Causality and Evidentiality*

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Abstract

This paper formalizes the causal component of Davis & Hara's (2014) analysis of Japanese evidentiality, which defines "indirect evidence" as an observation of the *effect* state of the cause-effect dependency. The analysis correctly predicts that uttering *p-youda* only commits the speaker to 'if p, q must be true' but not to the prejacent p, and successfully derives the asymmetry between the prejacent p and the evidence source q.

1 Introduction

Japanese has an indirect evidential morpheme *youda*, which gives rise to (at least) two messages:

(1) Ame-ga futta youda.
rain-NOM fell EVID
'It seems that it rained.'
Message 1: "It rained." (M1)
Message 2: "The speaker has indirect evidence for 'it rained'." (M2)

Formal studies of evidentiality center around the following two questions: Q1. What are the statuses of the two messages? Q2. What is indirect evidence? Davis & Hara (2014) argued that unlike previous studies, M1 in (1) is an implicature while M2 is the assertional content of (1). Furthermore, Davis & Hara (2014) claim that indirect evidence for p is some state q which is usually caused by p. Thus, the at-issue content of (1) is that the speaker observed some state (say, wet streets) which is usually caused by a state which exemplifies the proposition "it rained". Davis & Hara's (2014) analysis overcomes the problems of the previous studies such as the lack of commitment to the prejacent and the evidential asymmetry, although the notion of causality is left as a primitive. The goal of this paper is to formally model the causality component in the interpretation of evidentials in the framework of causal premise semantics (Kaufmann, 2013).

This paper is structured as follows: We first review Davis & Hara's (2014) analysis which defines evidentiality as an observation of the effect state of the asymmetric causal relation in Section 2. To formalize the causality component in Davis & Hara's (2014) analysis, we review Kaufmann's (2013) causal premise semantics in Section 3.1. Section 3.2 demonstrates how the framework derives the evidential asymmetry. Section 4 concludes the paper.

2 Davis & Hara (2014)

2.1 p in p-*youda* is not an epistemic commitment

The previous studies on evidentials (Izvorski, 1997; Matthewson et al., 2006; McCready & Ogata, 2007; von Fintel & Gillies, 2010) predominantly argue that evidentiality is a kind of

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epistemic modality. That is, Evid(p) entails Modal(p). According to this line of analysis, since Modal(p) gives rise to an epistemic commitment to p, Evid(p) should also give rise to a commitment to p. In (2) and (3), to illustrate, both a bare assertion p and Modal(p) commit the speaker to p, thus p cannot be cancelled:

(2) #Ame-ga futta kedo jitsu-wa futtenai.
rain-NOM fell but fact-TOP fall-NEG
'#It rained but in fact it didn't.'

(3) #Ame-ga futta darou kedo jitsu-wa futtenai.
rain-NOM fell probably but fact-TOP fall-NEG
'#Probably, it rained but in fact it didn't.'

Thus, if an indirect evidential like *youda* were an epistemic modality, uttering *p-youda* should give rise to a commitment to p as well. However, Davis & Hara (2014) show that this treatment cannot be maintained since the prejacent p in *p-youda* is cancellable as in (4).[1]

(4) Ame-ga futta youda kedo, jitsu-wa futte-nai.
rain-NOM fell EVID but fact-TOP fall-NEG
'It seems that it rained, but in fact it didn't.'

In short, Davis & Hara (2014) conclude that the prejacent proposition is not an at-issue commitment of *p-youda* but a cancellable implicature.

2.2 What is indirect evidence?

McCready & Ogata (2007) treat evidentials as modals and offer a Bayesian semantics for evidentials, including *youda*. McCready & Ogata's account has the following two components:

(5) *McCready & Ogata's semantics of evidentials*:
p-youda, relativized to agent a, indicates that
1. some information q has led a to raise the subjective probability of p.
2. a takes p to be probably but not certainly true ($.5 < P_a(p) < 1$) after learning q.

According to McCready & Ogata (2007), thus, what counts as evidence is some information q that has led a to raise the subjective probability of p. In (6), a learns that the street is wet, which has led a to raise her subjective probability of p, hence the use of *youda* is acceptable.

(6) a. (Looking at wet streets)
b. Ame-ga futta youda.
rain-NOM fell EVID
'It seems that it rained.'

Although McCready & Ogata's theory provides a concrete way to define evidence and a reasonable analysis for (6), Davis & Hara (2014) show that it makes wrong predictions if we switch the prejacent proposition p and the evidence source q, as in (7). Learning that it is raining should also raise the agent's subjective probability of "the streets are wet", thus McCready & Ogata wrongly predict that *youda* is acceptable in (7).

[1] A similar argument is made for reportative evidentials by Faller (2002); Murray (2010); AnderBois (2014).

(7) a. (Looking at falling raindrops)
b. #Michi-ga nureteiru youda.
street-NOM wet EVID
'#It seems that the streets are wet.'

From this observation, Davis & Hara (2014) propose that indirect evidence for p is some event/state q that is usually caused by p. Wet streets are evidence for rain but rain is not evidence for wet streets because rain causes wet streets but not *vice versa*. Thus, in this analysis, p-*youda* is paraphrased as 'I perceived some underspecified event/state q which is caused by p.'

2.3 Evidentiality via Causality

From the observations discussed so far, Davis & Hara (2014) make the following two claims:

1. The prejacent p in p-*youda* is not an epistemic commitment but a cancellable implicature.
2. The semantics of *youda* needs to encode *asymmetric* causal dependencies, e.g., rain causes wet streets but not *vice versa*. In other words, what counts as evidence is an effect state of a cause-effect dependency.

Simply put, Davis & Hara (2014) define the interpretation of p-*youda* as follows:

(8) *Davis & Hara's interpretation of evidentials*
Evid(p) is true at w iff $\exists q$ such that the speaker perceives a state q at w and p causes q.

Under this analysis, (6) is paraphrased as 'I perceived a wet street and rain causes wet streets.' while (7) is paraphrased as 'I perceived rain and wet streets cause rain.' Since we know that the latter proposition is false according to our world knowledge, (7) is infelicitous.[2]

Although Davis & Hara (2014) overcome the problems of the previous analyses, the notion of causality is left unanalyzed as can be seen in (8). This paper formally implements the notion of causality in Kaufmann's (2013) causal premise semantics.

3 Formalizing the Causal Asymmetry

My analysis of interpretation of evidentials is built on the interpretation of conditional or modal statements. The important difference from the previous evidential-as-modal analyses is that the prejacent proposition p of Evid(p) contributes to the conditional antecedent or the modal restriction but not to the conditional consequent or the nuclear scope of the modal quantification. In a nutshell, I propose the following definition: Let M_c, O_c, w be a causal modal base, a causal ordering source O_c,and a possible world, respectively. An evidential statement Evid(p) is true at M_c, O_c, w just in case the speaker perceives some event/state q and if p is true, then q must be true at M_c, O_c, w:

(9) Proposal: *Interpretation of evidentials* (first version)
Evid(p) is true at M_c, O_c, w iff $\exists q$ such that the speaker perceives q at w and $\mathrm{Must}_p(q)$ is true at M_c, O_c, w.

[2]See Sawada (2006); Takubo (2007) for similar analyses. Sawada (2006) argues that *youda* is a modality that infers a cause. Takubo (2007) claim that *youda* is attached to a proposition that is abductively inferred. See Davis & Hara (2014) for an argument against Takubo's analysis.

The following subsections present the technical preliminaries that are necessary to implement the proposal. In particular, the modal base and the ordering source need to be causally structured in order to capture the evidential asymmetry discussed above.

3.1 Technical Preliminaries

Kaufmann (2013) introduces causal networks to Kratzer's (2005, among others) premise semantics to interpret counterfactuals. I claim that the same apparatus can predict interpretations of evidentials.

3.1.1 Premise Sets and Structures

Kaufmann's framework extends Kratzerian premise semantics by deriving and ranking premise sets. A brief review of Kratzer's premise semantics is in order. Conversational backgrounds, f, g, are functions that map possible worlds to sets of propositions. Following the linguistic convetion, I use $f(w)$ and $g(w)$ for the modal base and the ordering source, respectively.

Modal statements are interpreted relative to premise sets. The premise sets are consistent set of propositions obtained by adding propositions from the ordering source to the modal base:

(10) *Kratzer premise sets*
Let M, O be two sets of propositions. The set $Prem^K(M,O)$ of Kratzer premise sets contains all and only the consistent supersets of M obtained by adding (zero or more) propositions from O. (Kaufmann, 2013, 1141)

If p is entailed by every possible premise set constructed from M and O, p is a necessity relative to M and O. In contrast, if p is consistent with some of the premise sets, p is a possibility relative to M and O:

(11) *Kratzer necessity and possibility*
Let Φ be a set of premise sets and p a proposition.
  a. p is a necessity relative to Φ iff every premise set in Φ has a superset in Φ of which p is a consequence.
  b. p is a possibility relative to Φ iff there is some premise set in Φ such that p is consistent with all of its supersets in Φ . (Kaufmann, 2013, 1141)

Now, modal statements can be interpreted as follows:

(12) *Kratzer interpretation of modals*
  a. Must(p) is true at f, g, w iff p is a necessity relative to $\text{Prem}^K(f(w), g(w))$.
  b. May(p) is true at f, g, w iff p is a possibility relative to $\text{Prem}^K(f(w), g(w))$. (Kaufmann, 2013, 1141)

To illustrate, let us have a modal base $f(w) = \{p, q\}$ and an ordering source $g(w) = \{r, \bar{d}\}$. Then, we obtain the set of premise sets as in (13).

(13) $\text{Prem}^K(f(w), g(w)) = \{\{p, q\}, \{p, q, r\}, \{p, q, \bar{d}\}, \{p, q, r, \bar{d}\}\}$

Now, in order to capture the causal asymmetry, we introduce structures to the premise sets. Let f be a Kratzerian conversational background, which is a function from possible worlds to sets of propositions. Then, $\mathbf{f}$ is a *premise background* which is a function from possible worlds to sets of sets of propositions defined in (14). Note that $\mathbf{f}$ alone contains no more or less information than f.

(14) A *premise background* $\mathbf{f}$ *structures* a Kratzerian conversational background f iff at all worlds v, $\mathbf{f}(v)$ is a set of subsets of $f(v)$. (Kaufmann, 2013, 1144)

To introduce the ranking of premise sets, a set of *sequence structures* is recursively defined as in (15). "$\leq_1 \times \leq_2$"signifies the lexicographic order on the Cartesian product.

(15) a. If Φ is a set of sets of propositions, then $\langle \Phi, \leq \rangle$ is a (basic) sequence structure.
b. If $\langle \Phi_1, \leq_1 \rangle$ and $\langle \Phi_2, \leq_2 \rangle$ are sequence structures, then so is $\langle \Phi_1, \leq_1 \rangle * \langle \Phi_2, \leq_2 \rangle$, defined as $\langle \Phi_1 \times \Phi_2, \leq_1 \times \leq_2 \rangle$. (Kaufmann, 2013, 1146)

A premise structure that is used for interpreting modal sentences is the set of *consistent* sequence structures (16).

(16) *Premise structure*:
Prem($\langle \Phi, \leq \rangle$) is the pair $\langle \Phi', \leq' \rangle$, where Φ' is the set of consistent sequences in Φ and $\leq'$ is the restriction of $\leq$ to Φ'. (Kaufmann, 2013, 1147)

Modal statements can be interpreted in a way parallel to the Kratzer interpretation (12):

(17) *Interpretation of modals*:
a. Must(q) is true at $\mathbf{f}, \mathbf{g}, w$ iff q is a necessity relative to Prem$((\mathbf{f}^*\mathbf{g})(w))$.
b. May(q) is true at $\mathbf{f}, \mathbf{g}, w$ iff q is a possibility relative to Prem$((\mathbf{f}^*\mathbf{g})(w))$.
(Kaufmann, 2013, 1148)

To illustrate, given our conversational backgrounds, $\mathbf{f}(w) = \{\{p, q\}\}$ and $\mathbf{g}(w) = \{\emptyset, \{r\}, \{\bar{d}\}, \{r, \bar{d}\}\}$, we have the following set of premise structures (I follow Kaufmann's notation for readability: "$xy.$" stands for "$(\{x, y\}, \emptyset)$".):

(18) $\text{Prem}(\mathbf{f} * \mathbf{g}(w)) = \mathbf{f}(w) \times \mathbf{g}(w) = \{(\{p, q\}, \emptyset), (\{p, q\}, \{r\}), (\{p, q\}, \{\bar{d}\}), (\{p, q\}, \{r, \bar{d}\})\}$
$= \{pq., pq.r, pq.\bar{d}, pq.r\bar{d}\}$

3.1.2 Causal Premise Semantics

Now we are ready to introduce causal structures (19) to capture causal asymmetries. A causal network has two components. The first part is a *directed acyclic graph* (DAG) in which vertices represent variables/partitions (e.g., R and D in Figure 1 representing "whether it is raining" and "whether streets are dry", respectively) and edges represent causal influence. The second component is that only the values of its immediate parents influence each variable.

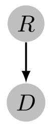

Figure 1: Rain and Dry street

(19) A *causal structure* for non-empty W is a pair $\mathcal{C} = \langle U, < \rangle$, where U is a set of finite partitions on W and $<$ is a directed acyclic graph over U. (Kaufmann, 2013, 1151)

As with Kaufmann, I assume that causal dependency is not deterministic: the values of its parents determine whether the value of each variable is a necessity or a possibility (17). Furthermore, the premise background constrained by the ordering source determines the value of parents.

In order to interpret evidentials, I follow Kaufmann (2013) and postulate a causal premise background $\mathbf{f}_c$. The causal premise background $\mathbf{f}_c$ consists of causally relevant truths (20-b).

(20) a. The set Π^U of *causally relevant propositions* is the set of all cells of all partitions in U.
b. The set of *causally relevant truths* at w: $\Pi_w^U = \{p \in \Pi^U | p \text{ is true at } w\}$
(^{U} is omitted hereafter.) (Kaufmann, 2013, 1152)

Furthermore, $\mathbf{f}_c$ is constrained by the closure under ancestors, which ensures the *asymmetric* relation between variables X and Y. We need to introduce two notions to define the closure under ancestors, *setting* and *descendant*:

(21) a. A variable X is *set* in a set of propositions P iff exactly one of X's cells is in P.
b. X is a *descendant* of Y iff there is a path from Y to X of zero or more steps along the direction of causal influence. (Kaufmann, 2013, 1153)

Closure under ancestors is defined as follows:

(22) A subset P' of P is *closed under ancestors* in P iff [for all $X, Y \in U$ such that X is a descendant of Y and both are set in P], [if X is set in P', then Y is also set in P']. (Kaufmann, 2013, 1153)

To illustrate, let us consider $P = \{r, \bar{d}\}$ with the causal network depicted in Figure 1. Subsets $\emptyset$ and $\{r\}$ are closed under ancestors because D is not set in $\emptyset$ and $\{r\}$. $\{\bar{d}\}$ is not closed under ancestors because D is set but R is not set. $\{r, \bar{d}\}$ is closed under ancestors because D is set and so is R.

Taken together, $\mathbf{f}_c$ is postulated as in (23).

(23) $\mathbf{f}_c(w) := \{X \subseteq \Pi_w | X \text{ is closed under ancestors in } \Pi_w\}$ (Kaufmann, 2013, 1153)

Thus, if we have causal relevant truths $\Pi_w = \{r, \bar{d}\}$, our causal premise background is: $\mathbf{f}_c(w) = \{\emptyset, \{r\}, \{r, \bar{d}\}\}$.

Also, the other premise background, i.e., the ordering source $\mathbf{g}$ satisfies the *Causal Markov condition* relative to a causal structure $\mathcal{C}$. To define Causal Markov condition, a brief introduction to Conditional Independence is in order. The idea is the following: Consider a partition $X \in U$ and sets of partitions $\mathbf{Y}, \mathbf{Z} \subseteq U$. X is conditionally independent of $\mathbf{Y}$ given $\mathbf{Z}$ under $\mathbf{g}(w)$ if and only if learning the setting of $\mathbf{Y}$ in $\mathbf{Z}$ does not alter the value of any cells in X:

(24) *Conditional independence*
Let $\mathbf{g}$ be a premise background, w a possible world, and U a set of partitions. For any $X \in U$ and disjoint sets $\mathbf{Y}, \mathbf{Z} \subseteq U$ not containing X: X is *conditionally independent* of $\mathbf{Y}$ given $\mathbf{Z}$ under $\mathbf{g}(w)$ iff for all cells $x \in X$, partial settings $\mathbf{y}$ of $\mathbf{Y}$ and settings $\mathbf{z}$ of $\mathbf{Z}$ such that $\mathbf{y} \cup \mathbf{z}$ is consistent, x is a necessity (possibility) relative to $\text{Prem}(\{\mathbf{z}\} * \mathbf{g}(w))$ iff x is a necessity (possibility) relative to $\text{Prem}(\{\mathbf{z} \cup \mathbf{y}\} * \mathbf{g}(w))$
(Kaufmann, 2013, 1155)

The idea behind the Causal Markov condition is that any partition X in the causal structure is independent of any of X's ancestors except for X's immediate parents. Let $pa(X)$ be the set of X's parents and $de(X)$ be the set of X's descendants. Causal Markov condition is defined as follows:

(25) *Causal Markov condition*
Let $\mathcal{C} = \langle U, < \rangle$ be a causal structure and $\mathbf{g}$ a premise background. $\mathbf{g}$ satisfies the **Markov condition** relative to C if and only if for all $w \in W$ and $X \in U$, X is conditionally independent of $U \backslash (de(X) \cup pa(X))$, given $pa(X)$, under $\mathbf{g}(w)$.
(Kaufmann, 2013, 1156)

3.2 Deriving evidentiality from causality

Our interpretation of evidentials is built on the general interpretation of conditionals. In the current framework, we obtain a premise background $\mathbf{f}[p]$ by hypothetically updating a premise background $\mathbf{f}$ with the antecedent proposition p:

(26) *Hypothetical update*
For all w: $\mathbf{f}[p](w) := \{\{p\}\}^{*}\mathbf{f}(w)$. (Kaufmann, 2013, 1148)

For example, consider our pre-update modal base $\mathbf{f}(w)$ as in (27-a). We acquire the post-update modal base $\mathbf{f}[r](w)$ by appending the hypothetical proposition r before each member of $\mathbf{f}(w)$:

(27) a. $\mathbf{f}(w) = \{\emptyset, \{p\}, \{p, q\}\}$
b. $\mathbf{f}[r](w) = \{\{r\}\} * \{\emptyset, \{p\}, \{p, q\}\} = \{r., r.p, r.pq\}$

Finally, we define the interpretation of evidentials. Evid(p) is true at $\mathbf{f}_c, \mathbf{g}, w$ when there is some state q such that the speaker perceives q at w and q is a necessity relative to Prem($(\mathbf{f}_c[p]^{*}\mathbf{g})(w)$):

(28) *Interpretation of evidentials* (final version)
Evid(p) is true at $\mathbf{f}_c, \mathbf{g}, w$ iff $\exists q$ such that the speaker perceives q at w and Must$_p(q)$ is true at $\mathbf{f}_c, \mathbf{g}, w$.

Note that the prejacent p of *p-youda* contributes to the antecedent rather than the consequent. In other words, Evid(p) only commits the speaker to Must$_p(q)$ and not to Must(p).

Let us illustrate the working of (28). Consider now the three-variable network in Figure 2 (the variable H represents "whether water is hose-sprayed") with the causally relevant propositions $\Pi = \{r, \bar{r}, h, \bar{h}, d, \bar{d}\}$.

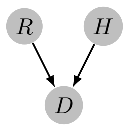

Figure 2: Rain, water-Hose and Dry street

Let us take example (4) repeated here as (29) first. (29) shows that the speaker can felicitously deny the prejacent proposition of the evidential statement.

(29) Ame-ga futta youda kedo, jitsu-wa futte-nai.
rain-NOM fell EVID but fact-TOP fall-NEG
'It seems that it rained, but in fact it didn't.'

Suppose that at w, it is not raining ($\bar{r}$), water is hose-sprayed (h), and streets are wet ($\bar{d}$) as in (30-a). By (23), we obtain (30-b). Note that $\{\bar{d}\} \notin \mathbf{f}_c(w)$, that is, $\{\bar{d}\}$ is not closed under ancestors in Π_w since D is set but R and H are not set in $\{\bar{d}\}$. Next, we obtain the premise structure (30-c) by hypothetically updating $\mathbf{f}_c(w)$ with r and removing any inconsistent sequences. As for the ordring source, let us assume that $\mathbf{g}$ prescribes that normally, water is not hose-sprayed, rain implies wet streets and so does hose-spraying (30-d). From (30-c) and (30-d), we obtain (30-e). Since $\bar{d}$ is a necessity relative to $\mathrm{Prem}((\mathbf{f}_c[r]^*\mathbf{g})(w))$, $\mathrm{Must}_r(\bar{d})$ is true at $\mathbf{f}, \mathbf{g}, w$.

(30) a. $\Pi_w = \{\bar{r}, h, \bar{d}\}$
b. $\mathbf{f}_c(w) = \{\emptyset, \{\bar{r}\}, \{h\}, \{\bar{r}, h\}, \{\bar{r}, h, \bar{d}\}\}$
c. $\mathrm{Prem}(\mathbf{f}_c[r](w)) = \{r., r.h\}$
d. $\mathbf{g}(w) = \{\emptyset, \{\bar{h}\}, \{r \to \bar{d}\}, \{h \to \bar{d}\}\}$
e. $\max \mathrm{Prem}((\mathbf{f}_c[r]^*\mathbf{g})(w)) = \{r.h.(r \to \bar{d}), r.h.(h \to \bar{d})\}$

As a result, given that the speaker perceives $\bar{d}$ at w, $\mathrm{Evid}(r)$ is true at $\mathbf{f}_c, \mathbf{g}, w$ because $\mathrm{Must}_r(\bar{d})$ is true at $\mathbf{f}_c, \mathbf{g}, w$, even though r is not true at w, Thus, (29) can be uttered felicitously without the speaker's commitment to r.

Finally, let us see if (28) can explain the evidential asymmetry. Let us derive the felicitous interpretation of (6) repeated here as (31) first.

(31) a. (Looking at wet streets)
b. Ame-ga futta youda.
rain-NOM fell EVID
'It seems that it rained.'

Suppose that the causally relevant truths at v are as in (32-a). Note that $\mathbf{g}(w) = \mathbf{g}(v)$.

(32) a. $\Pi_v = \{r, \bar{h}, \bar{d}\}$
b. $\mathbf{f}_c(v) = \{\emptyset, \{r\}, \{\bar{h}\}, \{r, \bar{h}\}, \{r, \bar{h}, \bar{d}\}\}$
c. $\mathrm{Prem}(\mathbf{f}_c[r](v)) = \{r., r.r, r.\bar{h}, r.r\bar{h}, r.r\bar{h}\bar{d}\}$
d. $\mathbf{g}(v) = \{\emptyset, \{\bar{h}\}, \{r \to \bar{d}\}, \{h \to \bar{d}\}\}$
e. $\max \mathrm{Prem}((\mathbf{f}_c[r]^*\mathbf{g})(v)) = \{r.\bar{h}.(r \to \bar{d}), r.\bar{h}.(h \to \bar{d}), r.r\bar{h}\bar{d}.(r \to \bar{d}), r.r\bar{h}\bar{d}.(h \to \bar{d})\}$

Assuming that the speaker perceives $\bar{d}$ at v, $\mathrm{Evid}(r)$ is true at $\mathbf{f}_c, \mathbf{g}, v$ because $\bar{d}$ is a necessity relative to $\mathrm{Prem}((\mathbf{f}_c[r]^*\mathbf{g})(v))$, hence $\mathrm{Must}_r(\bar{d})$ is true at $\mathbf{f}_c, \mathbf{g}, v$. The speaker of (31) is asserting that she perceived wet streets and if it rains, streets must be wet, i.e., rain causes wet streets.

Finally, we derive the infelicity of (7), repeated here as (33).

(33) a. (Looking at falling raindrops)
b. #Michi-ga nureteiru youda.
street-NOM wet EVID
'#It seems that the streets are wet.'

Take the same world v as above, thus we have the same causally relevant truths Π_v and causal modal base $\mathbf{f}_c(v)$ as the ones in (32). Now (33) translates to $\mathrm{Evid}(\bar{d})$, so the modal base is altered by hypothetically updating $\mathbf{f}_c(v)$ with $\bar{d}$ as in (34-c). Together with the ordering source $\mathbf{g}(v)$, Evid($\bar{d}$) is interpreted relative to the set of premise structures shown in (34-e).

(34) .

a. $\Pi_v = \{r, \bar{h}, \bar{d}\}$
b. $\mathbf{f}_c(v) = \{\emptyset, \{r\}, \{\bar{h}\}, \{r, \bar{h}\}, \{r, \bar{h}, \bar{d}\}\}$
c. $\text{Prem}(\mathbf{f}_c[\bar{d}](v)) = \{\bar{d}., \bar{d}.r, \bar{d}.\bar{h}, \bar{d}.r\bar{h}\}$
d. $\mathbf{g}(v) = \{\emptyset, \{\bar{h}\}, \{r \to \bar{d}\}, \{h \to \bar{d}\}\}$
e. $\max \text{Prem}((\mathbf{f}_c[\bar{d}]^*\mathbf{g})(v)) \supseteq \{\bar{d}.\bar{h}.(r \to \bar{d}), \bar{d}.\bar{h}.(h \to \bar{d})\}$

Evid($\bar{d}$) is *not* true at $\mathbf{f}_c, \mathbf{g}, w$ because r is is not a necessity relative to $\text{Prem}((\mathbf{f}_c[\bar{d}] * \mathbf{g})(v))$, i.e., $\text{Must}_{\bar{d}}(r)$ is false at $\mathbf{f}_c, \mathbf{g}, v$. Put another way, (33) is infelicitous since the speaker is making a false claim, 'wet streets cause rain' (even if the speaker does observe rain).

3.3 Summary

We offer a formal implementation of the causal component of evidentiality which correctly predicts the lack of commitment to the prejacent proposition and derive the asymmetry of the evidential dependency between the prejacent and the evidence source from the asymmetry between the ancestor and the descendent in a causal network.

4 Conclusion

We formalized the causal component of Davis & Hara's (2014) analysis of Japanese evidentiality, which defines "indirect evidence" as the *effect* state of the cause-effect dependency, correctly predicts that uttering *p-youda* only commits the speaker to $\text{Must}_p(q)$ but not to the prejacent p, and successfully derive the asymmetry between the prejacent p and the evidence source q.

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