Contents

TWO KINDS OF ENGLISH NON-MANNER 'HOW'-COMPLEMENTS

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ABSTRACT. I show that English has two kinds of non-interrogative, non-manner embedded *how*-clauses: clauses that are licensed by perception, memory, and fiction verbs and allow paraphrase by a DP of the form *the event in which* [$_\text{TP}$] (cf. Umbach et al., submitted), and clauses that are licensed by presuppositional and 'say'-verbs and allow paraphrase by a DP of the form *the fact that* [$_\text{TP}$] (see Legate, 2010; Nye, 2013a). I provide a compositional semantics for reports with these two kinds of *how*-clauses. This semantics captures the intuitive entailment behavior of these reports. In doing so, it provides an answer to the question of how the different non-manner readings of *how* come about and why natural languages use the manner word *how* for this purpose.

KEYWORDS. Non-manner *how*-clauses, free relative clauses, factivity, presuppositionality, entailment patterns, experiential attitudes, event semantics, situation semantics.

1. INTRODUCTION

In the complements of perception and memory verbs (e.g. *see*, *remember*), embedded *how*-clauses typically have a manner-reading. On this reading, these clauses describe the particular manner, instrument, or method in which a given event (in (1a): Berta's packing) is performed (see (1b); cf. Sæbø, 2016):

(1) a. Anna remembers [how Berta was packing her bag]
     b. Anna remembers [the manner/way in which Berta was packing her bag]

Recently, Legate (2010) (cf. Nye, 2013a,b) and Umbach et al. (submitted) have argued (for English resp. German) that non-interrogative embedded *how*- [German *wie*-]clauses also have a non-manner reading (hereafter, '*how*$_\text{M}$'). However, Legate and Umbach provide mutually incompatible characterizations of this reading. Specifically, their characterizations diverge on which verbs license (English resp. German) *how*$_\text{M}$-clauses, whether *how*$_\text{M}$-clauses allow for negation and stative content, and whether *how*$_\text{M}$ is restricted to colloquial language register. In evidence of this divergence, the German counterpart of Legate's English sentence (2a) [ex. (1) in Legate, 2010], i.e. (2b), is semantically deviant (see Umbach et al., submitted, p. 11).

(2) a. They told me [how$_\text{M}$ the tooth fairy doesn't really exist]
     b. #Sie erzählten mir, [wie$_\text{M}$ die Zahnfee nicht wirklich existiert]

This paper resolves the seeming incompatibility of (Legate, 2010) and (Umbach et al., submitted). In particular, it provides empirical support for the assumption that English non-manner *how* is ambiguous between an Umbach-style eventive use, i.e. *how*$_\text{E}$ (which is licensed by perception, memory, fiction, and report verbs, introduces a process, and is unmarked with respect to register); and a Legate-style factive use, *how*$_\text{F}$ (which is licensed by presuppositional and 'say'-verbs, allows for negation and stative content, and is informal in register). The non-availability of *how*$_\text{F}$ in German explains Umbach et al.'s surprise about the Legate data.

The paper is organized as follows: to show that Legate- and Umbach-style *how*-clauses involve different non-manner uses of the manner wh-word *how*, I first compare the syntactic and semantic properties of factive and eventive *how*-complements and present different

diagnostic tests for the distinction between these two kinds of complements (in Sect. 2). To provide the 'right' semantics for eventive and factive uses of *how*-complements, I then consider the intuitive entailment behavior of reports with these complements (in Sect. 3) and provide a formal semantics for embedded *how*-clauses that captures these entailments (in Sect. 4). While this semantics is essentially new, it employs some familiar elements, viz. a close variant of Umbach et al.'s (submitted) semantics for interrogative manner *how*, Kratzer's (2006) semantics for the factive complementizer, and Tulving's (1972) distinction between episodic [≈ event-] and semantic [≈ propositional] memory (see Werning and Cheng, 2017).

The remainder of the paper extends the proposed semantics to the semantics of manner *how*-complements (in Sect. 5) and answers the question why some languages allow for different non-manner uses of *how* (in Sect. 6). The paper closes with a summary of our results and with pointers to future work.

2. FACTIVE AND EVENTIVE USES OF 'HOW'

2.1. **Legate-style factive 'how'-complements.** In (Legate, 2010), Legate investigates "a construction in English [. . .] whereby a declarative embedded clause is introduced by *how* rather than *that*" (p. 121). Legate associates this construction with colloquial language register (in her case: informal English). This association is supported by the presence of contractions in her example sentences (e.g. the use of *doesn't* in (2a)) and by the source of the majority of these sentences (viz. online blogs and forums). A representative subset of her example sentences is given below:

(3) a. They told me [how$_M$ the tooth fairy doesn't really exist]   (i.e. (2a))
     b. [he] whispered [how$_M$ we would be together forever]   (Legate's ex. (24j))
     c. Kenneth admitted [how$_M$ there are times when he struggles to keep control of his anger]   (ex. (24a))
     d. He explained [how$_M$, like Wanda, he tries very hard not to counter rudeness with rudeness]   (ex. (24a))

(4) a. Remember [How$_M$ Whites Were Too Racist to Vote Obama]?   (ex. (24d))
     b. Ever noticed [how$_M$ you always have your computer turned on] when you realise you need to clean the mouse   (ex. (24e))
     c. I hate [how$_M$ she claims to be a New Yorker]   (ex. (24f))
     d. And Red can't hide from me [how$_M$ he likes it, too]   (ex. (24c))

Legate's paper focuses almost exclusively on syntactic issues: the paper aims to show that embedded non-manner *how*-clauses are syntactically <u>DPs</u>, rather than CPs. The CP-status of these clauses may be wrongly assumed from the observation that some[1] Legate-style *how*-clauses (incl. all *how*-clauses in (4)) are semantically equivalent to *that*-clauses (see e.g. (5)):

(5) a. Ever noticed [how$_M$ you always have your computer turned on] when you realise you need to clean the mouse   (see (4b))
  ≡ b. Ever noticed [<u>that</u> you always have your computer turned on] when you realise you need to clean the mouse

As a result of its syntactic focus, Legate's paper largely refrains from giving a semantic characterization of the examined construction.[2] However, Legate's examples allow for

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[1]The include factive verbs (e.g. the matrix verbs in (4)), and exclude non-factive presuppositional verbs (cf. (3c/d)) and verbs of saying (cf. (3a/b)).

[2]In fact, Legate "leave[s] to future exploration [. . .] the semantic role [. . .] played by *how* in the [described] construction[s]" (Legate, 2010, p. 133). My compositional semantics for factive *how*-complements (see Sect. 4.1) fulfills this task.

some interesting conclusions about the lexical and selectional semantics of embedded non-manner *how*-clauses. Most of these conclusions are obtained from an investigation of the matrix verbs that license Legate-style embedded *how*-clauses. In particular, all non-manner *how*-clauses in (Legate, 2010) occur in the complements of presuppositional verbs[3] (e.g. *admit*, *remember*; see Kastner, 2015; cf. Cattell, 1978; Hegarty, 1990) or of verbs of saying (e.g. *tell*; see Levin, 1993, pp. 209–210; cf. Gropen et al., 1989).

Presuppositional verbs are verbs which assume that the proposition that is denoted by the CP in their complement is part of the common ground (see Kastner, 2015, p. 160; cf. Honcoop, 1998, p. 167). They include factive verbs (e.g. the matrix verbs in (4)) as a proper subclass. Examples of presuppositional and 'say'-verbs are given in (6). In this list, verbs that occur in Legate's original examples are marked with a superscript asterisk ('*').[4] Factive verbs are marked with a superscript dagger ('†'):

(6)   **Presuppositional verbs:**   accept, admit*, agree, approve[†,*], concede*, confess[†], confirm, explain*, find out[†,*], forgive[†,*], hide[†,*], know[†], notice[†,*], observe[†,*], realize[†], regret[†], remember[†,*], verify[†], . . .

     Verbs of saying: claim, convey, declare, mention, note, proclaim, recount, remark, report, say, state, tell*, whisper*, promise*, . . .

The presuppositionality of the matrix verbs in (3c/d) and (4) is evidenced by the observation that these verbs do not allow their complement's consistent retraction from the common ground (see e.g. (7); cf. Kastner, 2015, p. 159):

(7)   Kenneth admitted [how$_M$ there are times when he struggles to keep control of his anger]. #But no one had ever claimed that this was the case.

The factivity of the matrix verbs in (4) is evidenced by the observation that the *that*-clause complements of these verbs cannot be consistently negated (see e.g. the negation of the complement in the *that*-clause variant of (4c), in (8); *vis-à-vis* the negation of the complement in the *that*-clause variant of (2a), in (9)):

(8)   I hate [that she claims to be a New Yorker]. #But then, she never claimed that

(9)   They told me [that the tooth fairy doesn't really exist], ✓but they were lying

Arguably, Legate-style *how*-clauses do not serve as complements of presuppositional verbs like *deny*. To exclude such constructions (e.g. (10b); cf. Legate, 2010, fn. 13), I assume that Legate-style *how*-clauses are only licensed by a proper subclass of presuppositional verbs that are compatible with a presupposition of the truth of the CP. In what follows, I will call this subclass *positive presuppositional verbs*.

(10)   a. Mary denied [that she ate the cookies]
      b. *Mary denied [how$_M$ she ate the cookies]

Admittedly, Legate (2010) does not include examples for all presuppositional and 'say'-verbs from (6). To support my claim that Legate-style *how*-clauses are licensed by positive presuppositional verbs and 'say' verbs <u>in general</u>, I provide real examples for the above verbs that are not included in (Legate, <u>2010) (in (11)</u>–(13)). With the exception of (11e)[5] (which adds a *remember*-example to Legate, 2010), these examples are all taken from the enTenTen15 corpus (see Jakubíček et al., 2013).[6]

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[3]Haegeman and Ürögdi (2010) call these verbs *referential verbs*.
[4]To avoid an overly broad empirical domain, I exclude Legate's examples of *how$_M$*-embedding prepositional verbs (e.g. *start in on*, *cringe at*) and non-verbal predicates (e.g. *embarrassed of*, *outraged by*).
[5]This sentence is taken from the Corpus of Contemporary American English (see Davies, 2009).
[6]enTenTen15 is an English web corpus with 15 billion words. The corpus has lemmatization and PoS tagging, and is supported by the Sketch Engine corpus manager (see https://app.sketchengine.eu).

Note that the examples in (11) to (13) do not have an acceptable meaning-preserving German translation. (This is shown, by means of example, for (11a–c)). I will identify the reason behind the deviance of their German counterparts in Section 2.2.

(11) **Examples with factive verbs:**

    a. One of Lou's men even confessed [how$_M$ he once had dreams to serve in ministry]
[German: #Einer von Lous' Männern gestand sogar, wie$_M$ er einst davon geträumt hatte, dem kirchlichen Dienst beizutreten]

    b. everybody knows [how$_M$ the former ISI chief had doled out money from the secret funds]
[#jeder weiß, wie$_M$ der frühere ISI-Chef Gelder aus den geheimen Fonds verteilt hat]

    c. It makes you realize [how$_M$ the rest of the animal kingdom regards us with tremendous fear]
[#Es macht dir klar, wie$_M$ der Rest des Tierreichs uns mit enormer Angst betrachtet]

    d. She regrets [how$_M$ society measures people in terms of male success patterns]

    e. Jack remembered [how$_M$ beavers were sometimes killed by the very tree they were cutting down]

(12) **Examples with non-factive presuppositional verbs:**

    a. We need to accept [how$_M$ the right of return will be resolved through monetary compensation]

    b. I agree [how$_M$ the government anti-trust actions are dubious from several points of view]

    c. McGraw-Hill's CEO confirmed [how$_M$ the new Tablet gadget from Apple will be based on apple iphone OS]

    d. You should always verify [how$_M$ the City Code and Florida Building Code apply specifically to your property]

(13) **Examples with verbs of saying:**

    a. Many patients even claimed [how$_M$ the natural ways are cheaper and far more efficient than traditional medical treatment]

    b. I hope my words have conveyed [how$_M$ the possibilities are truly endless]

    c. high level officials [. . .] declared [how$_M$ the governor of Plateau State was to blame for unrest in his state]

    d. In my last post on the sector I mentioned [how$_M$ the big run was probably over]

    e. Mr. Bathily noted [how$_M$ the influx of refugees to the Lake Chad Basin region has over-stretched Government capacities]

    f. Isha remarked [how$_M$ the donations were made possible due to her connections with GWLN]

    g. It's been widely reported [how$_M$ the Bush administration wanted Downer to head the IAEA]

    h. Several of them said [how$_M$ the forest was 'life']

    i. Mimi Underwood stated [how$_M$ the ratings given don't actually influence search engine rank]

The non-manner use of the embedded occurrences of *how* in (11) to (13) is supported by the observation that these occurrences fail Umbach et al.'s diagnostic criteria for manner-readings (see Umbach et al., submitted, pp. 4–5). These include the admissible accenting of *how* (and the possible follow-up by a manner clarification question; see (14) for an application to (1a)), the paraphrasability by *the manner/way in which* [$_{\text{TP}}$] (and the possible continuation with a sentence that specifies the manner or method; *pace* Legate, 2010, pp. 127–128; see (15)), and the possibility of conjoining the *how*-complement with a *wh*-interrogative of any type, including *how* itself (see (16); cf. Zimmermann, 1991):

(14) a. ✓Anna remembers [HOW$_{\text{M}}$ Berta was packing her bag]
      b. ✓ . . . and HOW$_{\text{M}}$ was Berta packing her bag?

(15) a. ✓Anna remembers [the manner/way in which Berta was packing her bag]
      b. ✓ . . . namely very hastily (manner) / shoes first, then some t-shirts (method)

(16) Anna remembers [how$_{\text{M}}$ Berta was packing her bag], ✓[who was helping her], and ✓[what she was packing]

Legate-style *how*-complements fail these tests, as is shown for (11d) in (17) to (19):

(17) a. #She regrets [HOW society measures people in terms of male success patterns]
      b. # . . . and HOW does society measure people in terms of male success patterns?

(18) a. #She regrets [the way in which society measures people in
          terms of male success patterns]   (redundant)
      b. # . . . namely in terms of male success patterns   (redundant)

(19) She regrets [how society measures people in terms of male success patterns], #[who does the measuring], #[what they measure], and #[how$_{\text{M}}$ the measuring proceeds]

Note that – since they can occur in the complements of <u>non</u>-factive presuppositional verbs – Legate-style *how*-clauses are <u>not</u> equivalent to *that*-clauses (*pace* Huddleston and Pullum, 2002, p. 954), but to overt definite presuppositionals of the form *the fact that* [$_{\text{TP}}$] (see (20)). The non-equivalence of Legate-style *how*-clauses and *that*-clauses is supported by the observation that, in the complements of non-factive verbs, non-manner *how*-clauses exhibit a different cancellation behavior from *that*-clauses: in contrast to non-factively embedded *that*-clauses (see (20a)), these clauses cannot be consistently negated (see (20b)). This matches the cancellation behavior of non-factively embedded DPs of the form *the fact that* [$_{\text{TP}}$] (see (20c); cf. Kastner, 2015, pp. 159–160). My example below is inspired by Kastner (2015, ex. (10)):

(20)   a. I explained [that the building collapsed] (but it didn't really)
   ≢   b. I explained [how$_{\text{M}}$ the building collapsed] (#but it didn't really)
(b. ≡ c. I explained [the fact that the building collapsed] (#but it didn't really))

The above provides the semantic counterpart to Legate's syntactic support for the claim that "*how* is not a simple alternate to *that*" (Legate, 2010). The equivalence of Legate-style *how*-clauses and DPs of the form *the fact that* [$_{\text{TP}}$] will be the key idea behind my compositional semantics for Legate-style *how*-clauses (see Sect. 4.1). In virtue of this equivalence, I will hereafter refer to Legate-style *how*-clauses as <u>factive</u> *how*-clauses.[7] Following their description of non-factive, non-manner readings of embedded German *how*-clauses as <u>eventive</u>, I will hereafter refer to Umbach-style *how*-clauses (in German and in English) as <u>eventive</u> *how*-clauses. The relevant uses of *how* will be labelled '*how*$_{\text{F}}$' (for factive *how*) and '*how*$_{\text{E}}$' (for eventive *how*), respectively.

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[7]In (Nye, 2013a,b), these clauses are called *complementizer-'how' clauses* (abbreviated 'CHCs').

2.2. **Umbach-style eventive 'how'-complements.** I have suggested in the introduction to this paper that (the English counterparts of) Umbach-style eventive *how*-clauses are different from Legate-style factive *how*-clauses. The difference between these clauses is evidenced by the observation that factive *how*-clauses fail Umbach et al.'s tests for eventive *how*-clauses. These include the possibility of continuing sentences containing such clauses with a sentence that adds another event (see (21a)) and of allowing paraphrase by a DP of the form *a (specific) event in which* [$_{TP}$] (see (21b); cf. Umbach et al., submitted, p. 4):

(21) a. Anna erinnert sich, [wie$_E$ Berta ihre Tasche packte] . . . und das Haus durch die Hintertür verließ
    [Anna remembers [how$_E$ Berta was packing her bag] . . . and was leaving the house through the back door]

  b. i. Anna remembers [how$_E$ Berta was packing her bag]
 ≡ ii. Anna remembers [a (specific) event in which Berta was packing her bag]

Factive *how*-clauses do not pass these tests, as is shown for (11d) in (22):

(22) a. She regrets [how$_F$ society measures people in terms of male success patterns] . . . #and [the event of . . .]

  b. #She regrets [a (particular) event (/process/situation/scene) in which society measures people in terms of male success patterns]

The possibility of paraphrasing eventive *how*-complements by an explicitly event-denoting DP suggests that reports with *how$_E$*-complements are direct in the sense of (Barwise, 1981; Barwise and Perry, 1983). In particular, perception reports with eventive *how*-complements constitute a subclass of Barwise's direct perception reports with bare infinitival or gerund complements. I will return to the directness of eventive *how*-clause reports in Section 2.3 (when I present different diagnostic tests for *how$_E$*) and in Section 3.3 (when I contrast the semantic properties of *how$_F$*-, *how$_E$*-, and *that*-clauses).

The ability of Umbach-style *how*-clauses to be paraphrased by an explicitly event-denoting DP suggests that these clauses induce imperfectivity (see Falkenberg, 1989, pp. 37–38; cf. Umbach et al., submitted, pp. 24–25). The imperfective nature of eventive *how*-clauses is suggested by the fact that the English translation of Umbach's example (i.e. (21a)) can[8] use progressive aspect and that *how$_E$*-clauses are roughly equivalent[9] to English gerund complements (see (23)):

(23) a. Anna remembers [how$_E$ Berta was packing her bag]   (! but see (64))
 ≈ b. Anna remembers [Berta packing her bag]

Since imperfectivity is typically unmarked in German, the process-perspective is only covert in the German version of (1a) (in (24)). However, the imperfectivity of the event denoted that is by the *how*-clause can be made explicit by using an infinitival construction of the form *dabei sein, . . . zu . . .* [*to be in the process of doing sth.*] (in (24a); see Falkenberg, 1989) or by using a regional variant of German, called the *Rheinische Verlaufsform* (in (24b); see Umbach et al., submitted, pp. 24–25). Both constructions use the infinitival form, which is usually taken to induce imperfectivity (see Ehrich, 1991).

(24) Anna erinnert sich, [wie$_E$ Berta ihre Tasche packte]

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[8]Contrary to what is suggested in (Umbach et al., submitted), the majority of occurrences of English eventive *how*-clauses in the enTenTen15 Corpus does not have progressive aspect. I attribute this observation to the fact that the predicates in these clauses denote activities or accomplishments, which already induce a progress perspective.

[9]The (subtle) semantic difference between gerund- and *how$_E$*-clause complements will be the topic of Section 3.1.

$\equiv$ a. Anna erinnert sich, [wie$_E$ Berta <u>dabei war</u>, ihre Tasche <u>zu</u> packen]

$\equiv$ b. Anna erinnert sich, [wie$_E$ Berta ihre Tasche <u>am</u> Packen <u>war</u>]

The imperfective nature of Umbach-style *how*-clauses is further supported by the observation that eventive *how*-clauses allow for the imperfective paradox (see Falkenberg, 1989, pp. 37–38; cf. Dowty, 1977). As a result of this paradox, the eventive reading of (1a) (in (25a)) does not entail (25b). The non-validity of this entailment is exemplified by the observation that, unlike (25b), (25a) allows for a consistent continuation with a sentence that denies the completion of the event (in (26)):

(25)   a. Anna remembers [(how$_E$) Berta (was) packing her bag]   (i.e. (1a))

   $\not\Rightarrow$ b. Anna remembers [that Berta packed her bag]

(26)   Anna remembers [how$_E$ Berta was packing her bag (when Anna came to apologize)]. $^{(\checkmark)}$Upon Anna's apology, Berta changed her mind, stopped packing, and stayed

In virtue of their imperfectivity, eventive *how*-clauses (in English and in German) license activities (see (25a)) and accomplishments (see (21a)), but not states (see the semantic deviance of (27) and (28); cf. Umbach et al., submitted, p. 25):

(27)   #Ich sah, [wie$_E$ Hans krank war]   (Umbach et al., ex. (47a))
        [#I saw how$_E$ Hans was (being) sick]

(28)   #Anna hörte/erzählte, [wie$_E$ Berta *Die Glocke* von Schiller auswendig konnte]
        [#Anna heard/reported how$_E$ Berta knew/was knowing Schiller's poem *Die Glocke*
        by heart]   (Umbach et al., ex. (47b))

In contrast, Legate-style *how*-clauses <u>allow</u> states, as is illustrated by (2a). In fact, the majority of factive *how*-clauses (see e.g. (11c–e)) denote statives or habituals.[10] The relation between factive *how*-clauses and statives is a topic for future research.

In virtue of their progress-character, eventive – but not factive – *how*-clauses further block negated content (see Umbach et al., submitted, p. 11). This behavior is evidenced by the deviance of (29) and by the acceptability of (2a) and (13i):

(29)   #Anna remembers [how$_E$ Berta was not packing her bag]
        [*only admissible reading:* Anna remembers Berta doing a whole lot of other things
                        while avoiding to pack her bag]

As one might expect, the lexical difference between the predicates in eventive and factive *how*-clauses is also reflected in the matrix verbs that license these clauses. In contrast to the licensers for Legate-style factive *how*-clauses, licensers for eventive *how*-clauses include verbs that are neither presuppositional- nor 'say'-verbs. Verbs of this class include representational counterfactual attitude verbs (e.g. *imagine*). An extended version of Umbach et al.'s list of how$_E$-licensers is given in (30) (see Umbach et al., submitted, p. 7).

To show the difference between licensers for factive and eventive *how*-complements, I deviate from Umbach et al.'s classification of how$_E$-licensers (see Umbach et al., submitted, p. 7). In particular, I split Umbach's class of cognitive verbs into (factive) attention/memory verbs and (non-factive, non-presuppositional) fiction verbs (see Giannakidou and Mari, 2020). To capture the commonality between verbs from the above classes and perception verbs (see Sect. 2.3), I will describe these verbs as *experiential attitude verbs* (see Stephenson, 2011). The latter are verbs that denote an agent's direct mental or perceptual relation to an event, a situation, or scene (see Stephenson, 2010; cf. Bernecker, 2010; Tulving, 1972).

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[10]I owe this observation to Keir Moulton.

Below, verbs that are included in Umbach et al.'s original list are marked with an asterisk (analogously to (6)). German verbs are given in brackets:

(30) **Experiential attitude verbs:**

Perception verbs: see* [sehen], hear* [hören], feel* [fühlen], experience* [erleben], ...

Attention/memory verbs: remember* [sich erinnern], think of* [daran denken], forget* [vergessen], notice* [(be-)merken], observe* [beobachten], ...

Fiction verbs: imagine* [sich vorstellen], dream (of) [träumen (von)],

Report verbs: report* [berichten], recount [erzählen, schildern], describe* [beschreiben], ...

Some enTenTen15 examples with the above matrix verbs and eventive *how*-complements are given in (31) to (34). To show that factive *how*-complements are not the only type of English non-manner *how*-complements, I focus on English examples. In contrast to the corpus examples from (11) to (13), these examples all have an acceptable, meaning-preserving German translation (as is shown below for (31)).

(31) **Examples with perception verbs:**

a. he saw [how$_E$ the couple were trying to force the tearful infant girl to walk]
[*German:* er sah, wie$_E$ das Paar versuchte, das weinende Mädchen zum Laufen zu zwingen]

b. Keeping his eyes shut, Sam heard [how$_E$ Dean got back into his bed]
[Sam hielt seine Augen geschlossen und hörte, wie$_E$ Dean wieder ins Bett ging]

c. I felt [how$_E$ the blood left my face]
[Ich fühlte, wie$_E$ das Blut mein Gesicht verließ]

d. Steve experienced [how$_E$ a kind, loving counselor could provide such great comfort]
[Steve erlebte, wie$_E$ ein netter, gütiger Berater so großen Trost spenden konnte]

(32) **Examples with attention/memory verbs:**

a. this just made me remember [how$_E$ Richard went windsurfing with a model [of Pamela Anderson] on his back]

b. He thought of [how$_E$ his mother had wiped away his tears after his father's death]

c. No one in Timbuktu has forgotten [how$_E$ the Moroccans conquered the city, plundered the libraries and dragged off the best scholars to Fes]

d. My son [...] noticed [how$_E$ I've been ducking working outside for a couple of months]

e. In the joint U of I/Germany study, researchers observed [how$_E$ water molecules dance with ubiquitin, one of the body's most prevalent proteins]

(33) **Examples with fiction verbs:**

a. She imagined [how$_E$ she would be marrying the beast from the tale of <u>The Beauty and the Beast</u>]

b. In the confines of his room at Hotel Lala, he dreamt of [how$_E$ his father died]

(34) **Examples with report verbs:**

    a. Speer later reported [how$_E$ he was travelling with Hitler in the Leader's private train on 7 November 1942]

    b. She recounted [how$_E$ the Scots-Irish left for the South after being shunned in New England]

    c. Some detainees [. . .] described [how$_E$, on the evening of 23 August, about 160 detainees began to flee the metal hangar they were being held in]

The inclusion of perception, attention/memory, and report verbs in the class of presuppositional verbs (see Barwise and Perry, 1983; Kastner, 2015; Giannakidou and Mari, 2020) leads us to expect that these verbs also license how$_F$-complements. The latter is indeed the case. Examples of perception verbs with factive *how*-clauses are given in (35):

(35)   a. In Soma City, [. . .] we saw [how$_F$ the tsunami had flattened the land]

    b. A trial heard [how$_F$ former nurse Webster, 54, tried to become a millionaire by murdering his wives in order to claim large insurance pay-outs]

    c. I felt [how$_F$ such events could never have been organized by me years ago]

    d. participants experienced [how$_{F(?)}$ Augmented Reality-enhanced applications may improve processes at work]

Note that, the above notwithstanding, different perception verbs seem to have a preference for different types of non-manner *how*-clauses. In particular, while *see* and *feel* prefer eventive *how*-complements; *hear* prefers factive *how*-complements. *Experience* even seems to have a very strong preference for eventive *how*-complements (see the questionable factive reading of the complement in (35d)). In contrast to *see*, *feel* and *experience* further have a strong preference for *de se*-readings (see Anand, 2011; Ninan, 2007; cf. Lewis, 1979).

2.3. **Diagnostics for eventive 'how'-complements.** To distinguish eventive from factive *how* in the complements of verbs that license both non-manner uses of *how*, we use Stephenson's (2010) diagnostic tests for reports of 'vivid' [= experiential, event-directed] attitudes. These tests include – next to (i) the possibility of substituting the complement in these reports with a DP of the form *a/the event in which* [$_{TP}$] (see (21b); cf. Umbach et al., submitted) – (ii) the possibility of modifying the matrix verb in these reports by an 'experiential' modifier like *vividly* or *in perfect detail* and (iii) the entailment of these reports to sentences that relate the agent's direct (mental or perceptual) witnessing of the event that is described by the complement of these reports. For factive occurrences of *see*, the phenomenon which underlies diagnostic (iii) is called *direct perception* in Barwise (1981) (see Barwise and Perry, 1983).

Reports with embedded eventive *how*-complements pass these tests, as is shown for the eventive *how*-reading of a variant of (32a) (see (36a)) in (36) to (38):

(36)   a. Bill remembered [how$_E$ Richard went windsurfing with a model of Pamela Anderson on his back]   (see (32a))

≡   b. Bill remembered [the (specific) event of Richard going windsurfing with a model of Pamela Anderson on his back]   (cf. (21b))

(37)   Bill vividly remembered/remembered in perfect detail [how Richard went windsurfing with a model of Pamela Anderson on his back]

(38)   a. Bill remembered [how$_E$ Richard went windsurfing with a model of Pamela Anderson on his back]

⇒   b. Bill has seen [= perceptually witnessed] Richard going windsurfing with a model of Pamela Anderson on his back

Since reports with embedded factive *how*-clauses are typically <u>not</u> used to describe directly witnessed events (see above), they fail the above tests, as is shown for (11e) in (39)–(41):

(39) a. Jack remembered [how$_F$ beavers were sometimes killed by the very tree they were cutting down]

   $\neq$ b. $^{??}$Jack remembered [<u>a specific event in which</u> beavers were (sometimes) killed by the very tree they were cutting down]

      (*Better, but still not equivalent:* Jack remembered [<u>a specific event in which</u> a beaver was killed by the very tree it was cutting down])

(40) $^{\#}$Jack <u>vividly</u> remembered/remembered <u>in perfect detail</u> [how$_F$ beavers were sometimes killed by the very tree they were cutting down]

(41) a. Jack remembered [how$_F$ beavers were sometimes killed by the very tree they were cutting down]

   $\not\Rightarrow$ b. Jack has (perceptually) witnessed a beaver being killed by the very tree it was cutting down

By inversing the finding from (20), we can complement the above tests for eventive readings of *how*-complements with another – negative – diagnostic for these readings, viz. the <u>impossibility</u> (in some situations) of preserving the truth of the report by substituting its complement with a DP of the form *the fact that* [$_{\text{TP}}$]. Reports with embedded eventive *how*-complements fail this test, as is shown for (36a) in (42):

(42) a. Bill remembered [how$_E$ Richard went windsurfing . . .]
      ($\equiv$ Bill remembered [<u>the event of</u> Richard going windsurfing . . .])

   $\not\equiv$ b. Bill remembered [<u>the fact that</u> Richard went windsurfing . . .]

The non-equivalence of the reports in (42a) and (42b) is due to the fact that one can remember the (real-world) fact that Richard went windsurfing without remembering the particular event of Richard going windsurfing (i.e. (42b) $\not\Rightarrow$ (42a)). This is the case since memory of facts about the real world requires neither memory of the particular space or point in time at which this fact is located (e.g. at Venice Beach, on 20 April, 2020, at 3:30 p.m. PST) nor memory of other facts about the event of which this fact is true (esp. of other agents in this event and their properties; e.g. that Richard was wearing his Hawaiian-print wetsuit and that Penny came surfing along).

Reports with embedded factive *how*-complements <u>pass</u> this last test, as is illustrated for (11e) in (43) (see also (20)):

(43) a. Jack remembered [how$_F$ beavers were sometimes killed by the very tree they were cutting down]

   $\overset{!}{\equiv}$ b. Jack remembered [<u>the fact that</u> beavers were sometimes killed by the very tree they were cutting down]

This completes my examination of the lexical and selection behavior of eventive and factive *how*-clauses. In Section 4, I will use the above observations about this behavior to model the semantic contribution of these clauses. To enable the compositional modelling of this contribution,[11] I close the present section with observations about the syntax of non-manner *how*-clauses.

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[11]This modelling uses the type-driven interpretation of the syntactic constituents of these clauses (see Heim and Kratzer, 1998; Zimmermann and Sternefeld, 2013; cf. Klein and Sag, 1985).

2.4. **The syntax of embedded non-manner 'how'-complements.** Legate (2010) and Umbach et al. (submitted) both assume that their investigated non-manner *how*-clauses are very similar in structure to free relative clauses, especially to manner free relative clauses: like manner *how*-complements (see Fig. 1), non-manner *how*-complements are DPs that are headed by a silent determiner, ∅, which takes the *how*-clause as its complement (see Fig. 2). The only difference between these two *how*-clause DPs lies in the internal structure of the embedded CP – especially in the base position of *how*: while *how* moves from a TP-internal position in manner *how*-clauses, thus leaving a trace (see Caponigro, 2003, 2004; cf. Groos and van Riemsdijk, 1981), it is base-generated in its surface position in non-manner *how*-clauses (see Legate, 2010, pp. 130–131; cf. Umbach et al., submitted, pp. 10–11):
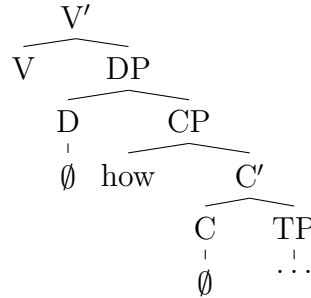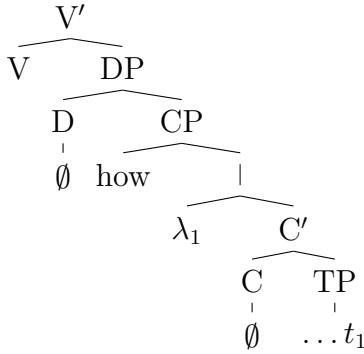
FIGURE 1. Manner *how*-complements.   FIGURE 2. Non-manner *how*-complements.

The free relative-like status of embedded non-manner *how*-clauses explains their DP-like distribution behavior (see Legate, 2010). This behavior includes the ability of factive *how*-clauses to serve as the complement of a preposition (see (44)), to be coordinated with a (content and non-content) DP (see (45b), (45a)), and to occur in the PP of CP/PP-neutral predicates (see (46); see Legate, 2010, pp. 122–124):[12]

(44)   a. They told me about [$_{DP}$the tooth fairy('s non-existence)]
       b. They told me about [$_{DP}$how$_F$ the tooth fairy doesn't really exist]
       c. *They told me about [$_{CP}$that the tooth fairy doesn't really exist]

(45)   a. They told me about [[$_{DP}$the tooth fairy] and [$_{DP}$how$_F$ it doesn't really exist]]
       b. They told me about [[$_{DP}$how$_F$ the tooth fairy doesn't really exist] and [the fact that many children are unwilling to accept this]

(46)   a. I fretted about [$_{DP}$the tooth fairy's non-existence]
       b. I fretted about [$_{DP}$how$_F$ the tooth fairy doesn't exist]
       c. *I fretted about [$_{CP}$that the tooth fairy doesn't exist]

Umbach-style eventive *how*-clauses exhibit the same behavior, as is shown for (47)[13] in (48) to (50):

(47)   Ida is imagining/dreaming [how$_E$ a unicorn is prancing in the sun]

(48)   a. Ida is imagining about [$_{DP}$a unicorn's prancing in the sun]
       b. Ida is imagining about [$_{DP}$how$_E$ a unicorn is prancing in the sun]
       c. *Ida is imagining about [$_{CP}$that a unicorn is prancing in the sun]

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[12]Related arguments for the DP-status of superficially clausal complements can be found in (Kastner, 2015, Sect. 5).

[13]Since Umbach's main example sentence, i.e. the German counterpart of (1a), is ambiguous between an eventive and a factive reading (as I show below), I do not use this sentence for the present purposes.

(49)   Ida is imagining (about) [[_DP_a unicorn] and [_DP_how_E it is prancing in the sun]]

(50)   a. Ida is dreaming of [_DP_a unicorn (prancing in the sun)]

       b. Ida is dreaming of [_DP_how_E a unicorn is prancing in the sun]

       c. *Ida is dreaming of [_CP_that a unicorn is prancing in the sun]

The DP-like behavior of factive and eventive *how*-complements is further evidenced by the the observation that these complements cannot appear in positions that are not assigned case (see Legate, 2010, p. 124):

(51)   a. *It was conceded [_DP_the tooth fairy's non-existence]

       b. *It was conceded [_DP_how_F the tooth fairy doesn't exist]

       c. It was conceded [_CP_that the tooth fairy doesn't exist]

(52)   a. *It was conceded [_DP_a unicorn (prancing in the sun)]

       b. *It was conceded [_DP_how_E a unicorn is prancing in the sun]

       c. It was conceded [_CP_that a unicorn is prancing in the sun]

Beyond the above, embedded non-manner *how*-complements block extraction, i.e. they form strong islands. In particular, such complements disallow the extraction of adjuncts and objects (see Legate, 2010, pp. 125–126) as well as of subjects (see (53)–(54); cf. Kastner, 2015, pp. 157, 167–168):

(53)   They told me [how_F she buys junk food everyday because she can't cook]

       a. *What did they tell you [how_F she buys ___ everyday]?   (object)

       b. *Who did they tell you [how_F ___ buys junk food everyday]?   (subject)

       c. #Why did they tell you [how_F she buys junk food everyday ___]? (adjunct)

(54)   Ida is imagining [how a unicorn is chasing kittens for entertainment]

       a. *What is Ida imagining [how_E a unicorn is chasing ___ for entertainment]?

       b. *Who is Ida imagining [how_E ___ is chasing kittens for entertainment]?

       c. #Why is Ida imagining [how_E a unicorn is chasing kittens ___]?   (adjunct)

In contrast to the above, *that*-clauses which are embedded under the same verbs allow the extraction of objects, i.e. they behave only like <u>weak</u> islands (see (55); cf. Kastner, 2015, pp. 161, 163–164):

(55)   They told me [that she buys junk food everyday because she can't cook]

       a. What did they tell you [that she buys ___ everyday]?   (object)

       b. *Who did they tell you [that ___ buys junk food everyday]?   (subject)

       c. #Why did they tell you [that she buys junk food everyday ___]?   (adjunct)

The 'strong island'-status of embedded non-manner *how*-clauses can be explained by assuming that these clauses are <u>definite</u> DPs (see also Kastner, 2015). The definiteness of embedded non-manner *how*-clause DPs is supported by the observation that these DPs do not license NPIs and that they do not allow NPIs to be licensed by negation from within (see (56), (57)):

(56)   a. *She told me [how_F any animals exist here]

       b. *Nobody told me [how_F any fairies exist]

(57)   a. *Ida is imagining [how_E any unicorn likes lucky clover]

       b. *Nobody is imagining [how_E any unicorn likes lucky clover]

For factive – but not for (all) eventive – *how*-clause DPs, definiteness is further supported by the observation that the content of these DPs is presupposed (see Sect. 4.4; cf. Kastner, 2015). As a result of this presupposition, the content of Legate-style *how*-complements cannot be consistently negated (see (8), (20b)).

With the syntactic and lexical behavior of eventive *vis-à-vis* factive *how*-complements in place, I now turn to the compositional semantic modelling this behavior. To ensure that I am modelling the right behavior, I precede this modelling with an investigation of the entailment properties of different non-manner *how*- and *that*-clause reports.

3. Properties of Factive and Eventive 'how'-Complements

I have already stated in Section 2.3 that – due to the proper inclusion of facts in events – attitude reports with factive *how*-complements do not license entailments to the eventive reading of these complements (see (42); i.e. B $\not\Rightarrow$ A in (58), below). My observation about the different assertoric strength of *that*- and factive *how*-clause complements (see the cancellability of factively embedded *that*-, but not of *how*_F-clauses; in (20)) further suggests that *that*-clause attitude reports are assertorily <u>weaker</u> than reports with factive *how*-complements. This suggestion is corroborated by the intuition that the *that*-clause report in (59-C) does not entail the factive *how*-clause in (59-B). The observed non-entailment is in line with Nye's intuition that "CHCs [. . .] contribute something additional [to the interpretation of factive *that*-clauses]" (Nye, 2013b, p. 122).

To provide the 'right' semantics for eventive and factive uses of embedded *how*-clauses, I also consider the inverse direction of the above entailments. These include the entailment from reports with eventive- to reports with factive *how*-complements (see A $\Rightarrow$ B in (58)) and from reports with factive *how*- to reports with *that*-clause complements (see B $\Rightarrow$ C in (59)). Below, these entailments are illustrated on different variants of the memory report in (1a). In (58-A), the progressive form of the embedded verb makes explicit the imperfective nature of eventive *how*-complements (see (24)–(28)). To obtain a minimal pair of *remember*-reports, (58) uses the progressive form of the verb in the complement in B:[14]

(58)   A: Anna remembers [how_E Berta was packing her bag]
            ($\equiv$ Anna remembers [a (specific) event in which Berta was packing her bag])

$\not\Leftarrow\Rightarrow$ B: Anna remembers [how_F Berta was packing her bag]
            ($\equiv$ Anna remembers [the fact that Berta was packing her bag])

(59)   B: Anna remembers [how_F Berta packed her bag]
            ($\equiv$ Anna remembers [the fact that Berta packed her bag])

$\not\Leftarrow\Rightarrow$ C: Anna remembers [that Berta packed her bag]

I start with an investigation of the semantic relation between A and B (i.e. the entailment from the first to the second line in (58)).

3.1. Epistemic positiveness of non-manner 'how'-complements.
I have argued in Section 2.2 that eventive *how*-clause complements are 'roughly' equivalent to English[15] gerund complements. Support for this equivalence comes from the eventive nature of these two kinds of complements (see (36)–(37)) and from the direct witnessing requirement of these complements (see (38)). Support for their non-equivalence – and the reason for its

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[14]This form is not very natural (although it is judged 'acceptable' by native speakers). My use of this form is motivated by my focus on the entailment behavior of reports with eventive and propositional *how*-complements, rather than on entailment differences due to aspect. The (non-)entailment between (58-A) and (59-B) is discussed in Section 4.4 (see (84)).

[15]Since German *erinnern* rejects gerund complements, this equivalence cannot be expressed for German.

classification as a rough equivalence – comes from the epistemic neutrality of gerund complements (see Barwise, 1981; Barwise and Perry, 1983; cf. Dretske, 1969) and the epistemic positiveness of eventive *how*-complements (see Umbach et al., submitted; *pace* Falkenberg, 1989).

The epistemic neutrality of gerund complements is reflected in the possibility of cancelling the entailment from gerund- to *that*-clause reports (see (60) for such a cancellation). This cancellability is supported by the possibility of continuing gerund attitude reports with a *that*-clause report that describes a positive attitude towards the (implicit or explicit) negation of the content of this gerund (see (61), *vis-à-vis* (61b)). The example in (61a) is taken from Barwise (1981, p. 374).

(60)   a.   Ralph saw [a spy hiding a letter under a rock]

   $\not\Rightarrow$ b.   Ralph saw [that a spy was hiding a letter under a rock]

(61)   a.   Ralph saw [a spy hiding a letter under a rock], $^\checkmark$ but thought [that she was tying her shoe]

         (*More generally:* Ralph saw [a spy hiding a letter under a rock], $^\checkmark$ but did not see [that the/a spy was hiding a letter under a rock])

       b.   Ralph saw [that a spy was hiding a letter under a rock], $^\#$ but thought [that she was tying her shoe]

In contrast to gerund complements – but like *that*-clause complements –, eventive *how*-complements block the continuation with a *that*-clause report that describes a positive attitude towards the negation of the content of the how_{E}-complement (see (62)):

(62)   Ralph saw [how_{E} a spy was hiding a letter under a rock], $^\#$ but thought [that she was tying her shoe]

Reports with eventive *how*-complements thus force an entailment to their *that*-clause variants (see (63)):

(63)   a.   Ralph saw [how_{E} a spy was hiding a letter under a rock]

   $\Rightarrow$ b.   Ralph saw [that a spy was hiding a letter under a rock]

As a result of their epistemic positiveness (*vis-à-vis* the epistemic neutrality of gerund complements), reports with eventive *how*-complements entail their 'gerund'-variants, but not *vice versa* (see (64)):

(64)   a.   Anna remembers [how_{E} Berta was packing her bag]   (cf. (23))

   $\not\Leftarrow \Rightarrow$ b.   Anna remembers [Berta packing her bag]

As their paraphrasability with '*the fact that* [$_{\text{TP}}$]' correctly suggests, observations like the ones above also hold for factive *how*-complements. The epistemic positiveness of Legate's tooth-fairy example (see (2a)) is evidenced by (65):

(65)   They told me [how_{F} the tooth fairy doesn't really exist], $^\#$ but they didn't tell me [that the tooth fairy doesn't really exist]

The above supports the validity of (66) (and, attendantly, the validity of B $\Rightarrow$ C in (59)).

(66)   a.   They told me [how_{F} the tooth fairy doesn't really exist]

   $\Rightarrow$ b.   They told me [that the tooth fairy doesn't really exist]

I will provide a summary of the properties of how_{E}-, how_{F}-, and *that*-clause complements at the end of this section (in Table 1). However, before I do so, I briefly turn to another semantic property of these reports that is relevant to the formal semantic modelling of attitude complements, viz. referential opacity/transparency (see Quine, 1956).

Since opacity is today one of the best-investigated properties of attitude reports (see e.g. Percus, 2000; Pearson, 2020; Zimmermann, 1993), it is imperative that we also consider the opacity behavior of the different types of complements. We will see that – contrary to what is suggested by Barwise (1981) (see Falkenberg, 1989) – transparency patterns with direct witnessing, rather than with epistemic positiveness.

3.2. **Referential transparency of eventive 'how'-complements.** The epistemic positiveness of eventive and factive *how*-complements suggests that these complements are referentially opaque [= non-transparent] in the sense that they block the truth-preserving substitution of co-referential or truth-conditionally equivalent expressions (see Quine, 1956). However, as it turns out, this is only the case for factive *how*- and for *that*-complements (see e.g. (67), (68)):

(67)   a.   <u>They told me [how$_F$ the tooth fairy doesn't really exist]</u>

    ⇏ b.   They told me [how$_F$ the chupacabra doesn't really exist]

(68)   a.   <u>They told me [that the tooth fairy doesn't really exist]</u>

    ⇏ b.   They told me [that the chupacabra doesn't really exist]

In particular, if *how$_F$*- and *that*-complements were referentially transparent, they would allow the substitution of *the tooth fairy* by *the chupacabra*, since the set of tooth fairies and the set of chupacabras coincide at the world of evaluation (i.e. they are both ∅).

In contrast to the above, eventive *how*-complements are referentially transparent (i.e. they allow the truth-preserving substitution of co-referential or truth-conditionally equivalent expressions). For (1a), this behavior is evidenced below:

(69)   a.   Anna remembers [how$_E$ Berta is packing her bag]

        b.   <u>*Assumption:* The bag which Berta is packing is a black leather duffle bag</u>

    ⇒ c.   Anna remembers [how$_E$ Berta is packing the black leather duffle bag]

Arguably, the validity of the above inference relies on the identification of the sets of Berta-packed bags and of black leather duffle bags at Anna's remembered mental scene (rather than at the originally perceived visual scene). In particular, in cases where Anna's memory does not (or no longer) include the above identity information,[16] the inference does not seem valid. The common identification of evaluation situations with partial possible worlds (see e.g. Percus, 2000; Kratzer, 2002) excludes such cases (see Sect. 4).

3.3. **Interim summary.** I close this section with a summary of the lexical and selectional properties of *how$_E$*-, *how$_F$*-, and *that*-clause complements that are most relevant for the formal semantic modelling of non-manner *how*-clause reports. These include (i) the identity/ontological status of the object that serves as the denotation of the complement, (ii) the possibility (resp. non-possibility) of paraphrasing the complement by a *that*-clause, (iii) the (in-)directness (in the sense of Barwise, 1981) of these reports, and (iv) the epistemic positiveness (resp. neutrality) of these reports. In particular, reports with eventive *how*-clause DPs are direct and epistemically positive, but do not allow their complement's truth-preserving paraphrase by a *that*-clause (see the first column in Table 1). They differ from reports with factive *how*-complements in their directness. *That*-clause reports share the non-directness and epistemic positiveness of reports with factive *how*-clauses. They differ from the latter in allowing paraphrase by a *that*-clause.

Since referential transparency (see Sect. 3.2) and the denotation of an event/process (see Sect. 2.2) show the same pattern as direct witnessing, I do not list them as separate

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[16]This is due to the fact that – in contrast to event-perception – event-memory is often partial [= informationally incomplete]: over the course of time, we lose (or 'forget') information about the perceived visual event/scene that is the source of the memory (see Liefke and Werning, 2018).

characterizing properties in Table 1.

		'HOW'$_\text{E}$-CLAUSE	'HOW'$_\text{F}$-CLAUSE	'THAT'-CLAUSE
(i)	DENOTATION	event	fact	proposition
(ii)	'THAT'-PARAPHRASE?	✗	✗	✓
(iii)	DIRECT WITNESSING?	✓	✗	✗
(iv)	EPISTEM. POSITIVE?	✓	✓	✓

TABLE 1. Semantic properties of 'how$_\text{E}$'-, 'how$_\text{F}$'-, and 'that'-clause complements.

I will show below that the different properties of how_E-, how_F-, and *that*-complements are all associated with specific combinations of semantic elements that give rise to the entailments (resp. non-entailments) in (58) and (59).

4. COMPOSITIONAL SEMANTICS

4.1. **The semantics of factive and eventive 'how'-clause DPs.** I have argued above that factive and eventive *how*-complements have the same syntactic structure (see Sect. 2.4). As a result, I assume that the difference between (58-A) and (58-B) is due to the semantic difference between factive and eventive occurrences of *how*. In particular, I assume that eventive *how* is interpreted as interrogative manner *how* (i.e. as how_M; in (70), where 'M(anner)' denotes a property of manners, modelled as similarity classes of events;[17] cf. Umbach et al., submitted; Umbach and Gust, 2014). Specifically, on my proposed account, eventive uses of *how* are interpreted as a function from propositions p (viz. the set of situations/events that serves as the denotation of the C′) to type-$\langle\langle s, t\rangle, t\rangle$ questions (i.e. to a set of proper subsets of p whose members represent a particular manner):[18]

(70) $\llbracket\text{how}_\text{E}\rrbracket \equiv \llbracket\text{how}_\text{M}\rrbracket \equiv \llbracket\text{wie}_\text{E}\rrbracket \equiv \llbracket\text{wie}_\text{M}\rrbracket = \lambda p\lambda q\,[(\forall j.\, q_j \to p_j) \wedge (\exists \text{M}.\, q = \text{M})]$

In contrast, how_F is interpreted as a factive complementizer (i.e. as Kratzer's (2006) $that_\text{F}$; in (71), where $\Pi := \lambda q\lambda j\,[q_j \wedge (\forall k.\, (q_k \wedge k \leq j) \to k = j)]$ is a function[19] that sends propositions to the set of their minimal exemplifiers [= facts]; see Kratzer, 2002). In virtue of this effect, I will hereafter call Π the *informational minimalizer*. In (71), i denotes the default point of evaluation. The underlined part in (71) captures the factivity presupposition on the complement of factive uses of *how*. It indicates the restriction of p to propositions that satisfy this restriction. To capture the non-availability of factive *how* in German, I assume that German *wie* does not have an interpretation of the form of (71).

(71) $\llbracket\text{how}_\text{F}\rrbracket \equiv \llbracket\text{that}_\text{F}\rrbracket = \lambda p:\underline{p_i}.\,[\Pi(p)]$
$\equiv \lambda p:\underline{p_i}.\,[\lambda j.\, p_j \wedge (\forall k.\, (p_k \wedge k \leq j) \to k = j)]$

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[17]As a result, it holds that $\text{M} := \lambda p(\exists j)(\exists\mathcal{F})[p = (\lambda k.\,\text{SIM}(k, j, \mathcal{F}))]$ (cf. Umbach et al., submitted), where $\mathcal{F}$ is a contextual parameter that includes the relevant dimensions of comparison and SIM is a similarity relation that compares same-type entities (here: situations/events) w.r.t. a given parameter.

[18]In what follows, I use a partial variant of Gallin's type logic TY_2 with basic types e (for individuals), s (for indices [= situations/events]), and t (for truth-combinations). I adopt Montague's notation for function types: $\langle\alpha, \beta\rangle$ is the type for (partial) functions from objects of type α to objects of type β. Below, I follow the convention that a function's simultaneous application to a sequence of arguments indicates successive application in the reverse order of the arguments ('Currying'). Index arguments will be written in subscript. I adopt the following typing convention for variables: x, y, z, u and i, j, j', k are individual resp. situation variables. e and e' are variables over events. p, p', q and T are variables over propositions (type $\langle s, t\rangle$) resp. over questions (type $\langle\langle s, t\rangle, t\rangle$). P, P', Q and $\mathcal{P}, \mathcal{Q}$ are variables over type-$\langle s, \langle e, t\rangle\rangle$ properties resp. over functions from events to propositions (type $\langle v, \langle s, t\rangle\rangle$).

[19]In this function, $\leq$ is a partial ordering on the set of situations that is induced by the informational incompleteness of situations. Formulas of the form '$k \leq j$' thus assert that the situation j contains all information of the form 'a Fs in w at t' that is contained in k, where a and F are an individual and a property or activity, respectively (see Liefke and Werning, 2018, pp. 658–659).

The syntax of our example reports (58-A) and (58-B) is given in (72) (see Fig. 2):

(72) $[_{\text{DP}}\emptyset\,[_{\text{CP}}\text{how}_{\text{M}}\,[_{\text{C}'}\emptyset\,[_{\text{TP}}\text{PAST}\,[\text{PROG}\,[\text{Berta pack her bag}]]]]]]$

Given the above, the (eventive) *how*-complement in A then denotes an event-dependent <u>manner</u> (!) (viz. the particular way in which Berta was packing her bag in the relevant event). The compositional interpretation of the *how*-complement of (58-A) is given in Figure 3:

$\llbracket\emptyset\,[\text{how}_{\text{E}}\,[\emptyset\,[\text{PAST}\,[\text{PROG}\,[\text{Berta pack}]]]]]\rrbracket$
$\lambda e\,[(f_e(\lambda p\,[(\forall j.\,p_j \to (t_j \prec t_i \land (\exists k.\,j \preccurlyeq k \land pack_k(berta)))) \land (\exists \text{M}.\,p = \text{M})]))]$

$\llbracket\emptyset\rrbracket$
$\lambda T\lambda e$
$[f_e(T)]$

$\llbracket\text{how}_{\text{E}}\,[\emptyset\,[\text{PAST}\,[\text{PROG}\,[\text{Berta pack}]]]]\rrbracket$
$\lambda p\,[(\forall j.\,p_j \to (t_j \prec t_i \land (\exists k.\,l \preccurlyeq k \land pack_k(berta)))) \land (\exists \text{M}.\,p = \text{M})]$

$\llbracket\text{how}_{\text{E}}\rrbracket$
$\lambda q\lambda p\,[(\forall j.\,p_j \to q_j)$
$\land\,(\exists \text{M}.\,p = \text{M})]$

$\llbracket\emptyset\,[\text{PAST}\,[\text{PROG}\,[\text{Berta pack}]]]\rrbracket$
$\lambda j\,[t_j \prec t_i \land (\exists k.\,j \preccurlyeq k \land pack_k(berta))]$

$\llbracket\emptyset\rrbracket$
$\lambda p:\,(\forall j.\,p_j \to (\exists k.$
$\underline{j \preccurlyeq k \land p_k)).\,p}$

$\llbracket\text{PAST}\,[\text{PROG}\,[\text{Berta pack}]]\rrbracket$
$\lambda j\,[t_j \prec t_i \land (\exists k.\,j \preccurlyeq k \land pack_k(berta))]$

$\llbracket\text{PAST}\rrbracket$
$\lambda p\lambda j\,[t_j \prec t_i \land p_{j'}]$

$\llbracket\text{PROG}\,[\text{Berta pack}]\rrbracket$
$\lambda j\,(\exists k)[j \preccurlyeq k \land pack_k(berta)]$

$\llbracket\text{PROG}\rrbracket$
$\lambda p\lambda j\,\underbrace{(\exists k)[j \preccurlyeq k \land p_k]}$
a natural continuation of j

$\llbracket\text{Berta pack}\rrbracket$
$\lambda j\,[pack_j(berta)]$
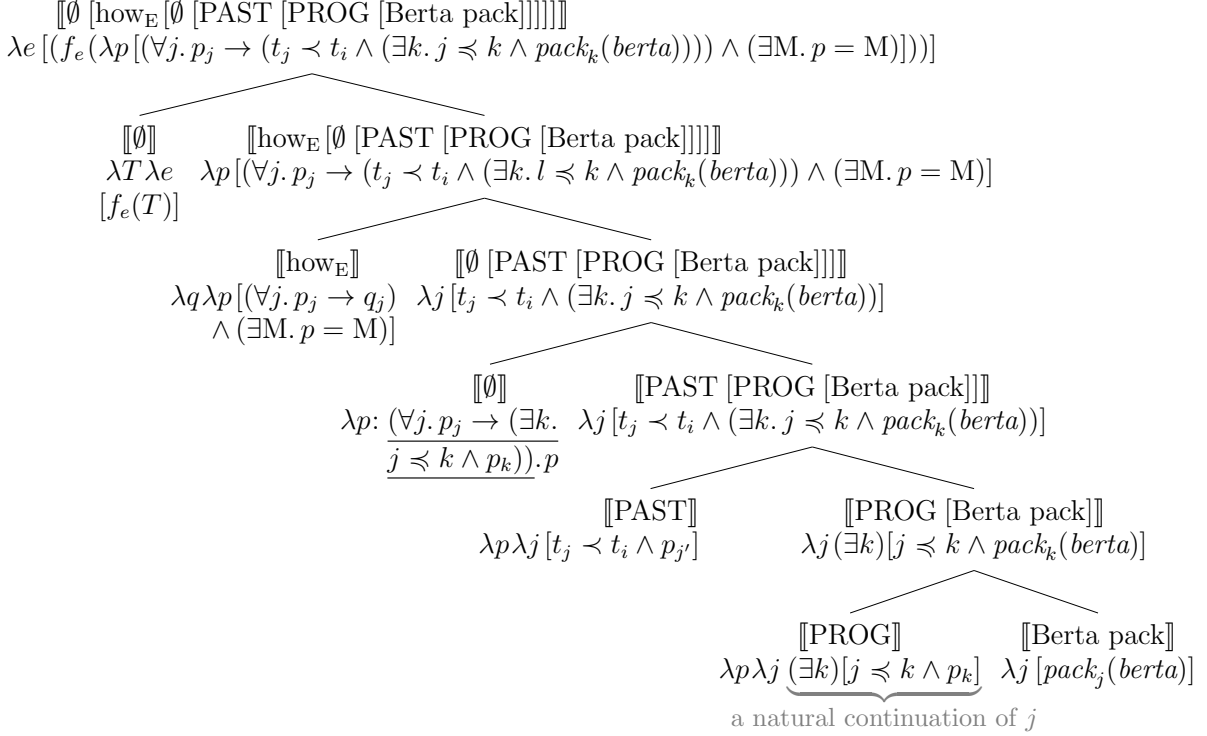
FIGURE 3. The interpretation of the *how*$_{\text{E}}$-clause DP in (58-A).

In Figure 3, the TP '[PAST [PROG [Berta pack]]]' denotes a proposition [= a set of events j]. The latter are the events that temporally precede the evaluation time t_i (i.e. $t_j \prec t_i$) and that are each part of a larger event, k, that is a natural continuation of j (i.e. $\exists k.\,j \preccurlyeq k \land pack_k(berta)$). The events' temporal precedence to t_i captures the past tense, PAST, of the verb *pack* in (58-A). The existence of a natural continuation of j, k, captures the progressive aspect of this verb, PROG (cf. Landman, 1992; Bonomi, 1997). The silent complemetizer $\emptyset$ captures the verb's progressive aspect in cases where the verb is not marked for aspect (e.g. in German; see Sect. 2.2). Since our example sentence A contains a progressive-marked verb, this complementizer has no semantic effect in the interpretation of A.

I have already mentioned above that eventive uses of *how* receive the same interpretation as manner uses of *how* (see (70)). From an efficiency/learnability point of view, this is desirable since it avoids assuming different lexical entries for eventive and manner *how* (see Sect. 6). However, the interpretation of eventive *how* as manner *how* results in a mismatch between the type of the *how*$_{\text{E}}$-CP (i.e. Roelofsen et al.'s type for questions, $\langle\langle s, t\rangle, t\rangle$; see the term starting with '$\lambda p\,[(\forall j.\ldots)\ldots]$' in Fig. 3) and the semantic type of the *remember*-complement (i.e. propositions/propositionally coded situations, $\langle s, t\rangle$; see Sect. 4.2). The semantics of the silent determiner $\emptyset$ remedies this type-mismatch by shifting the denotation of the eventive *how*-clause (type $\langle\langle s, t\rangle, t\rangle$) to the type for propositions (type $\langle s, t\rangle$). This shift is effected by a choice function, f, that chooses a member (i.e. a

particular manner, represented by a similarity class of events) from the set of manners that serves as the (question-)denotation of the eventive *how*-clause.[20]

To ensure that the function f chooses the 'right' manner (viz. the manner of which a more specific sub-manner represents the particular event that Anna remembers in i; see Sect. 4.2), the choice of manner proceeds in dependence of the external attitude event e (here: Anna's remembering event in i). The compositional interpretation of reports with eventive *how*-complements is ensured by letting the semantics of the silent determiner abstract over this event. As a result, the eventive *how*-clause DP in Figure 3 denotes a function from events to (the characteristic function of) the set of past events in which Berta was packing her bag in some particular manner.

In contrast to eventive *how*-clause DPs, factive *how*-clause DPs denote a constant function from events to a <u>set of facts</u> (including a true fact in i) that support the truth of the proposition that Berta was packing her bag. For the complement in (58-B), this set is obtained as follows (see Figure 4):

$[\![\emptyset \, [\text{how}_\text{F} \, [\emptyset \, [\text{PAST} \, [\text{PROG} \, [\text{Berta pack}]]]]]]\!]$
$\lambda e \, [\Pi(\lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta))])]$

$\quad [\![\emptyset]\!] \qquad [\![\text{how}_\text{F} \, [\emptyset \, [\text{PAST} \, [\text{PROG} \, [\text{Berta pack}]]]]]\!]$
$\quad \lambda p \lambda e \, [p] \quad \Pi(\lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta))])$

$\qquad\qquad [\![\text{how}_\text{F}]\!] \qquad\qquad [\![\emptyset \, [\text{PAST} \, [\text{PROG} \, [\text{Berta pack}]]]]\!]$
$\qquad\qquad \lambda p: \underline{p_i}. \, [\Pi(p)] \quad \lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta))]$

$\qquad\qquad\qquad\qquad [\![\emptyset]\!] \qquad\qquad [\![\text{PAST} \, [\text{PROG} \, [\text{Berta pack}]]]\!]$
$\qquad\qquad\qquad\qquad \lambda p \, [p] \qquad \lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta))]$

$\qquad\qquad\qquad\qquad\qquad\qquad [\![\text{PAST}]\!] \qquad\qquad [\![\text{PROG} \, [\text{Berta pack}]]\!]$
$\qquad\qquad\qquad\qquad\qquad\qquad \lambda p \lambda j \, [t_j \prec t_i \wedge p_{j'}] \quad \lambda j (\exists k)[j \preccurlyeq k \wedge pack_k(berta)]$

$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad [\![\text{PROG}]\!] \qquad\qquad [\![\text{Berta pack}]\!]$
$\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad \lambda p \lambda j (\exists k)[j \preccurlyeq k \wedge p_k] \quad \lambda j \, [pack_j(berta)]$

FIGURE 4. The interpretation of the *how*$_\text{F}$-clause DP in (58-B).

The above differs from the compositional semantics of the *how*-clause DP in (58-A) in dropping the progressive interpretation of the silent complementizer. This is required to capture the ability of factive *how* to license stative verbs (see Sect. 4.4). Since the type of the *how*$_\text{F}$-CP (i.e. $\langle s, t \rangle$; see the term starting with '$\Pi(\lambda j. \ldots)$' in Fig. 4) matches the required argument-type of *remember*, (58-B) further waives the type-shifter interpretation of the silent determiner. The event-dependence of the factive *how*-complement is chosen for parallelism with the semantics of eventive *how*-complements. This parallelism allows us to embed both kinds of non-manner *how*-clause DPs under the same lexical entry for *remember*.

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[20]Since this denotation is likely not a singleton (i.e. a set that only contains <u>one</u> manner), the desired type-shift cannot be achieved through the iota operator (as is done for free relatives in Jacobson, 1995). Similar observations hold for the use of Link's (1983) sigma operator (see a.o. Caponigro, 2003; Hinterwimmer, 2008) and Dayal's (1996) answerhood operator (see Chierchia and Caponigro, 2013), which would destroy the manner-nature of the DP.

This completes my discussion of the semantics of eventive and factive *how*-clause DPs. To model the entailment relations between memory reports with eventive and factive *how*-complements (see (58); in Sect. 4.3), I first need to specify the compositional semantics of *remember*. This is achieved in the next subsection.

4.2. **The semantics of 'remember'.** I have argued in Section 2.3 that reports with eventive *how*-complements denote relations to a specific, personally experienced event. This event depends on the particular activity that is described by the matrix attitude verb (in the case of (58-A/B): remembering), on the attitudinal agent (i.e. Anna), and on the point in time at which the agent holds the attitude (i.e. t_i). This dependence is supported by the following observation: if Anna has witnessed Berta's packing event from a different visual perspective than Ralph (assume that Anna was in the room while Ralph just caught a glance from the kitchen) – and/or if Anna has better event memory than Ralph –, the (informationally partial) event that serves as the object of Anna's remembering will be different from the event that serves as the object of Ralph's remembering. Similar observations even hold for Anna's remembering of the same originally perceived event at different times.

In the semantics of *remember* (and of all other verbs for event-directed attitudes; see (30)), I capture this dependence through a subset selection function, C (see von Fintel, 1999; cf. Kratzer, 1998). This function chooses a subset from a given set of situations/events $\lambda j\,[\ldots]$ in dependence on a parameter, e, for the described remembering event. This subset codes the situation or event that serves as the object of the particular remembering event. It contains as its members isomorphic [= qualitatively identical] situations (see Kratzer, 2002, p. 667; cf. Fine, 1977, p. 136). The latter are situations in which exactly the same propositions are true (resp. false).

Note that the propositional coding of the objects of experiential attitudes also allows us to model attitudes to situations that are not located (or *anchored*) in a particular space or time. These attitudes include attitudes (e.g. imagining) that are denoted by fiction verbs (see (30)): since one can imagine an event (e.g. a unicorn prancing in the sun) without committing to a particular point in time at which this event is located, fiction verbs resist an interpretation as relations to (spatio-temporally anchored) events. The possibility of representing such events by <u>sets of</u> isomorphic events with different spatio-temporal anchors compensates for this shortcoming. Following Quine (1946), anchored events (e.g. the specific event – witnessed by Anna – in which Berta was packing her bag) can then be represented by their singleton sets.

My proposed semantics for event-selecting occurrences of *remember* is given in (73) (see Liefke, 2020 for a detailed motivation of this semantics). Since this semantics also yields an intuitively correct interpretation of memory reports with factive *how*-complements (e.g. (58-B)), I also use this semantics for occurrences of *remember* that combine with a factive *how*-clause DP. The fact that how_{F}-reports fail the diagnostic properties for how_{E}-reports (see Sect. 2.3) can then still be explained through the particular interaction of the semantics for how_{F} and for eventive *remember* (see Sect. 4.3, esp. (76)).

In what follows, *remember* is a non-logical constant of type $\langle s, \langle v, \langle\langle s, t\rangle, \langle e, t\rangle\rangle\rangle\rangle$, where v is the designated type for events. The latter is a subtype of the more general type for situations, s.

(73) $[\![\mathrm{remember}_{(\mathrm{EXP})}]\!]^i \;=\; \lambda \mathcal{P}\lambda z\,(\exists e)[\mathit{remember}_i(e, z, C_e(\mathcal{P}(e)))]$

The third argument of *remember* in (73), i.e. $C_e(\mathcal{P}(e))$, denotes a set of situations that codes the real-world situation/event that the attitudinal agent z remembers in the remembering event e at the evaluation situation i. In (73), the factivity of *remember* (here: the fact that $C_e(\mathcal{P}(e))$ is located in the world, w_i, that is associated with the evaluation

situation i) is ensured by the fact that C is dependent on a <u>remembering</u> situation. In virtue of this dependence, it holds for all remembering events e and propositions p that $C_e(p)$ is true at w_i.

4.3. **Entailments between eventive and factive 'how'-clause reports.** The semantics for *remember* from (73) enables the compositional interpretation of (58-A) as follows:

(74) $[\![(58\text{-A})]\!]^i \equiv [\![\text{Anna remembers [how}_{\text{E}} \text{ Berta was packing her bag]}]\!]^i$

$\equiv [\![\text{remember}_{\text{EXP}}]\!]^i([\![\text{Anna}]\!], [\![\text{how}_{\text{E}} \text{ Berta was packing her bag}]\!])$

$= \lambda\mathcal{P}\lambda z\,(\exists e)[remember_i(e, z, C_e(\mathcal{P}(e)))](anna,$
$\quad\quad \lambda e'\,[f_{e'}(\lambda q\,[(\forall j.\,q_j \to (t_j \prec t_i \wedge (\exists k.\,j \preccurlyeq k \wedge pack_k(berta)))) \wedge (\exists \text{M}.\,q = \text{M})])])$

$\equiv (\exists e)[remember_i(e, anna, C_e(f_e(\lambda q\,[(\forall j.\,q_j \to (t_j \prec t_i \wedge$
$\quad\quad\quad\quad\quad\quad (\exists k.\,j \preccurlyeq k \wedge pack_k(berta)))) \wedge (\exists \text{M}.\,q = \text{M})])))]$

$\equiv (\exists e)[remember_i(e, anna, \underbrace{C_e(\lambda j.\,t_j \prec t_i \wedge (\exists k.\,j \preccurlyeq k \wedge pack_k(berta)))}_{\text{(a representation of) an \textbf{event} in } w_i})]$

According to the above, (58-A) asserts the existence of a remembering event in i with agent Anna whose theme is a past event in the evaluation world in which Berta is packing her bag.[21] Notably, the event's location in w_i depends on identity of the matrix attitude verb: when it occurs in the complement of a fiction verb, e.g. *imagine*, the *how*-clause DP from (58-A) can denote a <u>counterfactual</u> event that is <u>not</u> located in w_i. The w_i-anchoredness of particular remembering event in (74) is thus a feature of *remember*, not of the eventive *how*-clause DP in its complement.

The equivalence of the last two lines in (74) is due to the assumption (see (75)) that the subset selection function C refines the effect of the manner choice function f:

(75) $(\forall\mathcal{P})(\forall e)[C_e(\mathcal{P}(e)) \subseteq f_e(\mathcal{P})]$

In virtue of this assumption, the result of applying C_e to an f_e-selected manner (where e is a fixed event) is equivalent to the result of applying C to the propositional content (in (74): $\lambda j.\,t_j \prec t_i \wedge (\exists k.\,j \preccurlyeq k \wedge pack_k(berta))$) of an event that proceeds in this manner. Analogous assumptions hold for all other experiential and report verbs.

The compositional interpretation of (58-B) is given below:

(76) $[\![(58\text{-B})]\!]^i \equiv [\![\text{Anna remembers [how}_{\text{F}} \text{ Berta was packing her bag]}]\!]^i$

$\equiv [\![\text{remember}_{\text{EXP}}]\!]^i([\![\text{Anna}]\!], [\![\text{how}_{\text{F}} \text{ Berta was packing her bag}]\!])$

$= \lambda\mathcal{P}\lambda z\,(\exists e)[remember_i(e, z, C_e(\mathcal{P}(e)))](anna,$
$\quad\quad\quad\quad \lambda e'\,[\Pi\,(\lambda j.\,t_j \prec t_i \wedge (\exists k.\,j \preccurlyeq k \wedge pack_k(berta)))])$

$\equiv (\exists e)[remember_i(e, anna, \underbrace{C_e(\Pi\,(\lambda j.\,t_j \prec t_i \wedge (\exists k.\,j \preccurlyeq k \wedge pack_k(berta))))}_{\text{(a representation of) a \textbf{fact} in } w_i})]$

Note that (76) applies the subset selection function C_e to the informational minimalizer Π. The result of this application (underbraced in (76)) denotes an actual fact [= an informationally minimal event that is located in w_i].

This completes the presentation of my semantics for reports with embedded eventive and factive *how*-clause DPs. Given the common assumption that the subset selection function C preserves the semantic inclusion relation between its input arguments (see (77b)) and that *remember* is upward monotonic in its complement position (see (77c)), this semantics straightforwardly captures the entailment from (58-A) to (58-B):

---

[21]To keep the logical translations of English/German sentences as short as possible, I refrain from adopting full event-semantic notation (along the lines of Champollion, 2015).

(77)   a. $[\![A]\!]^i \equiv [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{E}} \text{ Berta was packing her bag}]]\!]^i$
           $= (\exists e)[remember_i(e, anna, C_e(\lambda j. t_j \prec t_i \wedge (\exists k. j \preccurlyeq k \wedge pack_k(berta))))]$

       b. $(\forall p)(\forall q)[p \subseteq q \rightarrow (\forall e. C_e(p) \subseteq C_e(q))]$

       c. $\underline{(\forall e)(\forall z)(\forall p)[remember_i(e, z, p) \rightarrow (\forall q. (\forall j. p_j \rightarrow q_j) \rightarrow remember_i(e, z, q))]}$

  $\Rightarrow$ d. $[\![B]\!]^i = (\exists e)[remember_i(e, \underline{anna}, C_e(\Pi(\lambda j. t_j \prec t_i \wedge (\exists k. j \preccurlyeq k \wedge pack_k(berta)))))]$
           $= [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{F}} \text{ Berta was packing her bag}]]\!]^i$

The invalidity of the entailment in the other direction, i.e. (58-B) $\not\Rightarrow$ (58-A), is due to the observation that the proposition that is denoted by the TP in A is not semantically included in the set of informationally minimal situations that is denoted by the how_{F}-clause in B. The resulting non-inclusion of Anna's remembered (likely informationally rich) event in A in Anna's remembered (informationally depleted) fact in B (see (78b)) then captures the non-validity of the entailment from (58-B) to (58-A):

(78)   a. $[\![B]\!]^i \equiv [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{F}} \text{ Berta was packing her bag}]]\!]^i$
           $= (\exists e)[remember_i(e, anna, C_e(\Pi(\lambda j. t_j \prec t_i \wedge (\exists k. j \preccurlyeq k \wedge pack_k(berta)))))]$

       b. $\underline{\textit{But:} \quad (\lambda j. t_j \prec t_i \wedge \dots pack_k(berta)) \quad \not\subseteq \quad \Pi(\lambda j\,[t_j \prec t_i \wedge \dots pack_k(berta)])}$

  $\not\Rightarrow$ c. $[\![A]\!]^i = (\exists e)[remember_i(e, anna, C_e(\lambda j. t_j \prec t_i \wedge (\exists k. j \preccurlyeq k \wedge pack_k(berta))))]$
           $= [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{E}} \text{ Berta was packing her bag}]]\!]^i$

With our semantics for eventive and factive *how*-reports in place, I next turn to the relation between factive *how*- and *that*-clause reports (see the entailment in (59)).

4.4. **Entailments between factive 'how'- and 'that'-clause reports.** I have argued in Section 4.4 (see (20)) that factive *how*-complements of presuppositional and 'say'-verbs are not semantically equivalent to their corresponding *that*-clause complements. To account for this non-equivalence (esp. for the non-validity of the entailment from (59-B) to (59-C)), I assume that *remember* (in English and in German) is polysemous between an experiential reading, *remember*$_{\text{EXP}}$, on which it denotes a relation to a propositionally coded (minimal or non-minimal) <u>event</u> (see (73)), and a propositional reading, *remember*$_{\text{PRP}}$, on which it denotes a relation to a classical <u>proposition</u> (see (79)). The polysemy[22] of *remember* is supported by Tulving's (1972) distinction between episodic [$\approx$ event-] and semantic [$\approx$ propositional] memory (see also Stephenson, 2010) and by much subsequent work in psychology and cognitive science (see e.g. Cheng et al., 2016). The semantics for propositional occurrences of *remember* is given below:

(79) $[\![\text{remember}_{\text{PRP}}]\!]^i = \lambda p \lambda z (\exists e)[remember_i(e, z, p)]$
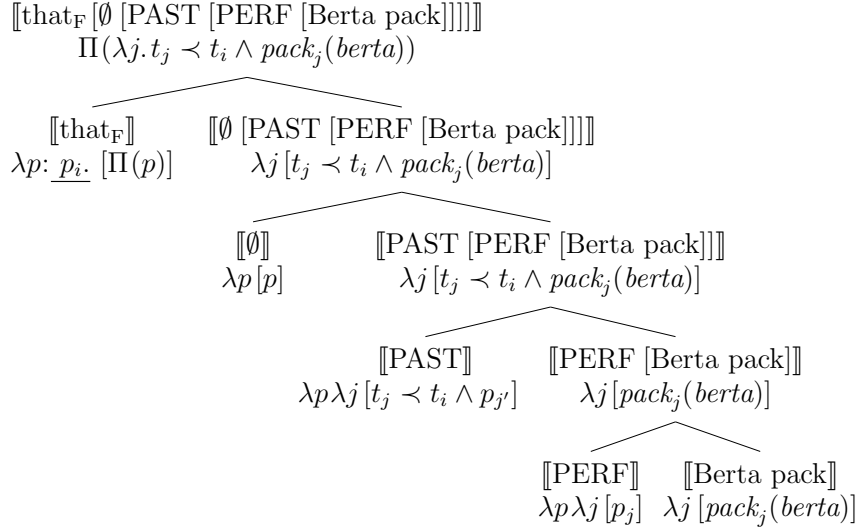
Note that, in the designation of the semantic contribution of *remember*$_{\text{PROP}}$, (79) uses the same non-logical constant, *remember*, as (73).[23] This move enables the straightforward obtaining of semantic inclusion relations between factive and propositional memory reports, as I will show below.

The interpretation of factively embedded *that* as the factive complementizer *that*$_{\text{F}}$ (see (71); copied below in (80)) then enables the compositional interpretation of (59-C) (in (81)). This interpretation uses the semantics of the *that*-clause in C from Figure 5:

(80) $[\![\text{that}_{\text{F}}]\!] \equiv [\![\text{how}_{\text{F}}]\!] = \lambda p: \underline{p_i}. \, [\Pi(p)]$

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[22]Since the different entries for *remember* have a common semantic core, *remember* is not ambiguous.

[23]This differs from Barwise and Perry (1983) and Stephenson (2010), who use different translations (with different-type arguments) of gerund- and *that*-clause experiential attitude reports. As a result, they cannot easily capture relations between factive and propositional memory reports (cf. Liefke, accepted, where this is shown for experiential and propositional *see*).

$$\llbracket \text{that}_F\,[\emptyset\,[\text{PAST}\,[\text{PERF}\,[\text{Berta pack}]]]]\rrbracket$$
$$\Pi(\lambda j.t_j \prec t_i \wedge pack_j(berta))$$

$$\llbracket \text{that}_F\rrbracket \qquad \llbracket \emptyset\,[\text{PAST}\,[\text{PERF}\,[\text{Berta pack}]]]\rrbracket$$
$$\lambda p\colon \underline{p_i}.\,[\Pi(p)] \qquad \lambda j\,[t_j \prec t_i \wedge pack_j(berta)]$$

$$\llbracket \emptyset\rrbracket \qquad \llbracket \text{PAST}\,[\text{PERF}\,[\text{Berta pack}]]\rrbracket$$
$$\lambda p\,[p] \qquad \lambda j\,[t_j \prec t_i \wedge pack_j(berta)]$$

$$\llbracket \text{PAST}\rrbracket \qquad \llbracket \text{PERF}\,[\text{Berta pack}]\rrbracket$$
$$\lambda p\lambda j\,[t_j \prec t_i \wedge p_{j'}] \qquad \lambda j\,[pack_j(berta)]$$

$$\llbracket \text{PERF}\rrbracket \quad \llbracket \text{Berta pack}\rrbracket$$
$$\lambda p\lambda j\,[p_j] \quad \lambda j\,[pack_j(berta)]$$

FIGURE 5. The interpretation of the *that*-clause in (59-C).

(81) $\llbracket C\rrbracket^i \equiv \llbracket \text{Anna remembers}_{\text{PRP}}\,[\text{that}_F\text{ Berta packed her bag}]\rrbracket^i$
      $\equiv \llbracket \text{remember}_{\text{PRP}}\rrbracket^i\big(\llbracket \text{Anna}\rrbracket, \llbracket \text{that}_F\text{ Berta packed her bag}\rrbracket\big)$
      $= \lambda p\lambda z(\exists e)[remember_i(e,z,p)]\big(anna, \Pi(\lambda j.t_j \prec t_i \wedge pack_j(berta))\big)$
      $\equiv (\exists e)[remember_i(e, anna, \underbrace{\Pi(\lambda j.t_j \prec t_i \wedge pack_j(berta))})]$

                  a **proposition** (represented by a set of different-world facts)

Note that, in contrast to its eventive and factive *how*-clause DP counterparts, the type-$\langle s,t\rangle$ denotation of the *that*-clause in (59-C) is not anchored to a specific world (in the sense that all situations/events in this denotation are parts of the same world). In particular, this dentation is neither an event (see (74)) nor a fact (see (76)) in the evaluation world w_i. Rather, it has as its members facts that are located in different worlds.

My earlier assumption that *how*$_F$ makes the same semantic contribution as *that*$_F$ (see (80)) is in line with Huddleston and Pullum (2002) (*pace* Legate, 2010). However, it agrees with Legate (2010) in that complements that are headed by these the words belong to a different syntactic category (viz. DP [*how*$_F$-complements] *vis-à-vis* CP [*that*$_F$-complements]) and are interpreted as different kinds of objects (viz. facts [denotations of *how*$_F$-complements] *vis-à-vis* propositions [denotations of *that*$_F$-complements]). The different interpretation of attitude reports with *how*$_F$- and *that*$_F$-complements gives rise to the observed differences in entailment behavior.

The interpretation of the non-progressive version of (58-B), i.e. (59-B), is given below:

(82) $\llbracket(59\text{-B})\rrbracket^i \equiv \llbracket \text{Anna remembers}_{\text{EXP}}\,[\text{how}_F\text{ Berta packed her bag}]\rrbracket^i$
      $= (\exists e)[remember_i(e, anna, \underbrace{C_e(\Pi(\lambda j.t_j \prec t_i \wedge pack_k(berta)))})]$

                  (a representation of) a **fact** in w_i

A comparison of (82) and (81) (see (83)) shows that the semantic complement of the occurrence of *remember* in (59-B) is a proper subset of the semantic complement of *remember* in (59-C). This is due to the presence of the function C in (82). Since this function selects a subset of the set, $\Pi(\lambda j.t_j \prec t_i \wedge pack_k(berta))$, that serves as the denotation of the *that*-clause complement in (59-C), the entailment from (59-C) to (59-B) is not valid. Because of this inclusion relation, the entailment in the other direction is valid, as expected.

(83)   a. $\llbracket(59\text{-C})\rrbracket^i \equiv \llbracket \text{Anna remembers}_{\text{PRP}}\,[\text{that}_F\text{ Berta packed her bag}]\rrbracket^i$
           $= (\exists e)[remember_i(e, anna, \Pi(\lambda j.t_j \prec t_i \wedge pack_j(berta)))]$

   $\not\Rightarrow$ b. $(\exists e)[remember_i(e, anna, C_e(\Pi(\lambda j.t_j \prec t_i \wedge pack_k(berta))))]$

$= [\![(59\text{-}B)]\!]^i \equiv [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{F}} \, \text{Berta packed her bag}]]\!]^i$

The non-entailment from (59-C) to (59-B) – and the attendant non-entailment from (59-C) to (59-A) (given the non-entailment from (59-B) to (59-A)) – supports Umbach et al.'s intuition that "[German *dass*-complements] are close in meaning but not equivalent to eventive readings of *wie*-complements" (p. 7).

I close this section with a remark on the entailment relation between (58-A) and (59-B): I have argued in Section 2.2 that – in contrast to their eventive counterparts – factive *how*-complements license stative predicates. In this case, the eventive *how*-report does not entail its stative counterpart due to the non-inclusion of $\lambda j \, [t_j \prec t_i \wedge pack_k(berta)]$ (see (84b)) in $\lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta))]$ (see (84a)):

(84) a. $[\![\text{A}]\!]^i \equiv [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{E}} \, \text{Berta was packing her bag}]]\!]^i$
       $\equiv [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{E}} \, \text{Berta packed her bag}]]\!]^i$ (cf. $[\![_{\text{C}}\emptyset]\!]$)
       $= (\exists e)[remember_i(e, anna, C_e(\lambda j. \, t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta))))]$

  $\not\Rightarrow$ b. $[\![(59\text{-}B)]\!]^i = (\exists e)[remember_i(e, anna, C_e(\Pi\,(\lambda j. \, t_j \prec t_i \wedge pack_k(berta))))]$
       $= [\![\text{Anna remembers}_{\text{EXP}} \, [\text{how}_{\text{F}} \, \text{Berta packed her bag}]]\!]^i$

This completes my comparison of the semantics of English *how*$_{\text{E}}$-, *how*$_{\text{F}}$-, and *that*-clause complements. To investigate the relation between manner and non-manner *how*-clauses, I close this section by presenting the compositional semantics of attitude reports with manner *how*-complements.

5. Relating Eventive Non-Manner 'how' with Manner 'how'

I have mentioned in Section 2.4 that Umbach et al. (submitted) analyze the manner-reading of (1a) as having the syntactic structure in (85) (see Sect. 2.4, Fig. 1). In this structure, manner *how* is base-generated within the VP. From this position, it is moves to the position of specifier of the CP by leaving a trace (see Caponigro, 2003, 2004; cf. Frey, 2003 for German).
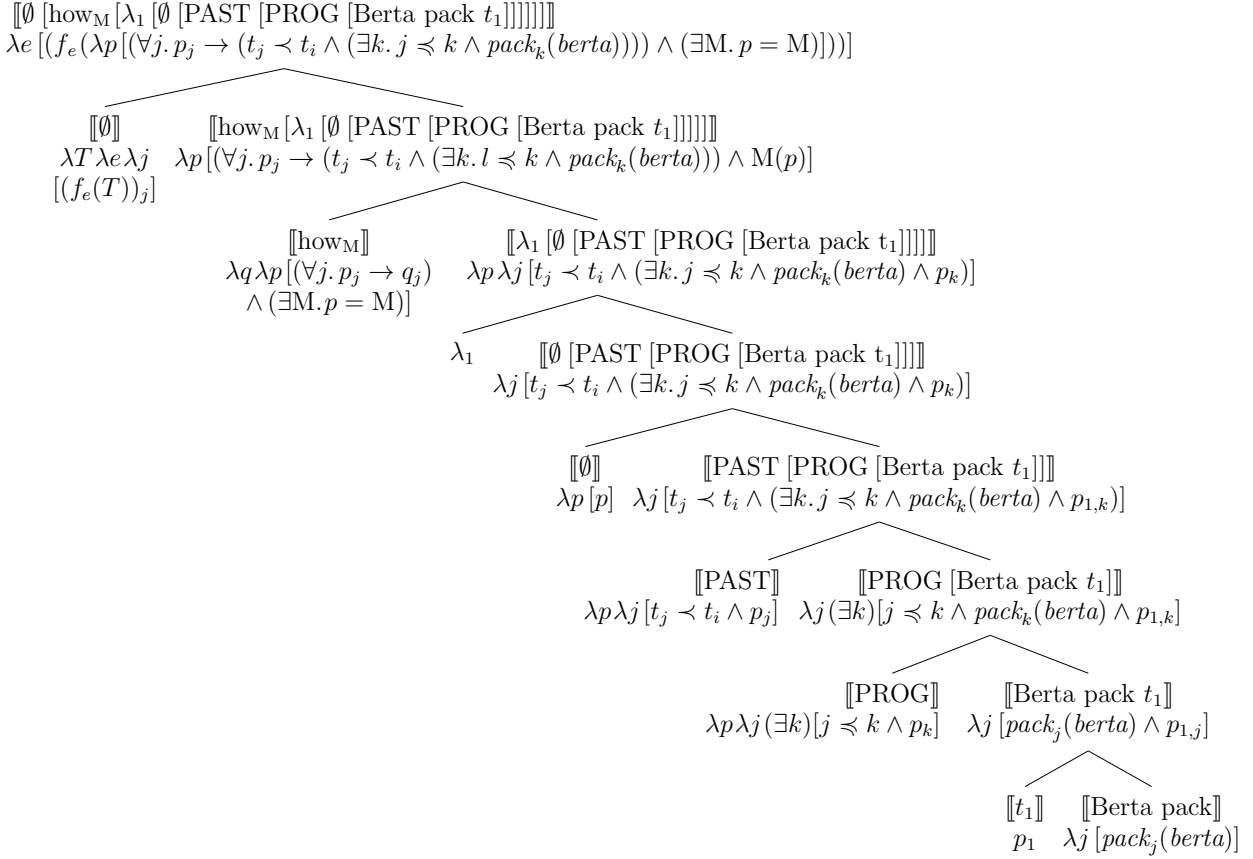
(85) $[_{\text{DP}}\emptyset \, [_{\text{CP}}\text{how}_{\text{M}} \, [\lambda_1 \, [_{\text{C}'}\emptyset \, [_{\text{TP}}\text{PAST} \, [\text{PROG} \, [\text{Berta pack} \, t_1]]]]]]]$

Assuming the semantics for *how*$_{\text{M}}$ from (70), the manner *how*-reading of (1a) then has the compositional semantics in Figure 6. In this figure, the interpretation of the TP, i.e. $\lambda j \, [pack_j(berta)]$, combines with the interpretation of the trace, t_1, of *how*$_{\text{E}}$, i.e. p_1 (where p_1 is a free propositional variable), through Heim and Kratzer's rule of Predicate Modification (see Heim and Kratzer, 1998, p. 65). To avoid a type-mismatch between the type of the C' and the type of the first argument of *how*$_{\text{M}}$, I lift this argument through a variant, $\text{ArgR} := \lambda \mathcal{O}^{\langle\langle s,t\rangle,\langle\langle s,t\rangle,t\rangle\rangle} \, \lambda \mathcal{S}^{\langle\langle s,t\rangle,s\rangle,t\rangle}\lambda p(\exists j)[\mathcal{S}(\lambda k. \, \mathcal{O}(\lambda l. \, l = k, p))(j)]$, of the familiar operation of argument raising (see Hendriks, 1987; see Montague, 1970):[24]

On the manner-reading of its complement, the report in (1a) then has the interpretation in (86). This interpretation assumes that experiential attitude verbs embed manner *how*-clause DPs on their experiential reading (see (73)):

(86) $[\![\text{Anna remembers}_{\text{EXP}} \, [\emptyset \, [\text{how}_{\text{M}} \, [\lambda_1 \, [[\emptyset \, [\text{PAST} \, [\text{PROG} \, [\text{Berta pack} \, t_1]]]]]]]]]\!]^i$
       $= (\exists e)[remember_i(e, anna, \underbrace{C_e(\lambda j. \, t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta)))}_{})]$
       (a representation of) the **manner** in which an event in w_i proceeded

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[24]Note that this operation is does not add any lexical content to the semantics of *how*$_{\text{M}}$ (i.e. it is semantically vacuous). Its only function is to resolve the problematic type-mismatch.

$\llbracket \emptyset \; [\text{how}_{\text{M}} \, [\lambda_1 \, [\emptyset \; [\text{PAST} \; [\text{PROG} \; [\text{Berta pack} \; t_1]]]]]] \rrbracket$
$\lambda e \, [(f_e(\lambda p \, [(\forall j. \, p_j \rightarrow (t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta)))) \wedge (\exists \text{M}. \, p = \text{M})]))]$

$\llbracket \emptyset \rrbracket$
$\lambda T \, \lambda e \, \lambda j$
$[(f_e(T))_j]$

$\llbracket \text{how}_{\text{M}} \, [\lambda_1 \, [\emptyset \; [\text{PAST} \; [\text{PROG} \; [\text{Berta pack} \; t_1]]]]] \rrbracket$
$\lambda p \, [(\forall j. \, p_j \rightarrow (t_j \prec t_i \wedge (\exists k. \, l \preccurlyeq k \wedge pack_k(berta)))) \wedge \text{M}(p)]$

$\llbracket \text{how}_{\text{M}} \rrbracket$
$\lambda q \, \lambda p \, [(\forall j. \, p_j \rightarrow q_j)$
$\wedge (\exists \text{M}. \, p = \text{M})]$

$\llbracket \lambda_1 \, [\emptyset \; [\text{PAST} \; [\text{PROG} \; [\text{Berta pack} \; t_1]]]] \rrbracket$
$\lambda p \, \lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta) \wedge p_k)]$

λ_1

$\llbracket \emptyset \; [\text{PAST} \; [\text{PROG} \; [\text{Berta pack} \; t_1]]] \rrbracket$
$\lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta) \wedge p_k)]$

$\llbracket \emptyset \rrbracket$
$\lambda p \, [p]$

$\llbracket \text{PAST} \; [\text{PROG} \; [\text{Berta pack} \; t_1]] \rrbracket$
$\lambda j \, [t_j \prec t_i \wedge (\exists k. \, j \preccurlyeq k \wedge pack_k(berta) \wedge p_{1,k})]$

$\llbracket \text{PAST} \rrbracket$
$\lambda p \, \lambda j \, [t_j \prec t_i \wedge p_j]$

$\llbracket \text{PROG} \; [\text{Berta pack} \; t_1] \rrbracket$
$\lambda j \, (\exists k)[j \preccurlyeq k \wedge pack_k(berta) \wedge p_{1,k}]$

$\llbracket \text{PROG} \rrbracket$
$\lambda p \, \lambda j \, (\exists k)[j \preccurlyeq k \wedge p_k]$

$\llbracket \text{Berta pack} \; t_1 \rrbracket$
$\lambda j \, [pack_j(berta) \wedge p_{1,j}]$

$\llbracket t_1 \rrbracket$
p_1

$\llbracket \text{Berta pack} \rrbracket$
$\lambda j \, [pack_j(berta)]$

FIGURE 6. The interpretation of the *how*_M-clause DP in (1a).

In virtue of the above, the interpretation of the manner-reading of (1a) is exactly the same as the interpretation of the report's eventive reading (see (74)). This is in line with Umbach et al.'s observation that "the difference between manner reading and eventive reading is subtle and sometimes even negligible" (see *ibid.*, p. 4). The proposed account explains this observation by allowing for two different – but equivalent – perspectives on the sets of events/situations that serve as the semantic values of experiential attitude complements: as (representations of) the <u>event</u> that is the object of the respective attitude (see (74)) or as (representations of) a/the particular <u>manner</u> in which this event proceeds (see (86)). The former perspective is associated with eventive readings of experiential attitude complements. The latter perspective is associated with manner-readings of these complements.

The equivalence of attitude reports with eventive- and manner *how*-complements explains why languages[25] use the manner *wh*-word *how* to introduce events in progress: this use is motivated by the observation that – when it is compositionally applied to the syntax of non-manner *how*-clause DPs and combined with the experiential semantics of the attitude verb – the familiar manner-interpretation of *how* yields exactly the intended meaning. The close semantic relation between eventive and factive *how*-clause DPs (see Sect. 4.3) explains the use of *how* for the introduction of facts.[26] I will return to the relation between manner, eventive, and factive *how*-complements in due course (in Sect. 6). However, before I do so, I briefly show that the presented semantics has a straightforward extension to the interpretation of manner interrogative clauses (e.g. (87)).

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[25]These languages include – next to German and English – Russian, Polish, and Kambaata (see Umbach et al., submitted, pp. 2–3, 12).
[26]These languages include – next to English – French, Greek, and Hebrew (see Legate, 2010, pp. 131–133).

(87)   Claire wonders [how Berta was packing her bag]

When they occur in the complements of rogative verbs (i.e. verbs like *wonder* that semantically select for questions; see Lahiri, 2002), manner *how*-clauses do not allow for an analysis as free relatives (e.g. (86); see Legate, 2010, p. 124). In this case, they are interpreted as CPs. The syntax and semantics of manner interrogative clauses is given in (88) (see Umbach et al., submitted, p. 15):

(88) $[\![_{\text{CP}}\text{how}_{\text{M}}\,[\lambda_1\,[_{\text{C}'}\text{Q}\,[_{\text{TP}}\text{PAST}\,[\text{PROG}\,[\text{Berta pack }t_1]]]]]]\!]$
$=\ \lambda p\,[(\forall j.\,p_j \rightarrow (t_j \prec t_i \wedge (\exists k.\,l \preccurlyeq k \wedge pack_k(berta))) \wedge \text{M}(p)]$

Assuming a standard compositional semantics for rogative verbs (see (89); cf. Uegaki, 2016), the report in (87) then has the interpretation in (90). In the lambda term describing this interpretation, *wonder* is a non-logical constant of type $\langle s, \langle v, \langle\langle\langle s,t\rangle, \boldsymbol{t}\rangle, \langle e,t\rangle\rangle\rangle\rangle$:

(89) $[\![\text{wonder}]\!]^i = \lambda Q^{\langle\langle s,t\rangle,t\rangle}\lambda z(\exists e)[wonder_i(e, z, Q)]$

(90) $[\![\text{Claire wonders }[_{\text{CP}}\text{how}_{\text{M},1}\,[_{\text{C}'}\text{Q}\,[_{\text{TP}}\text{PAST}\,[\text{PROG}\,[\text{Berta pack }t_1]]]]]]\!]^i$
$=\ (\exists e)[wonder_i(e, claire, \underbrace{\lambda p\,[(\forall j.\,p_j \rightarrow (t_j \prec t_i \wedge (\exists k.\,l \preccurlyeq k \wedge pack_k(berta))) \wedge \text{M}(p)]})]$
the **question** (represented by a set of manners) about how an event proceeded

I leave the detailed discussion of the semantics of manner interrogative clauses as a topic for future research.

6. The Need for Factive and Eventive 'how'

I have shown in Section 4 that factive *how*-complements make a different semantic contribution from eventive *how*-complements and from factive *that*-clause complements. A close examination of these contributions provides an answer to the question why some languages allow for non-manner uses of *how*, and why different languages (here: German *vis-à-vis* English) even allow for different non-manner uses of *how*.

The answer to the above question lies in the different semantic effect of experientiality and factivity in the interpretation of *how*- and *that*-complements. It is based on the observation that – due to the semantic effect of C – embedding under experiential occurrences of factive attitude verbs (e.g. *remember*) results in an actual (minimal or non-minimal) <u>event</u> (see (91a), (91b)); embedding under propositional occurrences of these verbs results in a <u>proposition</u> (see (91c) [for factive V] resp. (91d) [for non-factive V]). The minimality (and resulting <u>fact</u>-status) respectively the non-minimality (and resulting <u>event</u>-status) of the non-manner *how*-complements of experiential attitude verbs depends on the particular non-manner reading of *how*: on its eventive (= manner) reading, *how* does not make a genuine semantic contribution above and beyond the semantic contribution of the experiential V and, hence, brings about an event. On its factive reading, *how* makes the semantic contribution of the factive complementizer $that_{\text{F}}$ (see (80)). As a result, it reduces all situations/events in the domain of C to informationally minimal objects, yielding a fact.

The results of the different interactions of (non-)experientiality and (non-)factivity are given in (91):

(91)   a. $[\![\text{Anna V}_{\text{EXP}}\text{s }[\text{how}_{\text{E}}\,p]]\!]^i = (\exists e)[\text{V}_i(e, anna, \boldsymbol{C_e}(p))]$ (an <u>event</u> in w_i)
         b. $[\![\text{Anna V}_{\text{EXP}}\text{s }[\text{how}_{\text{F}}\,p]]\!]^i = (\exists e)[\text{V}_i(e, anna, \boldsymbol{C_e(\Pi(p))})]$ (a <u>fact</u> in w_i)
         c. $[\![\text{Anna V}_{\text{PRP}}\text{s }[\text{that}_{\text{F}}\,p]]\!]^i = (\exists e)[\text{V}_i(e, anna, \boldsymbol{\Pi}(p))]$ (a <u>proposition</u>/set of <u>facts</u>)
         d. $[\![\text{Anna V}_{\text{PRP}}\text{s }[\text{that}_{\text{T}}\,p]]\!]^i = (\exists e)[\text{V}_i(e, anna, \underline{p})]$ (a <u>propositn</u>/set of <u>events</u>)

I have noted in Section 2.2 that, in English, eventive *how*-complements are roughly equivalent to gerund complements (see (23)). In contrast, English does <u>not</u> have a 'natural' equivalent for factive *how*-complements: the only way to express the semantic content

of (74) is by using an overt definite presuppositional of the form *the fact that* $[_{\text{TP}}\ ]$ (see (92b); cf. (20)):

(92)   a. Anna remembers [how$_\text{F}$ Berta was packing her bag]
   ≡ b. Anna remembers [the fact that$_\text{F}$ Berta was packing her bag]

The above suggests the following: the factive use of *how* is a language's response to a certain evolutionary pressure. This pressure arises from the need for an easy way of expressing attitudinal relations to facts. The linguistic data from Section 4.4 shows that different languages respond to this pressure in different ways: while English has extended admissible uses of *how* to factive uses (see the acceptability of (3)–(4), (11)–(13)), German has resisted this extension (see the non-acceptability of (2b) and of the German translations in (11)).

The inverse relationship to the above holds for eventive uses of *how*: since German – unlike English – does not allow gerund attitude complements (and, in the case of *remember*, also does not allow bare infinitival complements; see (93) *vis-à-vis* (94)), it does not have an alternative direct way of expressing attitudinal relations to events. The admissibility of eventive uses of *how* in German can thus be seen as a response to the evolutionary pressure to have a short way of expressing these relations.

(93)   *Anna erinnert sich, [Berta ihre Tasche packen]

(94)   ✓Anna sah [Berta ihre Tasche packen]

Interestingly – like German –, English also allows for eventive uses of *how*. This can be explained by the fact that English gerund complements are not fully equivalent to eventive *how*-complements (see (64)), and by the a cultural influence of (and attendant parallelism between) German and English.

The different combinations of experientiality- and factivity-effects are summarized in Table 2. In this table, combinations for whose expression there is no designated simple construction are shaded in grey:

	FACTS (use of Π)	EVENTS (no use of Π)
EXPERIENTIAL (C_e)	*how*$_\text{F}$-complement	*how*$_\text{E}$-complement [≈ gerund]
NON-EXPERIENTIAL (w/o C_e)	*that*$_\text{F}$-complement	*that*$_\text{T}$-clause complement

TABLE 2. Different combinations of experientiality- and factivity-effects.

7. CONCLUSION

I have shown in this paper that English has two kinds of embedded non-manner *how*-clause DPs, viz. DPs that are licensed by perception, memory, fiction, and report verbs and denote (actual or other-worldly) events and DPs that are licensed by presuppositional and 'say'-verbs and denote actual/real-world facts. These DPs correspond to Umbach-style and Legate-style *how*-clauses, respectively. Umbach and Legate's focus on different kinds of non-manner *how*-clause DPs – and the non-availability of factive *how*-clause DPs in German – explains Umbach et al.'s surprise about the Legate data.

My semantics for eventive and factive *how*-clause reports enables a compositional interpretation of these reports that yields insights into the interaction of attitude verbs and their *how*-complements. This semantics answers Legate's question about "the semantic role [that is] played by [factive uses of] *how*" (Legate, 2010, p. 133): when it occurs in the complement of a factive attitude verb, *how* is interpreted as Kratzer's factive complementizer (i.e. as an informational minimizer). Contrary to what is silently suggested by Legate, factive *how* is thus not semantically vacuous. However, according to my seman-

tics, the more important semantic role is played by (the experiential reading of) the matrix attitude verb: it is the experiential semantics of this verb that identifies its semantic complement with a <u>single</u> spatio-temporally anchored fact.

The proposed semantics also answers Umbach et al.'s questions about the reason behind the use of *how* for the introduction of non-manner entities (see also Legate, 2010) and about the emergence of different non-manner readings of *how*: the former lies in the fact that, when combined with the semantics of experiential attitude verbs and the familiar semantics for the TP, the manner-interpretation of *how* obtains an event, as desired. The latter lies in the observation that German and English lack a simple construction for the expression of relations to events and facts. The eventive semantics of experientially embedded manner *how*-clause DPs suggests an easy response to this evolutionary pressure.

I close this paper with a challenge for my explanation about the eventive use of *how*: As is suggested by (Legate, 2010, p. 131, fn. 15), attitudinal relations to events can also be denoted by temporal *wh*-phrases (see (95)):

(95)   a.   Anna remembers [when$_{\text{T(ime)}}$ Berta was packing her bag]
    ≡   b.   Anna remembers [<u>the event in which</u> Berta was packing her bag]

It remains to be seen to what extent the familiar denotation for *when* is compatible with the semantics of the experiential attitude verb, and what effect this has on my answer to Umbach et al.'s question about eventive *how*.

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