Rich Situated Attitudes

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Abstract We outline a novel theory of natural language meaning, *Rich Situated Semantics* [RSS], on which the content of sentential utterances is semantically *rich* and informationally *situated*. In virtue of its situatedness, an utterance's rich situated content varies with the informational situation of the cognitive agent interpreting the utterance. In virtue of its richness, this content contains information beyond the utterance's lexically encoded information. The agent-dependence of rich situated content solves a number of problems in semantics and the philosophy of language (cf. [14, 20, 25]). In particular, since RSS varies the granularity of utterance contents with the interpreting agent's informational situation, it solves the problem of finding suitably fine- or coarse-grained objects for the content of propositional attitudes. In virtue of this variation, a layman will reason with more propositions than an expert.

Keywords: Information-sensitivity · interpreter-dependence · propositional attitude contents · rich semantic content · situated semantics

1 Introduction

The same utterance of a (non-indexical) sentence has a different meaning to different interpreting agents. This is due to the fact that different agents have different information about the sentence's subject matter, which is used in the utterance's agent-specific interpretation: Depending on the agent's background knowledge, the utterance of (1) in a particular context will be interpreted as an informationally rich proposition (e.g. as a proposition which contains the information that *the inhabitant of Gobbler's Knob* is a groundhog/that Punxsutawney Phil *is a member of the largest existing marmot species*) or as an informationally poorer proposition which does not contain this additional information.

(1) Punxsutawney Phil is a groundhog.

Most formal theories of semantic natural language content (e.g. [9, 27, 28, 32]) restrict the content of sentential utterances to the utterances' lexical information (for (1): to the information that the referent of the name *Punxsutawney Phil* is

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a groundhog), and delegate all other available information about the utterance's subject matter to areas like pragmatics or psychology. However, Moltmann [26] (cf. [7]) has observed that they thus seriously underspecify the content of propositional attitudes. We observe that, as a result, these theories are unable to explain why an inference is valid for some agents, but invalid for others.

This paper solves the above problem by complementing the traditional notions of utterance content with a new kind of semantic content, *rich situated content*. The latter includes non-lexically encoded information that is available to the interpreter of the utterance at the time of the interpretation. Below, we first sketch our new theory of linguistic meaning, called *Rich Situated Semantics* (in Sect. 2). We then present the rigid granularity problem for the content of propositional attitudes (in Sect. 3) and show how Rich Situated Semantics solves this problem (in Sect. 4). Section 5 answers a salient objection to our solution to the rigid granularity problem. The paper closes by identifying other intensional phenomena that lend themselves to a rich situated semantic treatment (in Sect. 6).

2 Rich Situated Semantics

Rich Situated Semantics [hereafter, RSS] (cf. [19, 20]) is a new theory of natural language meaning on which the content of (utterances[1] of) declarative sentences is semantically *rich* and informationally *situated*. In virtue of its situatedness, the rich situated content of a sentence varies with the informational situation of the cognitive agent interpreting the sentence. In virtue of its richness, this content contains information beyond the sentence's lexically encoded information. Rich situated content is thus a special form of descriptive content.

Below, we first illustrate the richness and situatedness of sentential content and identify a number of theories from linguistics, philosophy, cognitive and computer science that suggest this richness and/or situatedness (in Sect. 2.1). We then specify the RSS-interpretation of sentences (in Sect. 2.2) and identify some notable consequences of this interpretation with respect to linguistic entailment and equivalence (in Sect. 2.3). The section closes with a definition of truth for Rich Situated Semantics (in Sect. 2.4).

2.1 Illustration and inspiration for RSS

To familiarize the reader with the core idea of RSS, we introduce rich linguistic contents by means of an example: Consider the interpretation of (1) by three agents, viz. Alf, Bea, and Chris. Assume that, *re* Punxsutawney Phil (hereafter, 'Phil'), these agents have the following information:

[1] We hereafter sometimes use the expression 'content of a sentence' (or 'sentential content'), instead of 'content of *an utterance of* a sentence'. This is merely a terminological shortcut. The reader is asked to keep in mind that sentences are uttered by a speaker (with certain background information) in a spatiotemporal and communicative situation, and are directed at an addressee (with a certain, likely different, background information). The relevance of the addressee's information for the interpretation of the utterance is the central topic of this paper.

Alf: Phil lives in Gobbler's Knob.

Bea: Phil is celebrated each February 2nd.

Chris: Phil lives in Gobbler's Knob; Phil is celebrated each February 2nd.

Since rich situated content includes the interpreter's information about the sentence's subject matter (here: Phil), (1) is interpreted by Alf as (1.i), by Bea as (1.ii), and by Chris as (1.iii):

(1) i. Phil is a groundhog who/and lives in Gobbler's Knob.
ii. Phil is a groundhog who is celebrated each February 2nd.
iii. Phil is a groundhog who lives in Gobbler's Knob and is celebrated each February 2nd.

The non-identity of the rich contents of (1) at Alf's, Bea's, and Chris' informational situation witnesses the *situatedness* of linguistic content in RSS. The greater informativeness of the rich content of (1) at any of the above situations in comparison to the sentence's traditional, possible-worlds content (which only contains the sentence's lexical information) witnesses the *richness* of linguistic content in RSS. In particular, the rich content of (1) at Alf's informational situation contains the information that Phil lives in Gobbler's Knob, which is not contained in the sentence's the lexical information.

The *situatedness* of linguistic content is inspired by work in situation semantics (cf. [3, 15]), semantic contextualism (cf. [13, 17]), relativism (cf. [6, 22]), and dynamic semantics (cf. [11, 42]). Situation semantics assumes that sentences are uttered in and their utterances evaluated with respect to partial possible worlds (i.e. situations). Contextualism and relativism assume, respectively, that the same sentence can have a different content in different contexts and that the truth-value or the content of a sentence vary with the context of assessment. Dynamic semantics suggests the situatedness of linguistic content by interpreting sentences as *state transitions*, i.e. as functions from information states to the result of updating these states with the sentence's lexical information.

Rich linguistic content is found in Fregean theories of belief content (cf. [5, 10]), in semantic descriptivism and generalized quantifier theory (cf. [2, 39]), and in frame semantics (cf. [1, 21]). Fregean theories of belief content assume that any adequate representation of belief contents involves the modes of presentation of the individuals and properties the beliefs are about. Descriptivism and generalized quantifier theory assume that proper names are interpreted analogously to definite NPs, i.e. as sets of properties of individuals. Frame semantics represents utterance contents by rich recursive feature structures that account for the content of mental concepts.

2.2 The RSS-interpretation of sentential utterances

To capture the *situatedness* of rich linguistic content, RSS interprets sentences as *functions from interpreters' informational situations* to the sentences' rich contents *at these situations* (i.e. to the sentences' *situated contents*). These functions are objects of type $s\alpha$, where α is the type for situated sentential contents.

The *richness* of situated sentential contents is captured via (characteristic functions of) partial sets of situations (s.t. $\alpha := st$).[2] Such sets are familiar from the representation of sentential contents in generalizations of possible world semantics, including some versions of situation semantics (e.g. [15, 28]). However, the set of situations that serves as the content of a sentence in RSS is generally much smaller than the set of situations that serves as the content of this sentence in situational generalizations of possible world semantics. This is due to the fact that – in addition to being restricted to situations in which the sentence is true – the RSS-set is further restricted to situations which contain the interpreting agent's information about the sentence's subject matter. For example, while (1)-as-received-by-Alf is interpreted as (2) in situational possible world semantics, it is interpreted as (3) in RSS. Below, i is a variable over situations, as reflected in the superscript s. The formulas $\mathit{groundhog}(\mathit{phil})(i)$ and $\mathit{livesinGK}(\mathit{phil})(i)$ assert that Phil is a groundhog in i and that Phil lives in Gobbler's Knob in i.

$$\lambda i^s[\mathit{groundhog}(\mathit{phil})(i)] \tag{2}$$

$$\lambda i^s[\mathit{groundhog}(\mathit{phil})(i) \wedge \mathit{livesinGK}(\mathit{phil})(i)] \tag{3}$$

To capture the informational imperfection of cognitive agents, we identify situations with *partial* (i.e. informationally incomplete) spatio-temporal parts of worlds[3] in which the parts' individual inhabitants may fail to have some of the properties which they have at the relevant world-part. Situations in rich situated semantics are thus "partial specifications of some of the entities in the universe with [their] properties" [23, p. 614]. They are obtained from worlds by reducing the information about the world's inhabitants to the information available to the agent at the given point in time. As a result, situations are agent- and time-specific: the same agent may be in different informational situations at different points in time.

We assume that situated sentential contents are *partially* (or *selectively*) *rich*, i.e. that they contain – next to the sentence's lexical information – all and *only* information *about the sentence's subject matter* that is available to the interpreter of the sentence at the time of the interpretation. As a result, RSS interprets any sentence p as a function from informational situations i to sets of situations whose members contain the lexical information of p together with all information from i which regards some individual about which p carries information. For convenience, sentences that carry information about some individual a will hereafter be called *aboutness-relevant with respect to a*, or *a-relevant*. Sentences that carry information about the same individuals are called *aboutness-identical (w.r.t. these individuals)*. The RSS-interpretation of a sentence p is given in (4).

$$\lambda i^s \lambda j^s[p^{st}(j) \wedge \forall q^{st}([q(i) \wedge \exists x^e(\mathit{abt}(x)(q) \wedge \mathit{abt}(x)(p))] \twoheadrightarrow q(j))] \tag{4}$$

[2] One can increase the granularity of situated sentential contents by analyzing them instead as semantically primitive (i.e. non-analyzable) propositions (cf. [8, 29, 32, 41]). The development of hyperfine-grained RSS is left for another occasion.

[3] The inclusion of *impossible* worlds or situations (cf. [12, 35]) captures the possibility of agents' misinformedness or false belief. For reasons of space, the consideration of impossible worlds or situations is left for future research.

In (4), x is a variable over individuals. The formula $\varphi^t \twoheadrightarrow \psi^t$ asserts that ψ contains the information of φ (i.e. that ψ is less partial/better defined than φ), s.t. ψ is true if φ is true and is false if φ is false (cf. [28, pp. 50, 47]). $\varphi \twoheadrightarrow \psi$ is defined as $((\varphi \wedge \psi) \vee ((\varphi \vee \psi) \wedge *)) = \varphi$, where $*$ is the neither-true-nor-false formula. The introduction of $\twoheadrightarrow$ is made necessary by our association of t with the set of truth-*combinations*, by the resulting existence of two different orderings on the type-t domain (i.e. a truth- and an approximation-ordering), and by the reference of the material conditional to the 'wrong' ordering for our purposes (i.e. to the truth-ordering; on this ordering, ψ is true if φ is true, *but φ is false if ψ is false*).

The formula $abt(x^e)(q^{st})$ asserts that q carries information about the referent of x. The behavior of *abt* is governed by a variant of the axioms from [30, p. 129] (cf. [18, p. 120–121]). These axioms include the aboutness-relevance (with respect to an individual) of atomic formulas that contain the designating constant for the individual as a constituent, the closure of aboutness-relevant formulas under non-contradictory conjunction,[4] the closure of aboutness-relevant formulas under disjunction (given that both disjuncts contain information about the subject matter), and the robustness of aboutness under semantic equivalence.

To better understand the interpretation of sentences in Rich Situated Semantics, consider the rich content of (1) at Alf's current informational situation, σ_{alf} (in (5)). We assume for simplicity that σ_{alf} only contains the information that Phil lives in Gobbler's Knob (cf. Sect. 2.1) and that Bea has red hair. Since only the first-mentioned informational item of σ_{alf} regards Phil, (1) will be RSS-interpreted at σ_{alf} as (3).

$$\lambda i\,[groundhog(phil)(i) \wedge \forall q([q(\sigma_{alf}) \wedge \exists x^e(abt(x)(q) \wedge abt(x)(p))] \twoheadrightarrow q(i))] \quad (5)$$
$$\equiv\ \lambda i\,[groundhog(phil)(i) \wedge \forall q([q(\sigma_{alf}) \wedge abt(phil)(q)] \twoheadrightarrow q(i))]$$

We next identify a concrete candidate for the set of situations described by (5): Assume a universe consisting of four situations, σ_{alf}, σ_1, σ_2, and σ_3 and two individuals: Phil (abbreviated p) and Bea (abbreviated b). We assume that Phil lives in Gobbler's Knob (Kp) in σ_{alf}, σ_1, and σ_2, that Bea has red hair (Rb) in σ_{alf} and σ_2, and that Phil is a groundhog (Gp) in σ_1, σ_2, and σ_3 (cf. Fig. 1).

Then, since the lexical information of (1) (i.e. Phil is a groundhog) and the Phil-relevant information from σ_{alf} (i.e. Phil lives is Gobbler's Knob) are included only in σ_1 and σ_2 (and in none of the other situations), the rich situated content of (1) at σ_{alf} is represented by the set $\{\sigma_1, \sigma_2\}$ (underbraced in Fig. 1).

2.3 Consequences of RSS

The RSS-interpretation of sentential utterances has a number of important consequences for the individuation of situated sentential contents. In particular, since RSS updates the available information about a sentence's subject matter

[4] To avoid the inclusion of information that does not regard the subject matter, we demand (*contra* Perry) that *both* conjuncts be aboutness-relevant. This also avoids the problem of obtaining aboutness-'relevant' conjunctions by combining an aboutness-irrelevant sentence with a trivially aboutness-relevant *verum*, or with *falsum*.

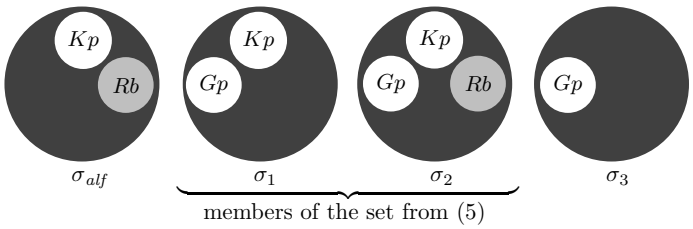

Figure 1. The rich content-at-σ_{alf} of (1).

with the sentence's lexical information, it identifies the rich contents of sentences at situations whose information about the sentence's subject matter differs only with respect to the inclusion of the sentence's lexical information. Consider the interpretation of (1) at Len's informational situation in which Phil is a groundhog and lives in Gobbler's Knob. (We assume that this situation does not contain any other information about Phil, s.t., as regards Phil, it is identical to σ_1): at this situation, (1) has the same rich content (i.e. $\{\sigma_1, \sigma_2\}$) as at σ_{alf}.

Note that, although (1) has the same rich content at Alf's and at Len's informational situation, its utterance has a different *effect* on Alf's than on Len's situation: while (1)-as-received-by-Alf updates Alf's information about Phil with the information that Phil is a groundhog (s.t. Alf's information is extended to the information from σ_2), it leaves Len's informational situation unchanged. The updating effect of (1) on Alf's Phil-specific information is witnessed by the fact that (the information associated with) the rich content of (1) at Alf's informational situation (i.e. $\{\sigma_1, \sigma_2\}$) is properly contained in (the information associated with) the rich content of (6) at Alf's situation (i.e. $\{\sigma_{alf}, \sigma_1, \sigma_2\}$).

(6) Punxsutawney Phil lives in Gobbler's Knob.

As a result of the richness of situated contents, RSS further identifies the contents of different aboutness-identical sentences at situations which contain the sentences' lexical information. Consider the interpretation of (1) and (6) at σ_1: since this situation already contains the lexical information of (1) and (6), these sentences have the same rich content (i.e. $\{\sigma_1, \sigma_2\}$) at this situation.

We will see in Section 4 that the identification-at-a-situation of the rich contents of different aboutness-identical sentences solves the problem of finding suitably fine- or coarse-grained objects for the content of propositional attitudes. This problem is described in Section 3.

2.4 Truth-evaluation in RSS

We have described situated sentential contents as the results of updating the available information about the sentence's subject matter with the sentence's lexical information. As a result of this description, situated sentential contents in RSS contain much more information than sentential contents in situational generalizations of possible world semantics. However, much of this information is irrelevant for the sentences' evaluation. For example, it does not (or should not) matter for the truth of (1) whether Phil lives in Gobbler's Knob. Since *non-*

situated sentential contents (type $s(st)$) do not have the 'right' type for truth-evaluable objects (i.e. they do not yield a truth-value when applied to a world), we need to provide a custom truth-evaluation procedure for sentences in RSS.

To evaluate the truth of a sentence in Rich Situated Semantics, we check whether the world of evaluation w is a member of the union of the sentence's rich contents at all informational situations. The resulting truth-definition is given below. In this definition, we use denotation brackets, $[\![\cdot]\!]$, as a notational device for rich non-situated sentential contents (i.e. type-$s(st)$):

Definition 1 (Truth at a world). *In Rich Situated Semantics, a sentence p is* true *at a world w iff $w \in \bigcup_{\sigma^s} [\![p]\!](\sigma)$, where $[\![p]\!](\sigma)$ is the rich interpretation of p at the situation σ.*

By taking the union of the rich contents, $[\![p]\!](\sigma)$, of p for each situation σ, we obtain the set of situations in which p is true. This set is a situational generalization of the classical Lewisian proposition denoted by p.

The rationale behind the above strategy is as follows: since we assume the existence of a situation for every consistent combination of information (including the 'empty' combination; cf. [31, 32]), the members of the above union will never share *more* than the lexical information of p (plus p's presuppositions). Since we identify the result of updating a situation's information via incompatible information with the empty set of situations[5], the members of this union will never share *less* than the lexical information of p. In particular, situations which contain the information that not-p will not contribute their information to the above union.

Notably, unions of rich situated contents provide an easy way of retrieving the traditional notion of (lexical, 'poor') content. This notion is required for the explanation of a number of phenomena, including the use of sentences to state facts (cf. (7)), to give reasons (cf. (8)), and to express shared belief (cf. (9)). For example, Eve may utter (1) to communicate the fact that Phil is a groundhog (rather than some other fact she knows about Phil) (cf. (7)) or to give a reason for Phil's long teeth (cf. (8)). Many other sentences which receive an identical interpretation at Eve's informational situation would not serve this purpose.

(7) Eve asserted that Phil was a groundhog.

(8) Since Phil is a groundhog, his teeth never stop growing.

(9) Len and Eve believe that Phil is a groundhog.

We next turn to the rigid granularity problem for the content of propositional attitudes. This problem lies in the fact that most theories of linguistic content assume a single, uniform level of granularity for belief contents. As a result of this assumption, these theories cannot explain why an inference is valid for some epistemic agents (given their background knowledge), but invalid for others.

[5] This is due to the fact that the available information about the sentence's subject matter at these situations will include the sentence's lexical information. Since we have excluded impossible situations from our considerations (cf. fn. 3), no situation contains both an item of information and its complement.

3 The Rigid Granularity Problem

To avoid predicting agents' logical omniscience, many theories of formal semantics (e.g. [9, 28, 32, 41]) assume hyperfine-grained sentential contents that have stricter identity-conditions than sets of possible worlds. The level of granularity of these contents is chosen in accordance with speakers' intuitions about synonymy (cf. [32, p. 553]). Since most speakers judge the contents of many intensionally equivalent sentences (e.g. of (1) and (10)) to be non-identical, hyperfine-grained semantics distinguish the contents of these sentences.[6]

(10) Punxsutawney Phil is a member of the largest existing marmot species.

The success of these semantics is hampered by the fact that the above identity- (or *non*-identity-)judgements are not shared by all speakers for all sentence-pairs. This is due to the fact that speakers' judgements about sentential synonymy are influenced by their background information about the sentences' subject matter. Depending on their informational situation, speakers will thus identify or distinguish the contents of the same sentences. Consider the case of (1) and (10): since she is familiar with the different properties of groundhogs, a groundhog expert (e.g. Eve in (11)) will identify the contents of (1) and (10). Since he is unaware of this fact, a groundhog layman (e.g. Len in (12)) will treat the contents of (1) and (10) as distinct. Any reasoner who is familiar with Eve and Len's level of groundhog expertise (s.t. (s)he knows that (1) and (10) have the same rich content at Eve's, but different rich contents at Len's informational situation), will conclude (11b) from (11a), but not (12b) from (12a). Since hyperfine-grained semantics assume the same level of granularity of content for *all* agents interpreting a sentence, they cannot distinguish between the validity of these inferences.

(11) a. Eve knows that Phil is a groundhog. **T**

b. Eve knows that Phil is a member of the largest existing marmot species. **T**

(12) a. Len knows that Phil is a groundhog. **T**

b. Len knows that Phil is a member of the largest existing marmot species. **F**

In particular, since hyperfine-grained semantics distinguish the contents of (1) and (10), they will counterintuitively predict the invalidity of (11). Since traditional (coarse-grained) possible world semantics identifies the content of (1) and (10), it will counterintuitively predict the validity of (12).

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Rich Situated Semantics solves the above problem by varying the granularity of sentential contents with the informational situation of the sentence's interpreter.

[6] The identification of these sentences' traditional contents in possible world semantics is due to the fact that, in the actual world at the current time (cf. the adjective *existing* in (10)), groundhogs *are* the largest marmot species.

This is possible since RSS identifies the contents of different aboutness-identical sentences at situations which contain the sentences' lexical information.

4.1 Solving the rigid granularity problem

Since, as we will hereafter assume, Eve's informational situation, σ_{eve}, contains the lexical information of (1), (6), and (10), RSS *identifies* the contents of (1) and (10) at this situation (i.e. (14)). Since Len's situation does *not* contain the lexical information of (10) (s.t. (10) is interpreted as an update on Len's information about Phil), RSS *distinguishes* the contents of (1) (i.e. (3)) and (10) (i.e. (14)) at Len's informational situation. With respect to the relevant subject domain, a layman will thus reason with *more* sentential contents than an expert.

$$\lambda i^s[groundhog(phil)(i) \wedge largestmarmot(phil)(i)] \tag{13}$$

$$\lambda i^s([groundhog(phil)(i) \wedge largestmarmot(phil)(i)] \wedge livesinGK(phil)(i)) \tag{14}$$

The variation of sentences' semantic granularity with the epistemic agent's informational situation explains the intuitive validity of the inference from (11) and the intuitive invalidity of the inference from (12). However, this explanation presupposes the reasoner's familiarity with Eve and Len's level of expertise about Phil (cf. Sect. 3). Reasoners who are *not* familiar with the two agents' levels of subject expertise (s.t. they are, in particular, unaware of Eve's identical interpretation of (1) and (10)) will not be able to make the inference from (11).[7]

To capture the dependence of (11) on the reasoner's awareness of the agent's subject expertise, we stipulate the following: when they occur in the complement of epistemic verbs like *know*, sentences are interpreted as sets of situations whose members only encode the agent's information about the sentence's subject matter *of whose availability to the agent the reasoner is aware*.[8] For the occurrence of (1) from (11a), this set is specified in (15). There, r is a variable for the reasoner. The formula $aware(r)(q)(\sigma)$ asserts the reasoner's awareness that σ includes the information of q.

$$\lambda i[groundhog(phil)(i) \wedge \forall q([\boldsymbol{aware(r)(q)(\sigma_{eve})} \wedge abt(phil)(q)] \twoheadrightarrow q(i))] \tag{15}$$

We illustrate the reasoner-dependence of epistemic inferences by means of an example: Compare the interpretation of (11a) and (11b) by two reasoners, Dan and Fred, who have different degrees of familiarity with Eve's information about Phil. In particular, Dan knows that, in σ_{eve} Phil is a groundhog, belongs to the largest existing marmot species, and lives in Gobbler's Knob. Fred only knows that Phil is a groundhog in this situation. The complements of the occurrences of *know* from (11a) and (11b) are then interpreted as (14) by Dan and as (2) (cf. (11a)) and (13) (cf. (11b)) by Fred. Since only Dan is, thus, aware of Eve's identification

[7] The ability of (11b) to extend the reasoner's knowledge depends on this unfamiliarity.

[8] Admittedly, the reasoner may wrongly assume that Len also knows (10). This assumption explains why the reasoner may still make the inference from (12). It can be captured by replacing the reasoner's required *awareness* of the inclusion of a particular item of information in the agent's information state by the reasoner's *belief* about this inclusion (which does not entail the factivity of this inclusion).

of the rich contents of (1) and (10), only he can make the inference from (11).

Notably, the inference from (11) can also be made solely on the basis of Dan's awareness of Eve's *general expertise* about Phil, which does not require Dan's familiarity with the particular content of Eve's information state. This expertise entails the inclusion-in-σ_{eve} of all Phil-relevant information that is true at the actual world, @. The resulting interpretation of (1) from (11a) is given in (16).

$$\lambda i\,[groundhog(phil)(i) \wedge \forall q\,([\textbf{\textit{aware}}\textbf{(}\boldsymbol{r}\textbf{)(}\boldsymbol{q}\textbf{)(@)} \wedge abt(phil)(q)] \twoheadrightarrow q(i))] \qquad (16)$$

Our previous considerations suggest the distinction between two types of validity, relative to an agent's informational situation. The types are defined below:

Definition 2 (Situational validity). *An inference is* valid relative to the informational situation σ *of some specific reasoner* (*or is* valid-at-σ) *iff the rich content at σ of the inference's premise*(*s*) *is a subset of the rich content at σ of the inference's conclusion.*

Definition 3 (Validity simpliciter). *An inference is* valid simpliciter *iff, at all informational situations σ, the rich content at σ of the inference's premise*(*s*) *is a subset of the rich content at σ of the inference's conclusion.*

The condition from Definition 3 corresponds to requiring the entailment of the traditional, possible worlds-interpretation of the conclusion by the traditional, possible worlds-interpretation of the premise(s). The different types of validity are illustrated respectively by (11) and (17):

(17) a. Eve knows that Phil is a groundhog and lives in Gobbler's Knob. **T**
b. Eve knows that Phil is a groundhog. **T**

Since the situated interpretation of (11a) does not entail the situated interpretation of (11b) at some situations (e.g. at σ_1), (11) is not valid *simpliciter*.

4.2 Consequences of situating attitudes

As a result of its rich situated interpretation of epistemic complements, RSS also predicts the validity of inferences between epistemic reports like (18), whose complements are not intensionally equivalent.

(18) a. Eve knows that Phil is a groundhog. **T**
b. Eve knows that Phil lives in Gobbler's Knob. **T**

The validity of these inferences may be justified by the reasoner's familiarity with the epistemic agent's level of subject expertise: a reasoner (e.g. Dan) who is aware of the agent's degree of informedness about the interpreted sentence's subject matter will follow the agent in identifying his/her situated interpretation of the complements of *know* from (18a) and (18b). However, intuitively, inferences like (18) have a different kind of validity from inferences like (11).

To block inferences of the form of (18), we modify the content of the epistemically embedded occurrence of (1) from (15) to the set of situations whose members only encode *the information contained in the complement's lexical information* of whose availability to Eve the reasoner is aware. This modification restricts

the set of validly substitutable complements of epistemic verbs like *know* to CPs that are classically entailed[9] by the CP. For the complement of *know* from (11a), this is achieved by (19). There, the variable w ranges over possible worlds.

$$\lambda i \forall q([(\forall w[\mathit{groundhog}(\mathit{phil})(w) \rightarrow q(w)] \wedge \mathit{aware}(r)(q)(\sigma_{eve})) \wedge \mathit{abt}(\mathit{phil})(q)] \twoheadrightarrow q(i)) \tag{19}$$

Consider Dan's interpretation of the complements from (18a) and (18b). Following (19), these complements are interpreted as (13) (cf. (18a)) and (20) (cf. (18b)). Since the set of situations denoted by (13) is not contained in the set of situations denoted by (20), the inference from (18) is no longer valid on this interpretation.

$$\lambda i^{s}[\mathit{livesinGK}(\mathit{phil})(i)] \tag{20}$$

The interpretation from (19) is in line with the understanding of propositional knowledge as focusing on *a particular item* of the agent's subject-relevant information (at a given time), rather than as surveying *all* of his or her information (at this time). It differs from most attitude treatments by extending propositional knowledge to the *union* of the sentence's lexical information and the available aboutness-relevant information of its traditional entailments.

Our previous considerations may have made it seem as if our interpretation of epistemic complements was only an *ad hoc* move to prevent counterintuitive inferences of the form of (18). This is not the case: Since different verbs have differently strict requirements on the substitution of their complements (with verbs like *remember* even allowing the replacement by other than the classically entailed complements), the same sentence requires a differently fine-grained interpretation in different contexts. This observation calls for a 'modular' approach to granularity, which varies the granularity of sentential interpretations with the sentence's embedding context. By assuming interpretations with the granularity of (5) as the default case, and allowing different verbs to reduce (cf. (15)) or relatively increase the level of granularity (cf. (19)), RSS provides such modularity.

Consider the substitution properties of the complements of the verbs *say verbatim*, *know*, and *remember*: while *know* allows the substitution of its complement by sentences with the same subject matter to which the complement is traditionally equivalent (cf. the intuitive support for (11)), *say verbatim* does *not* allow such a substitution (cf. the intuitive support against (21), below). In contrast to the class of 'substitutable' complements of the verb *know*, the class of substitutable complements of the verb *remember* extends *beyond* the complement's traditional equivalents. The substitution-generality of the complement of *remember* is witnessed by the intuitive support for the inference from (22).[10]

(21) a. Eve said verbatim that Phil was a groundhog. **T**

b. Eve said verbatim that Phil was a woodchuck. **F**

[9] Entailment is here defined in terms of (subset) inclusion of sets of possible worlds.

[10] This inference assumes that the complements of the two occurrences of *remember* from (22) describe the same remembered situation. The intuitive validity of this type of inference is discussed in detail in [20, Sect. 4, 5].

(22) a. Dan remembered that Phil was nibbling at a dandelion. **T**
b. Dan remembered that Phil was endearing. **T**

In addition to a modular account of complement restriction (above), RSS also enables a modular account of a granularity that is determined by *non*-linguistic context. This account explains the observation that the same sentence requires a differently fine- (or coarse-)grained interpretation in different *communicative* contexts. Consider the complement of the verb *say verbatim* from (21a): This verb typically does not allow the substitution of its complement by any other sentence. The described ban on substitution even extends to pairs of classically equivalent sentences which receive an identical RSS-interpretation at the epistemic agent's current information state: in court, a witness' utterance of (21b) – instead of the original (21a) – will be counted against her and may even be punishable. However, these and other substitutions seem admissible in cases in which less is at stake. These include less formal social contexts, like friends gossipping about Eve.

The interpretation of the complements of epistemic verbs from (15) and (19) suggests the possibility of providing a modular account of contextually determined granularity. Because of the semantic effect of pragmatic factors (here: the respective social context and its associated level of formality), this account would involve reference to some version of pragmatic enrichment (cf. [4, 34]). We leave the detailed development of this account for another occasion.

5 Objections and Answers

We have shown in the preceding section that RSS solves the rigid granularity problem for the content of propositional attitudes. However, there exists a widely-used – arguably simpler and more salient – alternative solution. This solution lies in the assumption of a hyperfine-grained semantics that distinguishes the contents of intensionally equivalent sentences and in the introduction of an additional premise stating the epistemic agent's awareness of the co-intensionality (equivalence) of the two complements. For (11), such a premise is given in (11b)′.

(11)′ a. Eve knows that Phil is a groundhog. **T**
b. Eve knows that Phil is a member of the largest existing marmot species *iff* he is a groundhog. **T**
c. Eve knows that Phil is a member of the largest existing marmot species. **T**

Premise (11)′ can even be replaced by the more general premise (11)″:

(11)″ b. Eve knows that groundhogs are the largest existing marmot species, and *vice versa*.

The introduction of either of the above premises serves the same role as the *rich* interpretation of the two complements in RSS: it connects the premise (i.e. (11a)) with the conclusion by asserting the obtaining of an equivalence relation between the complements of the two occurrences of the verb *know*. Since

RSS identifies the rich contents of the two complements at Eve's informational situation (s.t. the complements are also equivalent in RSS), it does not require the introduction of an additional premise establishing this equivalence.

Its initial appeal notwithstanding, the above strategy lacks three desirable features of our RSS-account of the rigid granularity problem. These include the possibility of enabling inferences of the form of (11) without reference to a specific item of the agent's knowledge (i), the easy generalizability to granularity problems involving verbs from other verb classes (ii), and the provision of a modular account of (linguistic or non-linguistic) contextually determined granularity (iii). Feature (iii) has been discussed in some detail at the end of Section 4.2. Features (i) and (ii) are discussed below:

Ad (i): Premises (11b)′ and (11b)″ specify the particular item of the agent's knowledge that enables the inference from (11a) to (11b). However, reasoning often proceeds more holistically through association (cf. [40]). In particular, to make the inference from (11), the reasoner does not need to identify a specific inference pattern that ensures formal validity. Instead, it suffices for him to know that, at σ_{eve}, the complements from (11a) and (11b) have the same rich content, such that they allow mutual substitution. This is achieved via the reasoner's awareness that σ_{eve} includes both the lexical information of (1) and (10) (cf. (15)) or through his awareness of Eve's general expertise about Phil (cf. (16)).

Ad (ii): Our previous considerations have focused on the complements of epistemic verbs like *know*. However, variants of the rigid granularity problem also arise for the contents of other attitudes, including perceptual attitudes (e.g. *see*), emotional attitudes (e.g. *fear*), and evaluative attitudes (e.g. *admire*). In contrast to premises like (11b)′ that specify epistemic attitudes, premises that specify perceptual, emotional, or evaluative attitudes are semantically deviant (cf. (23b))

(23) a. Eve saw/feared/admired that Len (would) pet Phil. **T**

b. # Eve saw/feared/admired that Len (would) pet the best-known member of the largest existing marmot species *iff* he (would) pet Phil. **?**

c. Eve saw/feared/admired that Len (would) pet the best-known member of the largest existing marmot species **T**

The deviance of (23b) can be removed by replacing the occurrence of *saw* (or of *feared* or *admired*) by the verb *know* (in (23b)′).

(23)′ b. Eve knew that Len (would) pet the best-known member of the largest existing marmot species *iff* he (would) pet Phil.

However, the resulting premise presupposes a connection between knowledge and perception (or between knowledge and evaluations or the emotions) that is not made explicit in everyday reasoning or in RSS.

The above is not to question the validity of the inference from (23a) and (23b)′ to (23c). Rather, it observes the difficulty of explaining this validity in semantic theories which exclude the agent's non-lexical information from the relevant notion of linguistic content. This difficulty originates in a lack of corre-

spondence between the contents of perception (or of emotion or evaluation) and of knowledge in these theories. In particular, in these theories, the occurrences of the sentence *Len pets Phil* from (23a) and (23b)′ are interpreted, respectively, as subsets of the set of Len-petting-Phil situations that are consistent with Eve's current *perceptual* (or emotional, or evaluative) situation (cf. (23a)) and as the set of Len-petting-Phil situations that are consistent with Eve's current *epistemic, informational* situation (cf. (23b)′). The absence of an explicit relation between these two sets impedes the inference from (23a) and (23b)′ to (23c).

One could try to avoid the above problem by replacing (23b)′ instead by the premise (23b)″.

(23)″ b. Eve saw/feared/admired that Len (would) pet the best-known member of the largest existing marmot species *iff* she saw/feared/admired that Len (would) pet Phil.

This replacement yields a non-deviant sentence that ensures the validity of the inference. However, since any justification of (23b)″ will, again, need to establish a connection between knowledge and perception (or evaluation, or the emotions), it suffers from the same problem as the replacement of (23b) by (23b)′.

Rich Situated Semantics allows the inference from (23) by identifying the rich contents of the complements of *saw* from (23a) and (23c) at Eve's informational situation (cf. (5), (15)). Since this identification establishes a strong semantic connection between the two sentences, it does not require the introduction of an additional premise making this connection, or a specification of the relation between perception and knowledge.

6 Other Applications of RSS

We have shown above that Rich Situated Semantics solves the rigid granularity problem for the content of propositional attitudes. Our presentation of RSS suggests that this semantics can also be used to explain several other intensional phenomena. In particular, RSS helps solve some familiar problems of intensionality that have recently resurfaced in the philosophy of language. These include the cognitive accessibility problem for propositions (cf. [14, 25]), the problem of rational illogical belief (cf. [36, 38]), and the substitution problem for the objects and contents of propositional attitudes (cf. [24, 33]). Respectively, these problems regard the difficulty of most mainstream theories of linguistic content to explain how communicative agents can grasp abstract propositions, how rational agents can jointly believe superficially contradictory propositions,[11] and how the *contents* of propositional attitudes (as denoted by the CP complements of epistemic verbs) differ from the *objects* of these attitudes (as denoted by the complements' nominalizations of the form *the proposition that* ___).

RSS solves these problems by incorporating the interpreting agents' information about the sentences' subject matter into the content of these sentences. This

[11] These include Pierre's simultaneous belief that London is pretty and that London is not pretty (cf. [16])

information corresponds to the agents' *mode of presentation* of the subject matter (cf. [5,10,37]). In RSS, an object's mode of presentation is represented by the set of situations (type *st*) in which the object has the properties that the agent associates with it.[12] Since rich situated sentential contents depend on the information of the sentence's interpreting agent, they are cognitively accessible. The ability of agents to interpret different occurrences of the same NP w.r.t. their informational situations at different times further explains the possibility of rational illogical belief. The non-substitutability of CPs by their NP nominalizations in many contexts is explained by the situated (rich) interpretation of embedded CPs and the non-situated (poor) interpretation of their nominalizations.

The RSS-solution to the substitution problem is presented in [20, Sect. 5.3]. The detailed description of a rich situated solution to the remaining problems is left as a project for future work.

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