL; FC1, CP1, CP5); central-right (CR; FC2, CP2, CP6); posterior-left (PL; P3, P7, O1); posterior-right (PR; P4, P8, O2)) as in Figure 3.

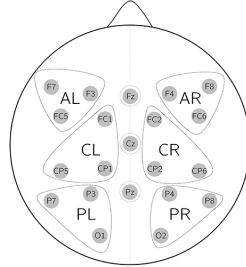


Figure 3: 6ROI (Taken from Kulakova et al. (2014))

See Hara et al. (2020) for more details on participants, procedure, EEG recording and statistics.

## 4.2 Result & Discussion

**Causality—lexical semantics of evidentials** A  $2 \times 2 \times 6$  repeated measures ANOVA with the factors CONTEXT (CE/EC), SFA (*y/d*) and ROI in the 500-700ms time window revealed a three-way interaction ( $F(5, 145) = 3.19, p < .01$ ) at the final auxiliary. The final auxiliary *yooda* in the ECy condition elicited a significantly more negative-deflection at AL compared to CEy ( $F(1, 29) = 8.06, p < .01$ ; see Figure 4).

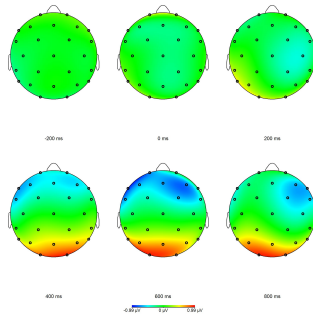


Figure 4: ECy–CEy

Hara et al. (2020) interpret the anterior negativity elicited by the ECy condition (Figure 5) as Left-Anterior Negativity (LAN), which is argued to be a correlate of successful causal inference (Baggio et al., 2008; Cohn & Kutas, 2015) as discussed in Section 3.2.<sup>8</sup>

<sup>8</sup>In Baggio et al. (2008); Cohn & Kutas (2015), causal inferences are evoked by the semantic content of the stimuli and the world knowledge, and not by a specific lexical item that marks causality like *yooda*. Thus, Hara et al. (2020) assume that LAN is an index of successful causal inference in general, and do not distinguish whether causality is prompted by the semantic content or by a lexicalized causal marker.

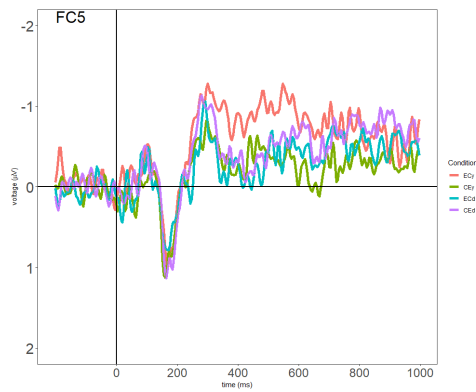


Figure 5: LAN (elicited by ECy) or P600 (elicited by CEy)

An alternative interpretation given by Hara et al. (2020) is to regard an anterior negativity elicited by the ECy condition (Figure 5) as a *positivity* elicited by the CEy condition. Incidentally, at PR, the CEy condition elicited a significantly more negative-deflection at ( $F(1, 29) = 7.03, p < .05$ ) compared to ECy. In this interpretation, the posterior negativity observed in Figure 6 and the anterior positivity observed in Figure 5 are N400/P600 pattern caused by semantic anomaly and reanalysis. Frontal P600 may seem unconventional because P600 elicited by grammatically anomalous constructions is usually observed in posterior regions (e.g., Coulson et al., 1998). However, as discussed in Section 3.3, Kaan & Swaab (2003) and Dwivedi et al. (2006) report that discourse anomaly evoked frontal P600. Also, as observed by Kuperberg (2007); Kulakova et al. (2014), semantically anomalous constructions tend to yield N400/P600 effect if the experiment is followed by an acceptability judgment task.

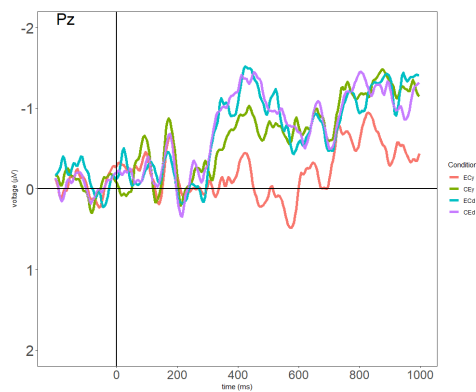


Figure 6: N400 (elicited by CEy)

While significant differences between the two *yooda* conditions were obtained, there was no significant difference between the two *daroo* conditions, CED and ECd. Hara et al. (2020) attribute this difference between two auxiliaries to the status of causality in each morpheme. That is, the ECd is only pragmatically anomalous since there is a better auxiliary, namely *yooda*, which fits the Effect-Cause context. Thus, pragmatical anomaly is not strong enough to affect the waveforms. In contrast, CEy is semantically anomalous since the semantics of *yooda* requires the morpheme to be attached to the cause event of a cause-effect relation.

**Processing of Modality** A  $2 \times 6$  repeated measures ANOVA with the factors SFA and ROI in the 300-500ms time window revealed that there was a significant SFA  $\times$  ROI interaction

( $F(5, 145) = 7.12, p < .001$ ) at the final auxiliary. *Daroo* elicited a significantly more negative-deflection at central (CL:  $F(1, 29) = 5.30, p < .05$ ; CR:  $F(1, 29) = 12.97, p < .01$ ) and posterior (PL:  $F(1, 29) = 4.85, p < .05$ ; PR:  $F(1, 29) = 12.14, p < .01$ ) regions compared to *yooda* as in Figure 7.

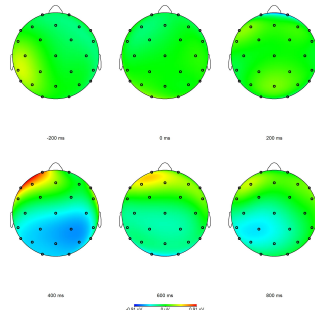


Figure 7: *daroo*–*yooda*

Hara et al. (2020) propose that the posterior and central negativity observed as  $SFA \times ROI$  interaction for *daroo* (Figure 8) is N400 and related to the processing of modality which involves processing of multiple possible worlds that poses increased processing demands.<sup>9</sup> This accords well with the findings in the previous studies discussed in Section 3.1.<sup>10</sup>

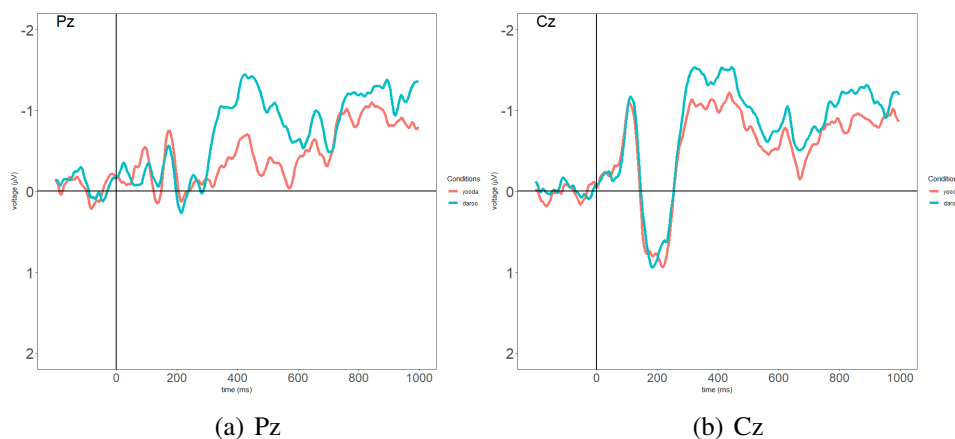


Figure 8: N400 elicited by *daroo*

## 5 Conclusion

Hara et al. (2020) observe that the evidential auxiliary *yooda* which marks an inference from an effect state to a cause event elicited LAN. The alternative interpretation of the result is that the anomalous CEy condition elicits N400/P600 effect of semantic anomaly and reanalysis. Furthermore, the result reveals that processing of modality, which involves processing of multiple possible worlds, induces N400 effect.

<sup>9</sup>Note that the causal meaning ‘ $p$  causes  $q$ ’ of  $p$ -*yooda* is formulated using the modal statement,  $\mathbf{Must}_p(q)$ , but it is in the presupposition and not in the assertional content, which only refers to the actual world  $w@$ .

<sup>10</sup>Note also that the observed N400 cannot be explained in terms of infrequency of *daroo* (c.f. Van Petten & Kutas, 1990), since as discussed in Hara et al. (2020), *daroo* is more frequent than *yooda* in BCCWJ (30686 *yooda* sentences and 47538 *daroo* sentences).

The result of Hara et al. (2020) has not only revealed indices of evidentiality and modality but it has important implications to the theoretical discussion of evidentiality and modality. First, the interpretation of *yooda* is dependent on causality, and evidentials and modals are separate categories. Previous analyses such as McCready & Ogata (2007) which assume that evidentiality and modality form a homogeneous category cannot predict the current results. Second, the effect of causality is stronger in *yooda* than *daroo*. The ECy condition where the causal context matches the semantics of *yooda* elicits LAN (alternatively the anomalous CE condition elicits N400/P600 effect), while no effect is observed for the CE<sub>d</sub> and EC<sub>d</sub> conditions. This result is in accordance with the theoretical claim made by Hara et al. (2020) that *yooda* semantically presupposes a causal relation while *daroo* lacks such a presupposition. Finally, EEG plays a crucial role in dissociating semantic violations from pragmatic ones. Both the introspection-based approach and the corpus study (see Hara et al., 2020) show that the interpretation/distribution of *daroo* is dependent on causality just like *yooda*, but neither can distinguish the nature of the violations.

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