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How to Update Information States: Review Article of McCready (2015)

Reliability in Pragmatics, by Eric McCready, Oxford University Press, Oxford, 2015, xi + 291pp.

1 INTRODUCTION

In the literature, studies of evidentials are quite variable. A number of researchers have investigated evidentials in various languages: Quechua (Faller (2002)), Cheyenne (Murray (2010)), St'át'imcets (Matthewson et al. (2007)) German (Faller (2006, 2012), Japanese (McCready and Ogata (2007)), just to name a few. Each language has its own evidential system distinct from other languages; for example, while Cuzco Quechua has direct, reportative, and inferential evidentials, Japanese has inferential and reportative evidentials but not direct ones, and while Japanese and Quechua evidentials are enclitics, the German reportative evidential *sollen* is obviously an auxiliary. Accordingly, how to analyze evidentials depends on what language is being dealt with. Faller (2002) argues that Quechua evidentials are illocutionary operators that modify the speech act of utterances, while Matthewson et al. (2007) analyze St'át'imcets evidentials as epistemic modals. Thus it seems quite difficult to give a unified account of evidentials in general.

McCready (2015), I believe, implies the possibility of a unified accounts. He proposes an interesting and remarkable approach to evidential systems in terms of dynamic semantics. His analysis captures the very nature of evidentials and information acquisition, from the position of dynamic semantics. In this paper, I introduce some remarkable points of McCready's system, and propose some revision of it, particularly about the system of update. In his system, information update does not eliminate possible worlds contained in an information state, but alters the ordering of plausibility between worlds. This type of update is quite different from existing dynamic semantic theories, and has some empirical problems. Thus, the aim of this paper is to integrate ordinary eliminative update into McCready's system, in order for the system to capture empirical facts that standard dynamic analyses have accounted for.

This paper is constructed as follows. Section 2 discusses very briefly the notion of evidential and shows what kinds of evidentials there are in Japanese, which is the language McCready (2015) and this paper mainly deal with. In section 3, I introduce relevant parts of McCready's system. In section 4, I present my proposal, introducing a new notion of information state, and compare my framework with McCready's system, in terms of whether they can account for facts about presupposition, pronoun

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resolution, and logical inference. Section 5 is the conclusion.

2 JAPANESE EVIDENTIALS

Generally speaking, evidentials are linguistic expressions that primarily indicate what type of evidence the speaker bases her utterance on (de Haan (1999) and Aikhenvald (2004)). For example, Cuzco Quechua has three evidential enclitics: *-mi* (direct), *-si* (reportative), and *-chá* (inferential). The example sentences from Faller (2002) are presented below.

(1) a. Para-sha-n-**mi**
rain-Prog-3-**mi**
Proposition = 'It is raining.'
Evidence: speaker sees that it is raining.
b. Para-sha-n-**si**
rain-Prog-3-**si**
Proposition = 'It is raining.'
Evidence: speaker was told that it is raining.
c. Para-sha-n-chá
rain-Prog-3-**chá**
Proposition = 'It is raining.'
Evidence: speaker conjectures that it is raining. (Faller 2002: 3)

In (1a), it is indicated that the speaker utters the proposition, based on what she has seen. In (1b), the evidence comes from someone's report, and in (1c), the speaker indicates that the proposition is based on the speaker's inference from some indirect evidence.

Japanese also has a number of evidential expressions, representatives of which are the reportative or hearsay evidential *-soo*, the inferential evidentials *-mitai*, *-yoo*, *-rashii*, and *inf-soo* (suffixed to infinitives). Here are some examples:

(2) a. hearsay *-soo*
John-wa mainichi sampo-suru soo da.
John-Top every day take a walk *soo* Cop.Pres
"I heard that John takes a walk every day."
b. inferential *-mitai*, *-yoo*, *-rashii*
John-wa mainichi sampo-suru mitai/ yoo da.
John-Top every day take a walk *mitai*/ *yoo* Cop.Pres
"I infer from pieces of evidence that John takes a walk every day."

Japanese evidentials, like evidentials in other languages, show a syntactically and semantically interesting behavior: they cannot be embedded under certain operators

(e.g., negation, conditional, modal, and question). Although I do not deal with this phenomenon, more detailed discussion about the scope relation between negation and evidentials is found in McCready and Ogata (2007) and Kalsang et al. (2013).

3 SUBSTATES IN INFORMATION STATE

In this section, I briefly introduce the system McCready (2015) proposes and its difference from ordinary dynamic semantics. He argues that the form and target of updates with evidentially marked sentences are different from what has been assumed to be information update. Let us look closely at some parts of his mechanism which are relevant to our discussion.

3.1 The standard update

Before the review of McCready (2015), let us see what the ordinary information update is like. In dynamic semantics[1], particularly in update semantics (Groenendijk et al. (1996)), it is assumed that there is an information state σ, which corresponds to what somebody knows and is a set of possible worlds. As each sentence ϕ is uttered, it updates the hearer's information state, resulting in the new information state σ' which is represented as σ[ϕ] = σ'. σ' represents what the hearer knows after understanding ϕ. If ϕ is a declarative sentence, the effect of update with ϕ is illustrated as follows:

(3) $\sigma[\phi] = \sigma' = \sigma \cap \{w\colon \|\phi\|(w) = 1\} = \{w \in \sigma \mid w \in \phi\}$

The new information state σ' is the intersection of two sets σ and the proposition ϕ. Thus standard updates are eliminative in the sense that worlds where ϕ does not hold (henceforth, ϕ-worlds) are excluded from the resulting state σ'. In this way, information states narrow down as discourse proceeds.

3.2 New forms of update

McCready (2015) revises this system, in order to capture facts about evidentials[2]. The simplest example which is problematic for the eliminative update is[3]:

[1] I wrote this introduction of ordinary dynamic semantics with reference to Portner (2009: 85-93).

[2] Note that here I introduce from McCready (2015) only a part relevant to our discussion. His entire system is much more sophisticated than what is written here.

[3] McCready himself does not point out that (4) is problematic for the standard dynamic semantics, but I think that this example is a typical case that his system can account for while the standard dynamic

(4) a. Ame-ga furu mitai
rain-Nom fall *mitai*
'It seems as if it'll rain.'
b. Demo Taro niyoruto fur-anai soo da
but Taro according-to rain-Neg *soo* Cop.Pres
'But according Taro it won't rain.'
(McCready 2015: 212)

Suppose that this sentence is uttered by one speaker and in one breath. This natural example will be ruled out by the standard dynamic semantics, because under the assumption that evidentials make no contribution to the semantics of sentences they are attached to, the form of updates in (4) will be $(\sigma[rain])[\neg rain]$, resulting in as state which is empty, and thus predicting that (4) should be unacceptable.

McCready (2015)'s proposal is that updates caused by evidentially marked sentences are not eliminative. In his system, as a result of updating of a state of an agent with an evidentially marked sentence, a world is privileged over another if it is considered more plausible by the agent. The formal definition of the model containing such an ordering and abbreviations used in what follows are given below:

(5) Plausibility frame
A plausibility frame is a multi-agent Kripke frame $<S, R_a>_{a \in A}$ where the accessibility relation R_a are called "plausibility orders" written $\leq_a$, and assumed to be locally connected preorders.
(S is a set of worlds, R a binary relation on S, and A a set of agents)

(6) Plausibility models
A plausibility model is a structure $S = < S, \leq_a, [[.]], s_0 >$, i.e. a plausibility frame together with a valuation function $[[.]]: At \mapsto \wp(S)$ and a designated world s_0, the "actual world." (S is a set of worlds.)

(7) a. $s \leq_a t$ iff world t is considered more plausible by agent a than world s.
b. $s \sim_a t$ if s and t are comparable for agent a, that is, epistemically indistinguishable in terms of hard information.
c. $s(a) = \{t \in S \mid t \sim_a s\}$ (a's epistemic alternatives at s)
(McCready 2015: 188)

With this notion of *plausibility orders*, McCready defines another type of update, represented as $[.]^{\Uparrow}$:

(8) $\sigma[\phi]^{\Uparrow} = \sigma'$, where $S' = S$ and $s \leq'_a t$ iff either (i) $s \notin \phi$ and $t \in s(a) \cap \phi$, or (ii) $s \leq_a t$. (McCready 2015: 190)

This definition roughly means that as a result of update with $[.]^{\Uparrow}$, the set of worlds that forms σ is left untouched, and world t is privileged over s if and only if either s is not

semantics cannot.

a ϕ-world and t is one of the a's epistemic alternatives at s and a ϕ-world, or before the update, t is privileged over s. McCready also defines the "standard" update in terms of this system, written as $[.]_!$:

(9) $\sigma[\phi]_! = \sigma'$, where $S' = \{s \in S \mid s \vDash \phi\}$ and $s \leq'_a t$ iff $s \leq_a t$ & $s, t \in S'$
(McCready 2015:190)

This roughly means that as a result of update with $[.]_!$, $\neg\phi$-worlds are excluded from σ and if s and t are both left in the resulting set of worlds, their plausible ordering is left untouched. This update equals the standard update plus the notion of plausibility ordering.

To understand how these updates work, let us see McCready's example. Consider the following single-agent model, with agent a, as shown in (10). Here the arrows represent plausibility preferences, p and q represent propositions true at a world. So $\{p, q\}$ is a world s where p and q are both true.

(10) $\{p, q\} \rightarrow \{\neg p, q\} \leftrightarrow \{p, \neg q\} \rightarrow \{\neg p, \neg q\}$

In this model, a has not excluded either p or q, but finds them less *plausible* than their negations. Let us call this information state σ. When you update σ with $[p]_!$ (i.e., $\sigma[p]_!$), the state of the form $\{p, q\} \rightarrow \{p, \neg q\}$ will result. That is, $\neg p$-worlds are excluded and the initial plausibility order between worlds remains intact.

What about the case of $\sigma[p]_{\Uparrow}$? This gives rise to the following state:

(11) $\{\neg p, q\} \rightarrow \{\neg p, \neg q\} \rightarrow \{p, q\} \rightarrow \{p, \neg q\}$

In new state σ' resulting from the update, p-worlds are preferred to $\neg p$-worlds, while the initial ordering between q-worlds and $\neg q$-worlds are maintained[4]. That is the illustration from McCready (2015: 191).

[4] Here, I wonder whether (11) is really derived from (8). Suppose that $\{p, q\}$ and $\{\neg p, q\}$ in (10), the state before update, are t and s in (8), respectively. Then with the update with p, (8) will correctly derive the resulting ordering $\{\neg p, q\} \rightarrow \{\neg p, \neg q\}$, that is, $s \leq_a t$. In this case, the condition (i) is applied, since the initial ordering is $\{p, q\} \rightarrow \{\neg p, q\}$, that is, $t \leqq_a s$, so (ii) cannot be applied. Next, suppose that $\{p, q\}$ is s and $\{\neg p, q\}$ is t. Then in the course of update, only the condition (ii) can be applied, since, while the initial ordering is $s \leq_a t$, s (i.e. $\{p, q\}$) is a member of p, so (i) cannot be applied. In this case, (8) will derive $s \leq_a t$, that is, $\{p, q\} \rightarrow \{\neg p, q\}$, the same as the initial state. Thus, depending on which world in a state is chosen as s and which world is chosen as t, the result of (8) will vary, an undesirable situation. It is possible that I have overlooked some assumption that McCready makes in other areas of his book. But it is the case that definition (8) alone cannot predict desirable results. In what follows, this problem is not relevant to our discussion. The revision of (8) is left for future research. What is important is that $\sigma[\phi]_{\Uparrow}$ does not eliminate $\neg\phi$-worlds but ranks ϕ-worlds higher than $\neg\phi$-worlds.

3.3 Substates contained in a state and merge operation

In order to associate information update with evidentials, McCready (2015) also revises the notion of information states. What he wants to capture is that, given two evidentials, $Evid_1$ and $Evid_2$ such that the evidence source marked by $Evid_2$ is more reliable than that marked by $Evid_1$, we want $\sigma[Evid_1\phi \wedge Evid_2\neg\phi]$ to correspond to $\sigma[\neg\phi]$ but not $\sigma[\phi]$. For example, direct evidence is generally more reliable than inferential evidence, so when an agent observes $Inf\phi \wedge Direct\neg\phi$, the update of the form $\sigma[Inf\phi \wedge Direct\neg\phi]$ will correspond to $\sigma[\neg\phi]$. To derive this result, he proposes that $Evid_1\phi$ and $Evid_2\neg\phi$ update distinct information states which are contained in the global information state.

(12) a. Global information state σ comprises sets of information states indexed by different evidence types.
b. Update with content marked as coming from evidence source e_i will induce an update in the corresponding $\sigma_i \in \sigma$.
c. That is, $\sigma = \{\sigma_i \mid i \in \text{Source}\}$,
where Source = {*direct*, *sensory*, *hearsay*…}

(13) $\sigma[\mathsf{E}_i\phi] = \sigma'$ where, for all $\sigma_j \in \sigma$, $\sigma'_j = \sigma_j[\phi]$ if $i = j$
$\sigma'_j = \sigma_j$ if $i \neq j$
(E is an existential quantifier over an evidence source, so $\mathsf{E}_i\phi$ represents a proposition with indication of the existence of evidence source *i*.) (McCready 2015: 195)

For example, sentences with direct evidentials do not update σ, that is, the global information state, but σ_{direct} which is a member of σ, and no other substates in σ are left untouched. McCready claims that the type of update that is exploited here is [.]⇑. Thus, after update, only the plausibility ordering between worlds in σ_{direct} is altered, and worlds in the substates remain intact.

This revision of information states alone is not sufficient for explanation of the fact that $\sigma[Evid_1\phi \wedge Evid_2\neg\phi]$ corresponds to $\sigma[\neg\phi]$. What is needed then is to transmit the result of the update of substates to the global information state. This is done by merging substates contained in σ. Such a merge operation occurs locally: each two substates are merged recursively, and finally one state is left as a result of the merging operation. Here is the formal definition.

(14) Lexicographic merge
$R_{a⫫b} := R_a^{\leq} \cup (R_a^{\leq} \cap R_b) = R_a^{\leq} \cup (R_a \cap R_b) = R_a \cap (R_a^{\leq} \cup R_b)$
(R_a represents *a*'s plausibility ordering over worlds.)

If there are two substates *a* and *b*, and the source associated with *a* is more reliable than that associated with *b*, represented as $a > b$, then this operation gives rise to a

new ordering where the ordering in *a* is retained and privileged over the ordering in *b*, and among the worlds ranked equally in *a*, *b*'s ordering is reflected.

Let us see how this operation works. Suppose that there are two substates *a* and *b* which are ordered $a > b$, and that each of them has the following plausibility ordering over worlds.

(15) a. Initial plausibility orderings
$\boxed{\{p, q\} \leftrightarrow_a \{p, \neg q\} \leftarrow_a \{\neg p, \neg q\}}$ $\boxed{\{p, q\} \rightarrow_b \{p, \neg q\} \rightarrow_b \{\neg p, \neg q\}}$
($\rightarrow_a$ represents the plausibility ordering in state *a*, and $\leftrightarrow_a$ means that two worlds connected by this symbol are indifferent in *a*, i.e., that there is no preference between them)

b. The result of merge operation
$\{p, q\} \rightarrow \{p, \neg q\} \leftarrow \{\neg p, \neg q\}$

In the initial situation in (15a), *a* ranks $\{p, \neg q\}$ over $\{\neg p, \neg q\}$, while *b* does the opposite. When such a conflict occurs, the reliability relation of sources is considered, and the plausibility ordering of the substate with the more reliable source is retained. In this case, since $a > b$, *a*'s ordering is maintained. On the other hand, *a* does not posit any ranking between $\{p, q\}$ and $\{p, \neg q\}$. In such a case *b*'s ordering is reflected on the result ordering. This merge operation is performed among substates recursively, and finally one information state is generated. McCready calls this state *the total information state*.

In the process of this merge operation, the plausibility ordering that survives is the ordering in a substate that is associated with reliable source. Therefore, in the case of $\sigma[Inf\phi \wedge Direct\neg\phi]$, the ordering in σ_{direct} that takes $\neg\phi$-worlds to be more plausible than ϕ-worlds will override the ordering in σ_{Inf} that ranks ϕ-worlds higher than $\neg\phi$-worlds, because direct evidence source is considered more reliable than inferential evidence sources. Thus $\sigma[\neg\phi]$ is derived, with ϕ-worlds $\leq_a \neg\phi$-worlds.

3.4 Interim summary

What has been introduced in this section as for McCready (2015) is repeated as follows:

(16) a. Information state σ is taken to be the global state, a set of substates indexed with different evidence sources.
b. Update caused by an evidentially marked sentence alters the plausibility ordering in substates, but it does not eliminate any world.
c. Merging substates gives rise to the total information state with a new plausibility ordering.

What is interesting in McCready's approach is that with this type of mechanism,

we might be able to reach a unified analysis of evidentials in general. As suggested in the beginning of this paper, a unified approach to evidentials in different languages is difficult mainly for two reasons: i) different languages have different evidential systems, and ii) evidentials differ across languages in terms of their grammatical category. The first problem is not so crucial. In McCready's system, the difference in evidential system is reduced to the difference in which evidential is associated with which substates. We can assume that even evidential-free sentences can update some substate (this possibility is suggested by McCready himself; we will return to it in the next section)[5, 6]. The second problem, on the other hand, is hard to deal with. Treating expressions in different grammatical categories in the same way is very difficult for a syntactic or compositional semantic approach. In McCready's system, however, even though the grammatical categories of evidentials are not the same universally, it does not matter, since their contribution is the same regardless of what category they belong to: they only designate what substate is updated. Of course, the syntactic approach and compositional approach are both necessary and important, but, at present, treating evidentials in those frameworks is very difficult.

Having reviewed the proposal of McCready (2015), we are ready to turn to our main concern: Whether his treatment of update, which does not allow elimination, is truly adequate?

4 HOW TO UPDATE INFORMATION STATES AND SUBSTATES

So far we have seen what McCready's (2015) mechanism is like. In this section, I propose some modification to it. Concretely, I propose that update by evidential-free information does not target a substate, but the global state, and accordingly, the global state is not a set of substates, but a set of possible worlds, and substates are subsets of the global state. By this modification, we will be able to treat phenomena which have been dealt with within the framework of ordinary dynamic semantics.

[5] Approaches like that of Faller (2002), in which evidentials alter the speech acts of sentences, can capture the difference by assuming each evidential in each language alters speech acts in its own way. However, a problem arises. In Faller's analysis, Cuzco Quechua evidentials alter the speech act *Assert*. This analysis is possible because they are not embeddable in other speech acts, e.g., *Question*. Some Japanese evidentials, in particular, (inf)-*soo*, are embeddable in questions. This means that when Faller's analysis is applied to the Japanese (inf)-*soo*, the input of (inf)-*soo* will not be constant, which seems to inflict the unity of the analysis, in which all evidentials alter *Assert*. In addition, if we extend Faller's approach to languages other than Cuzco Quechua, we have to write, for each evidential in each language, how it alters speech acts, while McCready's approach treats evidentials in different languages quite simply; for example, if an evidential is inferential, it updates $\sigma_{inf.}$ Of course, Faller's analysis has an obvious advantage in that it captures the idiosyncrasy of each evidential. In other words, application of McCready's proposal to every evidential is better in terms of unity, but it might be too strong and we might overlook the characteristics each evidential possesses.

[6] Speas (2010) points out that the maximal number of evidence types evidentials can encode is fixed universally. This supports McCready's analysis in that with this number limitation, we do not have to assume an infinite number of substates.

4.1 Substates as subsets

My main points are (i) that evidential-free information updates the global state in the way of $[.]_!$ and (ii) that substates are not members of the global state, but subsets of it. As for (i), in McCready's system, it is assumed that all sentences including evidential-free sentences have their own evidence source and their form of update is to alter plausibility orderings in a certain substate. It follows that in his system, information acquisition does not eliminate any world; it only orders worlds in substates. Even after the merge operation, no world is eliminated. This is crucial, since dynamic semantics so far have explained a variety of phenomena with the mechanism of elimination, e.g. presupposition. I will assume that elimination mechanism is preserved in the substates-system. Thus, in order for evidential-free information to update the global state, it has to be a set of worlds, hence (ii). Thus I propose the following formal definition.

(17) a. $\sigma[\phi] = \sigma[\phi]_!$ if ϕ is of the form ψ
$\sigma[\phi]_{\Uparrow}$ if ϕ is of the form $\mathsf{E}_i\psi$
b. $\sigma_i \subseteq \sigma$ for $i \in$ Source

If an agent acquires ϕ, then her global information state is updated in an eliminative manner. All $\neg\phi$-worlds including worlds contained in substates are eliminated from her state, represented in Figure 1 (in the next page, w_ϕ represents a ϕ-world). As is seen from Figure 1, there are worlds which do not belong to any substates. These worlds are not associated with any evidence source[7]. Instead, they can be thought of as worlds associated with what the agent already knows. One may argue that this update is too strong in that it eliminates $\neg\phi$-worlds not only the ones that do not belong to any substate, but also those that are contained in substates (in Figure 1, σ_i and σ_j). This predicts that after this update, one cannot utter $\neg\phi$ with any evidential, which is borne out:

(18) (Uttered by the speaker who knows that it is raining)
#Ame-ga futteinai yoo-da/soo-da/rashii.
rain-Nom fall-Prog-Neg *yoo*-Cop.Pres/*soo*-Cop.Pres/*rashii*
'I infer/heard that it is not raining.'

The global state of the utterer of (18) is updated by the proposition 'it is raining (*rain*)' since she knows that it is raining, so there is no $\neg$*rain*-world in her σ_{Inf} and σ_{Rep}. Therefore update by $Evid_{Inf}\neg rain$ and $Evid_{Rep}rain$ is infelicitous. (18) cannot be explained in McCready's system, where evidential-free sentences update some substate and leave other substates untouched.

One may question about how is the plausibility order of the worlds which are not

[7] One can say that these worlds are associated with *best possible grounds* in the sense of Faller (2002). I leave this possibility for future research.

contained in any substate and what merge operation in this revised system is like. As for the former, we need not order such worlds, because, as is the case with the standard information state, they constitute what one knows, and therefore they are equally maximally plausible. As for the second question, we need some kind of merge operation, since without it, update by evidentially marked sentences does not affect the global information, which is unintuitive. I assume that, also in the revised system, the lexicographic merge in (14) is operative. But the difference from McCready's system is that, in the revised system, the information state generated by merging all substates (let us call it σ_M) is merged with the global information state (σ_G) containing worlds that do not belong to any substates. Given that all of the worlds in σ_G is equally maximally plausible, the result of such merger will be the one in which worlds in σ_M are ranked lower than worlds in σ_G.

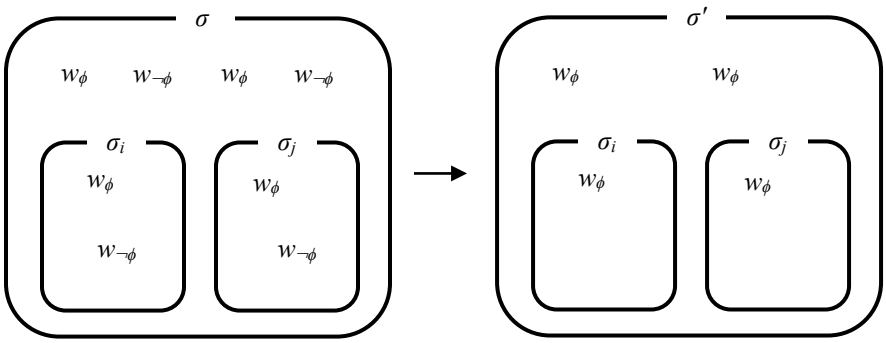

Figure 1: The result of update by evidential-free sentence

In the following subsections, I compare McCready's system with the revised version, in the light of whether they can capture phenomena that standard dynamic theories have accounted for.

4.2 Presupposition and pronoun resolution

In this section, I consider presupposition and a particular case of pronoun resolution. The standard dynamic theories are useful to treat these phenomena, so variants of dynamic theories have to be able to capture them.

4.2.1 Presupposition In order to discuss presupposition, let us see how presupposition is treated in standard dynamic theories. A sentence S that presupposes ϕ is defined only in worlds where ϕ holds. In terms of dynamic semantics, it means that S updates the information state in such a way that the intersection is made

between the proposition denoted by *S* and the worlds in the information state where ϕ holds. Put in another way, if ϕ holds in at least one world in the information state, the update by *S* is successful.

With this idea in mind, consider the following case.

(19)

Taro-wa	tabako-o	sut-tei-na-katta	
Taro-Top	tobacco-Acc	smoke-Prog-Neg-Past	
#ga	suu-no-o	yame-ta	yoo/soo-da.
but	smoke-that-Acc	stop-Past	*yoo*/*soo*-Cop.Pres.

'Taro had been smoking, but I infer/heard that he stopped smoking.'

If evidential-free proposition updates only some substate, (19) would be acceptable, because worlds necessary for the second conjunct to be defined, i.e. worlds where Taro had been smoking, are not excluded from σ_{Inf} or σ_{Rep}, and therefore evidentially marked sentences would successfully update their relevant substates, contrary to the fact. The absence of the mechanism of elimination causes this problem. In the revised version, however, all the worlds where Taro had been smoking are eliminated from the global state and every substate by the first sentence, so sentences with evidentials are not defined, hence unacceptability.

It might be possible that McCready assumes in his system that after lexicographic merge operation, worlds ranked lower are eliminated from every substate. If so, (19) will be explicable. What is needed then is, however, to define how highly worlds have to be ranked in order not to be eliminated. This question is very hard to answer.

4.2.2 Pronoun resolution Consider the following example.

(20)

Ookami-ga	ki-ta.	
wolf-Nom	come-Past	
Yatsu-wa	hara-ga-hetteiru	yoo/soo-da.
it-Top	hangry	*yoo*/*soo*-Cop.Pres

'A wolf came. I infer/heard that it is hungry.'

In order to treat this example, we should define how to treat pronouns. I adopt the idea of Groenendijk et al. (1996). They treat elements of information states are world-assignment pairs. Their idea is that when $\exists x\phi$ updates an information state, all $\neg\phi$-worlds and assignments paired with them are eliminated, and assignments paired with ϕ-worlds, which are left in the updated state, are extended so that they can assign the existentially introduced object to the new variable *x*. In (20), the object is the wolf, that is, the information "$x \rightarrow$ a wolf" is added to assignments of worlds where a wolf came.

In the revised version, as a result of the update by the first sentence, assignments of all the worlds where a wolf came, some of which are contained in σ_{Inf} and σ_{Rep} are extended, and since the second update targets such updated worlds and assignments contained in the relevant substate, the pronoun resolution will be successful. On the

other hand, in McCready's system the update by the first sentence targets only its relevant substate, and therefore it does not extend assignments paired with worlds contained in σ_{Inf} and σ_{Rep}. Then, the pronoun resolution should be unsuccessful, though it is actually not.

One might claim that an information state consists of not world-time pairs, but worlds, and one assignment is shared by all the worlds in the state, and that no matter what substate an existentially quantified proposition updates, it extends the shared assignments. For example, when update is caused by existentially quantifying proposition associated with reportative evidence, the existential quantification extends the shared assignment, and the worlds not only in σ_{Rep} but also in other substates exploit the extended assignment. In that case, (20) will be explained, since all substates including σ_{Inf} and σ_{Rep} can access to the extended assignment. Then, however, the following case is problematic[8].

(21) Ookami-ga ki-ta yoo/soo-da.
wolf-Nom come-Past yoo/soo-Cop.Pres
#Yatsu-wa hara-ga-hetteiru
it-Top hangry
'I infer/heard that a wolf came. It is hungry.'

If an assignment is shared by all substates, then the second sentence in (21) should be able to access to it, but (21) shows that it cannot. It follows that worlds do not share one assignment.

4.3 Logical inference The final case I deal with is logical inferences. Although this term can be interpreted in various ways, I will call inferences like ones presented below *logical inference*.

(22) Mary returned a book to the library yesterday.
The only book Mary had borrowed was *LGB*.

Mary returned *LGB* to the library yesterday.

The sentence under the line is the conclusion deduced from the above two sentences. In order to treat this type of inference in terms of dynamic semantics, let us make a natural assumption that in order for (22) to hold, it is necessary that the worlds in which *Mary returned a book to the library* (represented *Ret*(m, b)) holds have to be ones where *The only book Mary had borrowed was LGB* (*Borr*(m, L)) holds. This assumption is natural because, if you believe that Mary borrowed not only *LGB* but *Barriers*, or that it is possible that the second premise does not hold, this inference is not valid.

[8] This example is like modal subordination. For the detail discussion of it, See van Rooji (2005) and Asher and McCready (2007).

Let us turn to the case with evidentials. Consider the following.

(23) (Yesterday, you heard from Taro, "Today, Hanako retuned a book she had borrowed to the library." You are now talking with Jiro, your colleague and both you and Jiro know that Hanako borrowed only *LGB*, but Jiro does not know Hanako returned a book. You say)
Hanako-ga kinou kenkyuushitsu-ni *LGB*-o
Hanako-Nom yesterday library-to *LGB*-Acc
kaeshiniki-ta soo-da.
come to return-Past *soo*-Cop.Pres.
'I heard that Hanako returned *LGB* to the laboratory yesterday.'

The acceptability of this example indicates that the following inference is valid.

(24) *Rep* (Mary returned a book to the laboratory).
The only book Mary had borrowed was *LGB*.

Rep(Mary returned LGB to the laboratory.)
(where *Rep* (ϕ) represents ϕ has reportative evidence)

With the assumption made above, (24) means that at least in σ_{Rep}, *Ret*(h, b) holds in all the world where *Borr*(h, L) holds. This indicates that all the $\neg$*Borr*(h, L)-worlds are eliminated from σ_{Rep}.

In the case of inferential evidentials, the same happens.

(25) (When you entered the laboratory, you find a note left behind. The note said, "I retuned a book." but no name was written on the note. The book seemed to have been put in bookshelves, so you did not find what book had been returned. You smelled the perfume that Mary always wears. You and Jiro know that Mary borrowed only *LGB*. After that, when you see Jiro, You say)
Hanako-ga kenkyuushitsu-ni *LGB*-o
Hanako-Nom laboratory-to *LGB*-Acc
kaeshiniki-ta yoo-da.
come to return-Past *yoo*-Cop.Pres.
'I heard that Hanako returned *LGB* to the laboratory yesterday.'

In this case, too, the same inference pattern as (24) occurs and it is thought that all the $\neg$*Bor*(h, L)-worlds are eliminated from σ_{Inf}. The revised version, which allows update of the global information state, captures these facts about logical inference.

On the other hand, McCready's system cannot explain why such inferences are valid, since in his system the proposition *Borr*(h, L) does not update σ_{Rep} and σ_{Inf}. The assumption that all the *Ret*(h, b) worlds have to be ones where *Bor*(h, L) holds will not be satisfied. This is also due to the lack of elimination mechanism.

4.4 Rethinking information states in general

As has been discussed so far, the main problem of McCready (2015) is that his system does not assume eliminative update. But as is pointed out in section 4.2.1, McCready might assume some elimination strategy. It is possible that after the merge operation, worlds which are ranked low to some extent will be eliminated. But this type of mechanism is very difficult to construct, since it is hard to determine how plausible an information has to be in order to say that one "knows" the information. I think that this is an extra-linguistic matter.

It should be noted that the revised system also has a crucial problem. What is the most striking different between McCready's system and the revised version is that the latter allows worlds that do not belong to any substates indexed by evidence-types. This means that such worlds are not associated with any evidence source, and the propositions that update them, (i.e., ϕ without any evidence) is acquired through no evidence source. Is it possible? Probably, no. As McCready points out, "Presumably all newly acquired information comes from some observation or other (2015: 196)". In order to perform such a non-evidence source update, we have to establish some mechanism which convert $\sigma[\mathsf{E}_i\phi]$ into $\sigma[\phi]$, but this attempt is hopeless. For example, when an agent observe $\mathsf{E}_i\phi$, what kind of conditions should be met in order for the update by it to be $\sigma[\phi]$, but not $\sigma[\mathsf{E}_i\phi]$? One might claim that if the source indexed with i is sufficiently reliable, $\mathsf{E}_i\phi$ is converted into ϕ. Then, however, how reliable should the source be in order to allow such a conversion. Here, we confront the same problem described in the last paragraph.

To see what is problematic, take the case of (19). Suppose that the speaker of (19) is John and the hearer is Mary. When Mary hears the first sentence of (19), what is updated is not σ, but σ_{Rep}, since that sentence comes with the reportative source, John. Then the result of update by (19) will be different from what is desired. Thus, the problem is that when one observes or hears ϕ, it necessarily comes with some evidence source. As long as we assume that observing or hearing ϕ leads to updating only observer's (hearer's) information state, this problem will never be solved.

To avoid this problem, we have to change the model of information states and discourse updates. My rough and crude idea is as follows. In conversation, the hearer is considering what the speaker's information state is like, and creating in her mind the speaker's information state by hearing the speaker's utterances. If the speaker's state in the hearer's mind is made sufficiently sophisticated, then the hearer knows what the speaker knows and thinks. In that case the information transmission from the speaker to the hearer succeeded. And while the hearer is constructing the speaker's state, her state is simultaneously being updated, in the way described in the last paragraph.

Take again (19) for an example. Suppose that the speaker and hearer are John and Mary, respectively. Given the utterances in (19), Mary imagines in her mind what John's information state is like. The first sentence is evidential-free, which means that John knows that the proposition is true. Then the update caused by the first sentence is of the form $\sigma[\phi]$, an eliminative update. The second sentence is decorated with some evidential, and the update by it targets $\sigma_{Inf\,/\,Rep}$. As a result, what Mary considers to be John's information state is infelicitous one; in all worlds contained in $\sigma_{Inf\,/\,Rep}$,

presupposition of the second sentence does not hold. Therefore, John's information state is considered to be impossible by Mary, hence unacceptability. While updating John's information state in her mind, Mary also updates her information state. In this case, the update by the first and second sentence targets σ_{Rep}, since the information in (19) comes with the reportative evidence, John.

Put shortly, I suggest that when one hears utterances by someone, she updates not only her state, but also what she considers to be the speaker's state. And when the tentative speaker's state is not felicitous, the uttered sentences will be unacceptable. (19) and other examples in this paper will be explained in this way.

5 Conclusion

In this paper, I introduced McCready's (2015) treatment of evidentials. The idea of it is remarkable, and his mechanism contains the possibility of dealing with evidentials in general in a unified way. His main proposal is to divide an information state to several substates, and associate each of these substates with some evidence source. After the introduction, I proposed revision on his system. My main point is that there are worlds which do not belong to any substate, and that evidential-free information updates the global state in an eliminative manner. It was shown that this revision has empirical advantage over McCready's original system. Finally I propose a new form of processing the speaker's information state, which is necessary to integrate eliminative update into McCready's framework.

If my proposal here is on the right track, we can allow the standard dynamic theories, which exploit elimination mechanism and McCready's remarkable work, which captures the nature of our information acquisition, to coexist.

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