

Familiar *when*-relatives and peculiar *when*-relatives in English

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(Received 24 January 2021; revised 17 May 2022)

Typical headed relatives in English include a relative pronoun which takes the head as its antecedent. However, some modifying *when*-clauses in this language are peculiar relatives in that their heads are not the antecedent of *when* and they do not even have temporal referents. In view of the peculiarity of this type of relative clause, a novel account of the syntactic generation and interpretation of temporal *when*-clauses is proposed. Under this account four lexical entries of *when*, which have different semantic and syntactic properties, are recognized. The semantics of various *whens* are analyzed based on existing work, while the syntactic properties of different *whens* in non-interrogative sentences are characterized in the form of lexical information, which is implemented in the framework of Dynamic Syntax. The work in this article enriches the description of the diversity of relatives and suggests that the analysis of relatives can be unified semantically but not syntactically.

Keywords: *when*, relative clauses, temporal adverbial, Dynamic Syntax

1 Introduction

The syntax and semantics of *when* is intriguing since *when* occurs in four different types of clause, as illustrated below (data extracted from the *British National Corpus* (BNC; Hoffmann & Evert 2018); corpus tags are given in square brackets).

First, *when* is the *wh*-word in a *wh*-question.

- (1) When did you start acting? [A06 2313]

Second, *when* introduces a temporal adverbial clause.

- (2) When the tap on the bar is operated, gas forces the beer to the bar. [A0A 62]
- (3) It was when the semi-public nature of family matters became the subject of attention that the sources of the legitimacy of the state, the Irish nation, the church, democracy, were brought into conflict. [A07 950]
- (4) We are obviously not there when someone is being tortured or killed. [A03 642]

¹ The research was funded by the Social Science Foundation of China (21BYUY152). We are grateful to two anonymous reviewers for their constructive comments and suggestions. We are also grateful to James Watts for his help with the editing work. All remaining errors are our own.

Third, *when* introduces a free relative.

- (5) I really hated when John lied like that. (Hall & Caponigro 2010: 547)
 (6) His hands were manacled behind his back except when he ate or slept. [A03 549]

Fourth, *when* introduces a headed relative clause, the head of which is a temporal noun phrase.

- (7) He said there was never a day when he did not believe they would survive. [A1V 686]
 (8) This is the occasion when a reader can visit the same show and make a personal assessment of how helpful the art critic has been. [A04 1215]
 (9) We live at a time when reporters go to foreign countries where there is trouble and come back to write books in which they say that it was hard to make out what was going on. [A05 732]

Existing accounts of *when*-clauses distinguish *when*-interrogatives from other *when*-clauses (Bresnan & Grimshaw 1978) but argue that *when*-clauses as subjects, objects and adverbials are all free relatives (Grimshaw 1977; Bresnan & Grimshaw 1978; Hall & Caponigro 2010). In this article we first focus on a puzzling type of *when*-clause, which is more like a headed relative than a temporal adverbial though it is substantially different from typical headed relatives. We will then formulate a novel account of headed *when*-relative clauses, *when*-adverbial clauses and *when*-free relatives. We leave out the *when* in interrogative clauses because it involves the issue of interrogation, which requires the space of another article. The description and preliminary analysis of newly discovered *when*-clauses will be presented in section 2. In section 3, existing accounts of the syntax and semantics of various types of *when*-clause are reviewed. In section 4, a formal account of the syntactic generation and interpretation of four types of *when*-clause is formulated in the framework of Dynamic Syntax (Kempson *et al.* 2001; Cann *et al.* 2005). In section 5, the theoretical implications of this article are outlined by comparing the current account and the latest theoretical characterization of relatives with a double-head assumption (Cinque 2020). Section 6 is the conclusion of the article.²

2 Newly discovered *when*-clauses

A headed relative clause in English has been defined in the literature as a clause that is embedded inside a nominal expression (DP) which it modifies (Alexiadou *et al.* 2000), as illustrated in (10).

- (10) the book [which John has read]

There is a relation of dependency between what is called the relative pronoun, e.g. *which* in (10), and the containing phrase, and this dependency is said to be instrumental in determining the interpretation of the construction, i.e. restrictive modification by the

² Some *when*-clauses are not interpreted as temporal adjuncts but rather as concessive or conditional adjuncts, for example *Drugs often make people feel they're coping, when they're really not coping at all.* (A01 117). Such *when*-clauses are not considered in this article.

relative clause (Alexiadou *et al.* 2000). The above definition of headed relatives is good enough to accommodate familiar headed relatives. The dependency between the head and the relative pronoun in a relative clause construction that matches this definition is also clear, the former being the latter's antecedent. Nevertheless, we note that there are some cases where the dependency between the head and the relative clause is not as clear as that shown above. These cases are illustrated by sentences (11)–(18). In these sentences, *when*-clauses immediately follow noun phrases, as marked in italics.

- (11) I shall never forget *his expression when he saw me arriving on my bicycle with its empty pannier bags*. [G3B 1029]
- (12) I remember *my attitude when the Council of Europe recently passed a resolution calling for an armed intervention force in Yugoslavia under the aegis of the United Nations*. [HHW 1235]
- (13) One can imagine *his dismay when he returned to the port and found the ship had gone*, either earlier than planned or because the crew didn't want to be caught helping him. [A67 1064]
- (14) The curve of her neck and throat and jaw for example, *the look in her eyes when she was amused*, her ability to crack all her knuckles simultaneously. [AD9 2180]
- (15) Lineker also reveals *his anger when Taylor criticized him after an international against the Republic of Ireland and when he was dropped 24 hours before a friendly with France*. [CBG 8178]
- (16) I remember *my excitement when I had arrived there for the first time from St Aubyn's*. [H0A 933]
- (17) But, as she all at once realized that he thought, actually thought, that she had been pumping his secretary about him, so a tide of pink warmed her cheeks, and, Nothing! she exclaimed hotly, more startlement hitting her as it dawned on her that this then was the reason for *his fury when he'd seen them together*. [JYF 893]
- (18) 'I will never forget *the sight and smell of the place when we arrived*,' said [gap:name]. [HRT 1628]

There is evidence, from interpretation, that the *when*-clauses in sentences (11)–(18) are restrictive modifiers of the noun phrases that immediately precede them, as shown below. Three native speakers we consulted recognized the *when*-clauses as restrictive modifiers of the preceding noun phrases and provided paraphrases for the sentences in (11)–(18), listed correspondingly as (19)–(26), where the meanings of the *when*-clauses in (11)–(18) are paraphrased in three ways: an adverbial clause embedded in a relative clause, such as (19a, b, c), (20a, b, c), (21a, b), (22a), (24a, b, c), (25a, b) and (26a); a *when*-adverbial clause subordinate to a main clause, such as (23a) and (26c); an adjectival phrase plus a relative clause, such as (22c), or a prepositional phrase, such as (21c), (22b) and (23c).

- (19) (a) The speaker will not forget *the expression he saw when he arrived on his bike*.
 (b) I will never forget *the expression he had that time he saw me arriving on my bicycle with its empty pannier bags*.
 (c) I won't forget *the expression that he made when I arrived*.
- (20) (a) The speaker remembers *the attitude he had when the Council of Europe passed the resolution*.

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- (b) I remember *the attitude that arose within me that time the Council of Europe passed a resolution calling for an armed intervention force in Yugoslavia under the aegis of the United Nations.*
- (c) I remember *my attitude that time that the Council of Europe recently passed a resolution calling for an armed intervention force in Yugoslavia under the aegis of the United Nations.*
- (21) (a) You can understand *what he felt when he saw the ship was gone.*
- (b) You can imagine *his pain from the time that he returned to the port and found the ship had gone.*
- (c) One can imagine *the dismay of returning to port and finding the ship had gone.*
- (22) (a) The curve of her neck and throat and jaw for example, *how her eyes look when she is amused.*
- (b) The curve of her neck and throat and jaw for example, *the look of her amused eyes, her ability to crack all her knuckles simultaneously.*
- (c) The curve of her neck and throat and jaw, *the amused look she gave, her ability to crack all her knuckles simultaneously.*
- (23) (a) Lineker was angry *when Taylor criticized him and when he was dropped and he reveals that.*
- (b) Lineker also reveals *his anger from Taylor criticizing him after an international against the Republic of Ireland and when he was dropped 24 hours before a friendly with France.*
- (c) Lineker revealed *his anger with the situation where Taylor criticized him after an international against the Republic of Ireland and when he was dropped 24 hours before a friendly with France.*
- (24) (a) The speaker remembers *the excitement that he had when he arrived there.*
- (b) I remember *the excitement I had arriving there for the first time from St Aubyn's.*
- (c) I remember *the excitement that I felt arriving there for the first time.*
- (25) (a) But, as she all at once realized that he thought, actually thought, that she had been pumping his secretary about him, so a tide of pink warmed her cheeks, and, 'Nothing!' she exclaimed hotly, more startlement hitting her as she realized this was *why he was angry when he saw them together.*
- (b) But, as she all at once realized that he thought, actually thought, that she had been pumping his secretary about him, so a tide of pink warmed her cheeks, and, 'Nothing!' she exclaimed hotly, more startlement hitting her as it dawned on her that this then was *the reason for his fury at seeing them together.*
- (c) But, as she all at once realized that he thought, actually thought, that she had been pumping his secretary about him, so a tide of pink warmed her cheeks, and, 'Nothing!' she exclaimed hotly, more startlement hitting her as it dawned on her that this then was *the reason for the fury that he had upon seeing them together dawned on her.*³
- (26) (a) The speaker will never forget *how the place smelled when he/she arrived.*
- (b) I will never forget *the sight and smell the place had upon our arrival.*
- (c) When we arrived, the place had *a particular smell and sight, and I will never forget that particular smell and sight.*

³ The informant that offered this paraphrase indicated that it might sound kind of awkward.

Possibly, other native speakers may come up with more different paraphrases, but we believe that the three informants' input suffices to show that the *when*-clauses are restrictive modifiers of the preceding noun phrases in (11)–(18); in this sense, they are relative clauses.

There is other evidence that the *when*-clauses are relative clauses rather than temporal adverbial clauses that restrict the main clauses.

First, they cannot be fronted as temporal adverbial clauses can. Examples (27a, b) show that *when*-adverbials can be fronted and (28a, b) demonstrate that the *when*-relatives are ungrammatical for the interpretation where the *when*-relative modifies the head noun *those moments*; similarly, sentences (29a, b, c), where *when*-clauses are fronted, are ungrammatical for the interpretation where the *when*-clauses are intended to modify the noun phrases given in italics.

- (27) (a) When someone is ill with AIDS they are often in pain. [A01 185] [*when*-adverbial]
 (b) They are often in pain when someone is ill with AIDS. [*when*-adverbial]
- (28) (a) In those moments when a light was a dream or a miracle, you were light in that darkness. [A03 676] [relative]
 (b) *When a light was a dream or a miracle, in those moments, you were light in that darkness.
- (29) (a) *When he saw me arriving on my bicycle with its empty pannier bags, I shall never forget *his expression*.
 (b) *When the Council of Europe recently passed a resolution calling for an armed intervention force in Yugoslavia under the aegis of the United Nations, I remember *my attitude*.
 (c) *When I had arrived there for the first time from St Aubyn's, I remember *my excitement*.

Furthermore, our informants indicate that even if the *when*-clauses in (29a, b, c) are intended to be interpreted as temporal adverbials, the sentences are still unacceptable in that the *when*-clauses do not meet the requirements of tense and aspect that familiar *when*-adverbial clauses meet (for a semantic account of the matching patterns of tense and aspect between main clauses and *when*-adverbial clauses, see Declerck 1991).

Second, *when*-relative clauses cannot be emphasized by the *it*-cleft construction as temporal adverbial clauses can be. Sentence (30) illustrates the case where a *when*-adverbial clause occurs in the *it*-cleft construction and (31)–(33) are examples of ungrammaticality caused by the occurrence of *when*-clauses in the *it*-cleft construction. In the latter three cases, the sentences are ungrammatical if the *when*-clauses are intended to be interpreted as adverbials that modify the main clauses because their tenses do not match; the sentences are still ungrammatical if the *when*-clauses are intended to be interpreted as modifiers of the noun phrases as they do in (11)–(18).

- (30) It is when that figure falls below one-quarter that people begin to use the term 'modular', 'unit-credit', or its colloquial equivalents such as building-block, cafeteria, pick n'mix (or worse). [FA3 1424]

- (31) *It is when he saw me arriving on my bicycle with its empty pannier bags that I shall never forget *his expression*.
- (32) *It is when the Council of Europe recently passed a resolution calling for an armed intervention force in Yugoslavia under the aegis of the United Nations that I remember *my attitude*.
- (33) *It is when I had arrived there for the first time from St Aubyn's that I remember *my excitement*.

To summarize, *when*-clauses can function as restrictive modifiers of noun phrases, which express either states of affairs or entities. This use of *when*-clauses is different from the use of *when*-clauses that modify temporal noun phrases, in which case the relative pronoun in the clause and the noun phrase are coreferential; it is also different from the use of *when*-clauses that restrict a main clause, in which case the *when*-clause functions as an adverbial clause. A question that arises is how the head noun phrase and the *when*-clause are semantically combined if the *when*-clauses at issue are restrictive relative clauses. We will propose an account of the semantic composition of the head noun phrase and the *when*-relative clause, where the two are semantically connected through temporal relatedness. To avoid confusion, we will dub the newly discovered *when*-relative described in this section the peculiar *when*-relative (henceforth *when_p* for brevity) and dub the *when*-relative that modifies a temporal noun phrase the familiar *when*-relative (henceforth *when_f* for brevity). Next, we review existing theories on temporal *when*-clauses, including *when*-adverbial clauses and *when*-relative clauses, so as to make clear in what sense our account advances theoretical understanding.

3 Existing theoretical accounts of *when*-clauses

Given fact that *when_p*-relative clauses can modify non-temporal noun phrases, we first consider existing work on how the syntactic connection between the relative clause and the head is constructed. Chomsky (1977) argues that there is a relationship of dependency between the head and a gap in the relative clause, while later research (for one of the most recent reviews, see Cinque 2020) on relatives debates whether the head is fronted from within the relative (Schachter 1973; Vergnaud 1974; Chomsky 1977, 1993; Browning 1991) or the head is base-generated where it appears and the relative is an adjunct to the head (Carlson 1977; Higgins 1979; Barss 1986). One of the latest theoretical accounts of various types of relative clauses across languages suggests that both the relative and main clause involve the head, and, via either 'raising' or 'matching' and corresponding 'deletion' operations, different types of relative clauses are generated (Cinque 2020). However, the aforementioned *when_p*-relatives show that there is no explicit relationship of dependency between the heads and the relatives. Of course, there seems to be a way to fit the data in the theory. Some native speakers' paraphrases, given as (19a, b, c), (20a, b, c), (21a, b), (22a), (23a), (24a, b, c), (25a, c) and (26a), seem to suggest that the relation of modification between the head noun phrase and the *when_p*-relative like those in (11)–(18) can be accounted for by assuming

a relative clause in which is embedded a *when*-adverbial clause. However, this analysis of *when_p*-relatives suffers from at least two problems, as far as we can see. First, assuming the presence of implicit relative clauses to account for how *when_p*-relative clauses and their non-temporal head nouns phrases are connected invites the question of how implicit relative clauses are recovered since they are not expressed. A solution to this puzzle comes from various theories of ellipsis formulated in the framework of generative grammar. But this solution is not quite appealing in that any syntactic and contextual conditions under which the implicit relative clauses can be recovered do not appear in the surface structure and neither have any such conditions been defined in the literature (see Aelbrecht 2010; Merchant *et al.* 2001). Second, as can be seen in (19)–(26), different native speakers paraphrase *when_p*-relatives in different ways, some using relative clauses that subsume *when*-adverbial clauses but others not.

3.1 Existing work on the syntax of *when*-clauses

Hall & Caponigro (2010) propose an account of various temporal *when*-clauses, including *when*-adverbial clauses, *when_f*-relatives and *when*-free relatives. On this account, these different *when*-clauses are unitarily analyzed as referential expressions, which can be arguments of a verb or a preposition in the case where *when*-clauses appear as the subject or object complement of verbs or prepositions, while they are assumed to be the complement of a silent preposition in the case where they appear as a temporal adjunct. In addition, *when* itself, on this account, is assumed to be a referential expression which is fronted to the clause-initial position from the position of the complement of a silent preposition within the clause. The reason why they assume silent prepositions is that they want to explain the appearance of *when* as the complement of a verb or preposition and on the other hand they want this account of *when* to explain the similarity between *when* and prepositional phrases in terms of syntactic distribution. They base the assumption of a silent preposition within a *when*-clause on the fact that other expressions such as *the other day*, *nice places* and *that way* have been analyzed similarly in the literature (see Emonds 1976, 1987; McCawley 1988). Hall & Caponigro (2010) also argue that the assumption of a silent preposition is semantically motivated because without a preposition *when* cannot semantically combine with other expressions in the same sentence. Apart from assuming silent prepositions inside and outside the *when*-clause, Hall & Caponigro (2010) assume a silent syntactic operator ι , which has the function of a type shifter. ‘When ι applies to the denotation of CP1 (i.e. the set of time intervals or events when Bill left), it returns the maximal element of that set as the denotation of CP2’, as illustrated in (34) and figure 1 (Hall & Caponigro 2010: 549).

(34) I came to visit you when Bill left.

As shown in figure 1, this account involves the assumption of two silent prepositions, one inside the relative clause and the other outside the relative clause. In spite of such theoretical cost, this account still suffers from two problems.

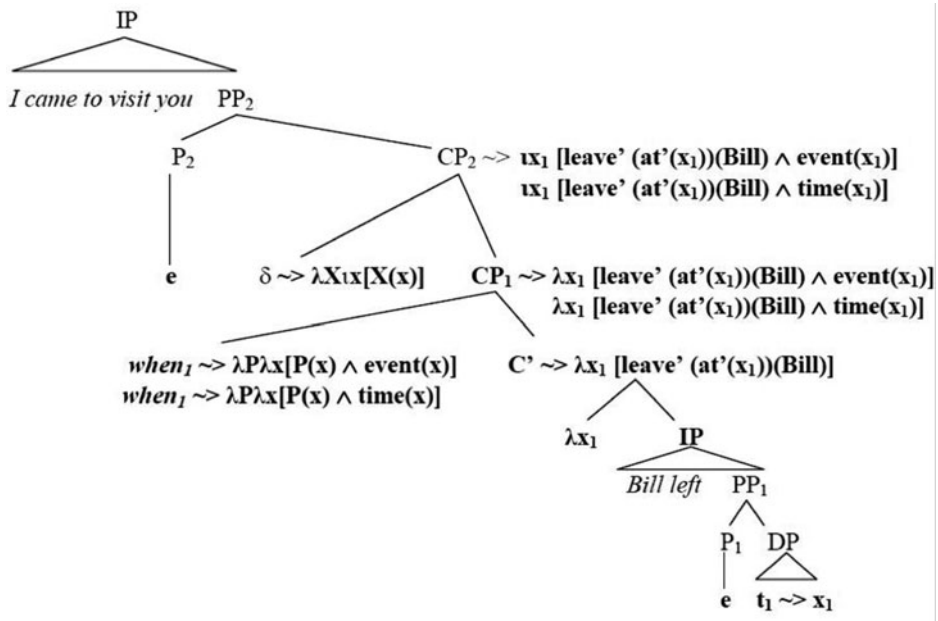


Figure 1. *I came to visit you when Bill left* (Hall & Caponigro 2010: 548)

First, assuming implicit prepositions faces empirical challenges. Inserting a pronounced preposition in the syntactic position of the assumed silent preposition results in ungrammaticality, as shown in (35) and (36). While Hall & Caponigro (2010) suggest that this restriction may exist due to the recoverability of the content of the preposition from other elements in the sentence, they offer no theory about what the restriction is.

(35) I lived in Spain (*during/on/in/at) when I was five. (Hall & Caponigro 2010: 550)

(36) I left the party (*during/on/in/at) when the band stopped playing. (Hall & Caponigro 2010: 550)

Second, the assumption of silent linguistic elements is poorly restricted. This assumption predicts that other free relatives have similar behaviors, i.e. triggering the insertion of a silent preposition without which no interpretation can be achieved. This, apparently, is not empirically borne out. Consider the following examples.

(37) (a) President Bush's recent pronouncements *on* what is just and moral during the Gulf war left me feeling empty and bitter. [A03 699]

(b) *President Bush's recent pronouncements what is just and moral during the Gulf war left me feeling empty and bitter.

(38) (a) You'll find lists of publishers and what magazines look *for* in the Writers' & Artists' Yearbook (A & C Black, £7.95). [EFG 2292]

(b) *You'll find lists of publishers and what magazines look in the Writers' & Artists' Yearbook (A & C Black, £7.95).

(37a) and (38a) both involve a preposition; (37b) and (38b), however, are ungrammatical sentences because of the absence of the prepositions. These facts suggest that adverbial *when*-clauses are not free relatives although *when*-clauses as the complement of verbs or prepositions are. In other words, *when*-clauses as complements of verbs or prepositions and *when*-clauses as temporal adverbial clauses are not the same grammatically. As far as we can see, although Hall & Caponigro (2010) claim that assuming different types of *when*-clauses is not theoretically elegant, their theoretical account seems to achieve some presumed elegance at the expense of ignoring empirical facts. Furthermore, the fact that *when*-clauses function either like noun phrases or like prepositional phrases suggests that there are different types of *when*-clauses because noun phrases and prepositional phrases are grammatically different.

The syntax of *when*-relatives is also considered along with *if*-conditionals in the literature (Gregoromichelaki 2006, 2011). The difference between *when*-clauses and *if*-clauses is mentioned but no account of them is provided. Furthermore, Gregoromichelaki (2017) mentions that each predicate needs to be associated with an independent event/situation argument. This assumption can account for the data in (11)–(18) because the *when*-relatives therein can be analyzed as restricting an event/situation variable argument predicated by the modified noun phrase. However, as a consequence of that assumption, all DPs/NPs will come with event/situation arguments, which can be considered theoretically redundant. In the account we will propose and implement within the same theoretical framework, there is no need to make such an inflationary assumption.

3.2 Existing work on the semantics of *when*

Existing literature on the semantic properties of *when*-clauses considers two issues: one is the temporal relationship between the *when*-clause and the main clause; the other is the semantic contribution of *when* in establishing the temporal relationship between the two clauses. And the conclusions already drawn are based on English (see Isard 1974; Ritchie 1979; Declerck 1991; Hall & Caponigro 2010) and other European languages, such as Italian (Bonomi 1997), Danish, Swedish and Norwegian (Vikner 2004). What the existing accounts agree upon is that the *when*-clause sets up a temporal reference for specifying the temporal location of the event expressed by the main clause (Isard 1974; Ritchie 1979), but the specific temporal relation between the main clause event and the *when*-clause event depends on the tense and aspect properties of the two clauses (see Ritchie 1979; Declerck 1991; Bonomi 1997; Vikner 2004: for various temporal relationships between the two events in English, Italian and Danish). With respect to the semantic contribution of *when*, Bonomi (1997) and Vikner (2004) treat *when* as an operator that takes two temporal meanings as its arguments and the sentence returns true if the two clauses/events have the temporal relationship of ‘overlap’ (in various ways). This operator account of *when* is criticized by Hall & Caponigro (2010), as we will explain immediately below. However, we will argue that the criticism is off target.

According to Hall & Caponigro (2010), the word *when* and the clause introduced by *when* are treated as syntactically and semantically different from all the other *wh*-words

and *wh*-clauses in the previous accounts mentioned above, which do not provide alternative explanations for the strong evidence that leads to the opposite conclusion. Furthermore, the two authors argue that temporal *when*-clauses are taken to express a proposition/event in the very same way as the matrix clause although temporal *when*-clauses can be replaced and paraphrased with DPs or PPs, as illustrated in (39) and (40).

(39) I really hated [when John lied like that]/[_{DP} the time(s) John lied like that]. (Hall & Caponigro 2010: 547, ex. (17))

(40) I left [when Bill arrived]/[_{PP} at the time Bill arrived]. (Hall & Caponigro 2010: 547, ex. (18))

A second aspect of the operator account which Hall & Caponigro (2010) take to be a problem is that on this account *when* is not analyzed as a *wh*-word undergoing movement and leaving a trace. Therefore, no island-effects are expected while, as they argue, there are island-effects with *when*-clauses.

(41) (a) I ate dinner [_{CP} when Mary thought [_{CP} that I should eat dinner]].

(b) I ate dinner [_{CP} when₁ Mary thought t_1 [_{CP} that I should eat dinner]]. Paraphrase: I ate dinner at a certain time and at that very same time Mary had the thought that I should eat dinner (at some later time).

(c) I ate dinner [_{CP} when₁ Mary thought [_{CP} that I should eat dinner t_1]].

Paraphrase: I ate dinner at a certain time and Mary had previously had the thought that I should eat dinner exactly at the time I did.

(d) *I ate dinner [_{CP} when₁ Mary made [_{DP} the suggestion [_{CP} that I should eat dinner t_1]]].

According to Hall & Caponigro (2010), (41a) has two interpretations, i.e. *when* in (41a) indicates either the time of Mary's thinking that I should eat dinner or the time at which I should have dinner. Sentences (41b) and (41c) are two paraphrases of (41a) that make the two interpretations explicit. In (41b) and (41c), *when*, which appears in a higher clause, is assumed to have been moved from within a lower clause. Hall & Caponigro (2010) believe that the two interpretations of (41a) constitute the evidence that *when* undergoes a movement. In contrast, (41d) where the DP *the suggestion* intervenes is ungrammatical for the interpretation associated with (41b). Hall & Caponigro (2010) explain the ungrammaticality of (41c) with regard to the relevant interpretation by invoking the notion of a complex noun phrase island from within which no constituent can move out.

Additionally, Hall & Caponigro (2010) indicate that the temporal operator analysis incorrectly predicts that temporal arguments should freely occur inside the *when*-clause, which, they argue, is not borne out. According to their intuition, a temporal phrase cannot occur inside a *when*-clause, which they illustrate with the sentence given in (42).

(42) *I read [when you recommended at 5pm].

It can be straightforwardly argued that the first two problems are not real problems for the operator account of *when*. *When*-clauses behaving like either prepositional phrases or

noun phrases suggests that there are distinct types of *when*-clauses, since prepositional phrases and noun phrases generally have different syntactic distributions and make different semantic contributions. Besides, although some temporal noun phrases can behave like *when*-clauses, not all noun phrases can be used in that way. For example, the location phrase *the place* cannot function as *where* does. This means that temporal noun phrases like *the moment* are peculiar in terms of function and it is the peculiarity of these temporal noun phrases that needs explanation. The theory that *when* is an operator that takes two clauses as its arguments does not exclude the possibility that the operator can have alternative underlying syntactic positions under the assumptions of the framework that Hall & Caponigro (2010) adopt; thus, the variable interpretation of sentences like (41a) and the ungrammaticality of (41c) can still be explained. In other words, the operator account can be intended as a way to just accommodate the semantic relationship between a main clause and a *when*-clause rather than cover every aspect of the behavior of *when*. The essence of the third problem, compared with that of the first two problems, is not so clear. If Hall & Caponigro's observation was reliable, what they notice would imply that *when* is in conflict with a temporal adverbial inside the clause it takes. Hall & Caponigro (2010) do take this observation to be evidence that *when* is part of a temporal adjunct inside the *when*-clause, and they assume that *when* is the complement of an implicit preposition, as indicated in the above review. Nevertheless, there is empirical evidence that Hall & Caponigro's observation is not sufficient to support the syntactic account that they propose. In some cases, a temporal adjunct can occur inside the *when*-clause even if there is no pause before the temporal adjunct, for example, *John had left when Bill walked in at 3 p.m.* (Hornstein 1993: 63, ex. (48)). In this sentence, *3 p.m.* is interpreted as modifying the clause *Bill walked in*. If Hornstein's observation is correct, Hall & Caponigro's claim is doubtful.

Although the operator account of *when* is not as problematic as Hall & Caponigro (2010) claim, it indeed requires some modification. The *when_p*-relative described in section 2 is a problem for this account because such relatives restrict a noun phrase rather than a clause. This fact cannot be directly captured in the operator account because *when_p* connects a noun phrase and a clause rather than connecting two clauses. In summary, the existing syntactic and semantic accounts of *when*-clauses are not sufficient to accommodate the facts that have been observed earlier in section 2.

4 At the syntax–semantics interface of various *when*-clauses

Having worked out the problems with the existing accounts of the syntactic and semantic properties of various *whens*, we now provide a lexicalist account of the generation of various *when*-clauses from a parsing perspective. This account is implemented in the framework of Dynamic Syntax (Kempson *et al.* 2001; Cann *et al.* 2005; Gregoromichelaki & Kempson 2015; Kempson *et al.* 2016), which provides sufficient and necessary theoretical tools and technical means to characterize complex lexical information. The work is to be carried out in two steps. The fundamental philosophy

and theoretical tools of Dynamic Syntax are introduced first; then, a theoretical characterization of the syntactic and semantic properties of four *whens* is proposed.

4.1 *The essentials of Dynamic Syntax*

Using the Logic of Finite Trees (LOFT) (Blackburn & Meyer-Viol 1994), Dynamic Syntax aims to model the syntax of natural language from a parsing perspective, treating a sentence as a string of words that are processed one by one from left to right, triggering lexical rules. In addition, the application of universal and language-specific computational rules drives the binary growth of partial semantic tree-structures, enriches information inhabiting the nodes of the trees, and combines semantic information accumulated from online-parsing and context-based pragmatic inference so as to derive a propositional formula. In this approach to natural language syntax, the lexical information of words consists of a set of procedures which, in combination with the computational rules, account for syntactic structures of sentences.

4.2 *Basic formal tools in Dynamic Syntax*

The growth of the partial semantic tree ('partial tree' henceforth) is goal-driven. Setting goals and achieving goals are realized via applying general computational rules and lexically encoded operations (called lexical actions), which are part of lexical information. Lexical information can be represented as macros, which take the form of 'IF...THEN...ELSE...' statements. In these statements, the conditions under which some lexical actions will be executed are introduced by the 'IF' part. The lexical actions themselves are introduced in the 'THEN' part. 'ELSE' indicates the actions which are taken if the conditions in the 'IF'-clause are not met. The action operators 'MAKE()' and 'GO()' respectively have the function of creating a new node that holds a tree-structural relationship to a current node, and move the pointer, which indicates the node currently under consideration, to another tree node. The operator 'PUT()' indicates how to annotate the current tree node with information, which consists mainly of requirements and/or semantic formulas. The zero-arity operator 'ABORT' has the function of terminating the parsing process if the 'IF' conditions are not met at the node where the pointer currently resides. DS also employs modalities from LOFT which, in combination with the LOFT tree-relations, function as operators which can indicate the tree-structural relationship between any two nodes on a partial tree. The existential modalities consist of an existential operator $\langle \dots \rangle$ combined with a tree-structural relation indicator. So does $[\dots]$, which is a universal operator. For example, the tree-structural modality operators $\langle \downarrow_0 \rangle$ and $\langle \downarrow_1 \rangle$ indicate a tree-structural relationship between the current node and another node, namely the argument daughter and function daughter respectively. In more detail, this is because the downward arrow, \downarrow , stands for a daughter node of the current node, and its reverse, \uparrow , stands for the mother node of a current node. The subscripted numerals '0' and '1' represent the argument type daughter and the functor type daughter respectively. Such operators can be applied recursively; for example, $\langle \uparrow_1 \rangle \langle \downarrow_0 \rangle$, indicates

the relationship between a functor-type tree node and its sister argument-type node. In addition, there are also inter-tree relationship connectors, i.e., the LINK operators $\langle L \rangle$ and $\langle L^{-1} \rangle$. Their responsibility is to indicate information sharing between two partial trees that are growing in parallel. The LINK operators are used in the parsing of adjunct structures, relative clauses, coordination, discourse relations etc.

The information on a tree node varies but basically includes requirements, indicated by ‘?’; a logical type, such as ‘t’ (propositional type), ‘e_s’(event argument), ‘e_s→t’(event predicate), ‘e’(entity argument), ‘e→(e_s→t)’ (two-place functor) among others. As we’ve already said, there is also the pointer ‘◇’ that appears on a unique tree node to indicate that the node on which it appears is the current node in a parsing process. The pointer moves as a result of applying some general computational rules or applying the procedural actions contributed by an online-parsed word. Technically, each tree node is assigned a tree node address, indicated by the operator Tn(), the argument of which is a specific address defined relative to the address of the root node of a tree, conventionally Tn(0), with its argument-type daughter node having the address Tn(00) and its functor-type daughter node having the address Tn(01), with the address of any daughter node defined by adding ‘0’, if it is an argument node, or ‘1’, if it is a functor node, to the right of the address of its mother node.

4.3 A dynamic account of when-clauses

Now, we demonstrate how various types of *when*-clause are constructed and what different *whens* contribute to the generation and interpretation of *when*-clauses. Descriptively, there are four lexical entries associated with the phonological form *when*. One is *when_p*, e.g. (43), the other is *when_f*, which occurs within a familiar *when*-relative clause, e.g. (44). Another is *when_{ad}*, which occurs in the *when*-adverbial clause, e.g. (45). The fourth is *when_{free}*, as illustrated by (46).

(43) John remembers the smell when Mary arrived. (*when_p*-relative)

(44) John arrived on the day when Mary arrived. (*when_f*-relative)

(45) John arrived when Mary arrived. (*when_{ad}*)

(46) John hates when Marry arrives. (*when_{free}*)

Syntactically, *when_p* and *when_f* are rather similar, both immediately following an expression denoting an entity. But semantically, the two are not the same in that the former restricts a non-temporal expression while the latter restricts a temporal expression. *When_{ad}* is syntactically different from the former two because the clause in which it appears can appear in alternative syntactic positions, either preceding or following the main clause or even between the subject and predicate inside the main clause, although such *when*-clauses also provide temporal information. Free *when*-relative clauses behave as noun phrases do. Theoretically, as mentioned before, we take a lexicalist approach from a parsing perspective, assuming that there are four lexical entries associated with *when* and they carry different syntactic and semantic information, which we characterize in the form of macros of lexical information.

Our theoretical account of the four *whens* will be provided by demonstrating the processes of parsing the above four illustrative sentences. To save space, we omit the details in the process of parsing words within clauses and merely demonstrate the stages where *when* is parsed and how the semantic relationship between the *when*-clause and the main clause is established.

4.3.1 *The dynamic syntax of peculiar when-relatives*

The process of parsing (43), represented as the growth of a binary semantic tree, starts with the axiomatic setting of an initial goal ?t on the root node of a growing binary semantic tree. The goal then splits into subgoals which are generated via applying some general parsing rules and satisfied by semantic content from online word parsing and pragmatic inference. After the lexical information from the parsed words has been processed, the partial tree grows into the state shown in figure 2.

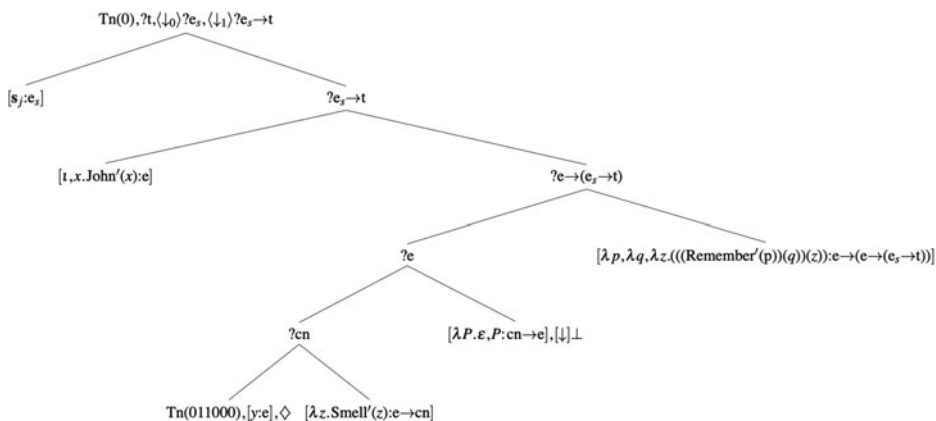


Figure 2. After parsing *John remembers the smell*

At this stage, the LINK ADJUNCTION rule is applied, which creates a LINK relationship between the current tree node and a tree node on another growing partial tree, which is to accommodate the semantic content of the relative clause (see figure 3).

$$\begin{array}{c}
 \text{LINK ADJUNCTION} \\
 \hline
 \{Tn(n), \dots, \langle MOD \rangle, \varphi : X, \dots, \diamond\} \\
 \hline
 \{ \dots \{Tn(n), \dots, \langle MOD \rangle, \varphi : X \dots\}, \{ \langle L^{-1} \rangle Tn(n), \dots, ?\varphi, \dots, ?\langle \downarrow^* \rangle, \varphi : X, \dots, \diamond \} \dots \}
 \end{array}$$

At the current stage, *when_p* is parsed. The lexical information of *when_p* is defined below, which is a critical component of the current account of *when_p*-relatives. The lexical information of *when_p* consists of triggering conditions and lexical actions. The triggering conditions are that the pointer is located on the node LINKed to a node annotated with [y:e] and on the current node is a ?t and somewhere below the current

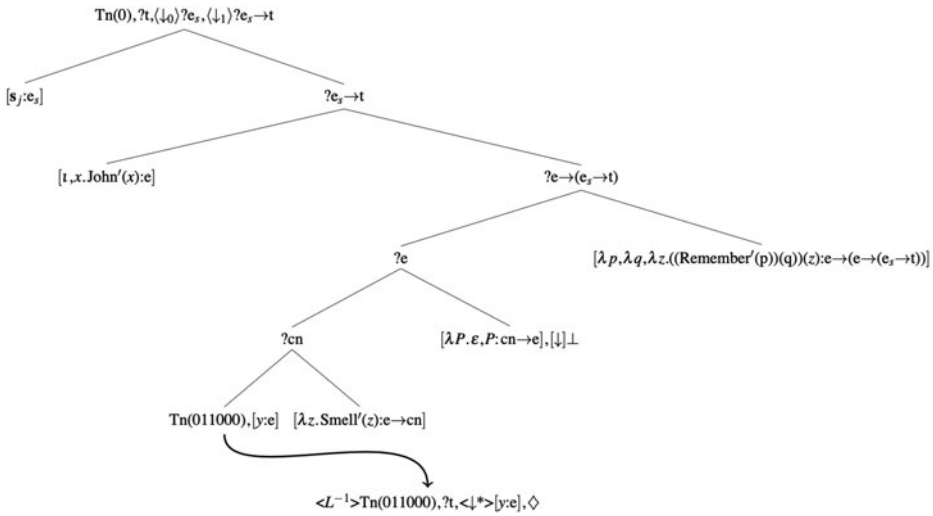


Figure 3. The effect of applying LINK ADJUNCTION

node exists the formula $[y:e]$. Once these conditions are available, the actions in the ‘THEN’ clause are employed, updating the partial tree under construction; otherwise, the action in the ‘ELSE’ clause is applied, i.e. the parsing process is terminated.

```

IF <L-1>[y:e],?t,<↓*>[y:e]
THEN MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e);
    MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λx.T(x):e→t); GO(⟨↑₁⟩);
    MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e); GO(⟨↑₀⟩⟨↑₀⟩);
    MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(?e→t);
    MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λP, λQ.WHEN(P, Q):e→(e→t)); GO(⟨↑₁⟩);
    MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e);
    MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λz.T(z):t→e); GO(⟨↑₁⟩);
    MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?t)
ELSE ABORT
    
```

With the lexical actions in the ‘THEN’ clause in the lexical information of $when_p$ applied, the LINKed tree is updated as shown in figure 4.

As shown in the definition of $when_p$ and the updated tree, $when_p$ contributes not only a package of lexical actions that drive the growth of the partial tree but also three functor-type formulas that are located on different tree nodes. The semantic content consists of two instances of the temporal operator T . The first instance takes an event and the other an entity to yield two temporal intervals. It also contributes the temporal-relationship predicate $WHEN$ that identifies the temporal relationship between the two temporal intervals. With respect to the semantic function of T , we leave it open because, in some cases, a $when$ -clause does not specify the event time but rather the reference time, as Hornstein (1993) and Demirdache & Uribe-Etxebarria (2004) argue. Regarding the temporal relation that $WHEN$ represents, we adopt the claim that it

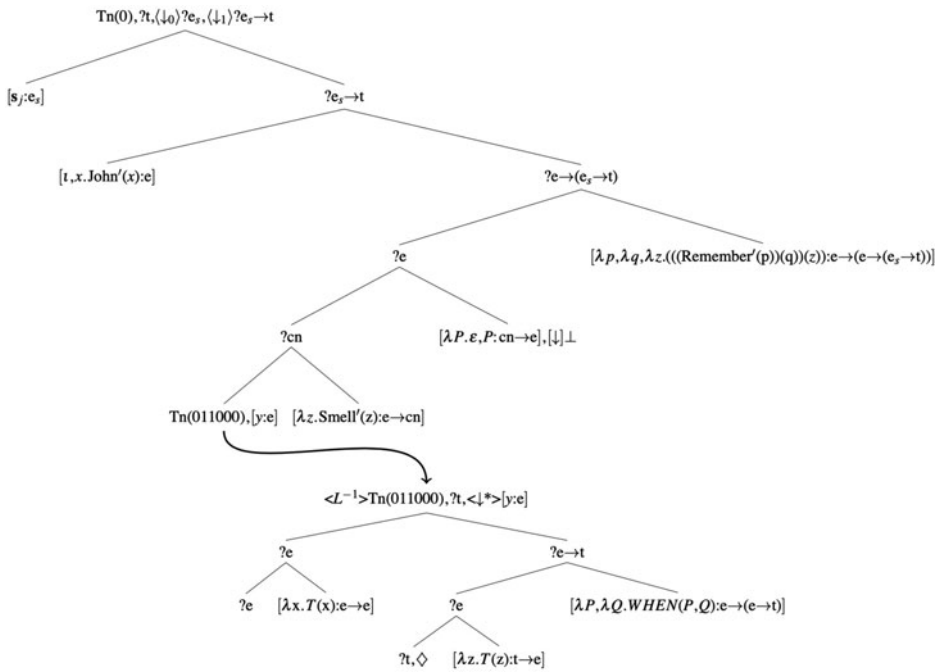


Figure 4. After parsing *John remembers the smell when*

specifies sloppy simultaneity (see Declerck 1991: 48). Syntactically, the ?t that *when_p* contributes requires the parsing process to continue. With the pointer now located on a node with ?t, a series of events like those presented above take place, through which the string *Mary entered* is parsed. When no nodes on the two parallel trees have outstanding goals, the COMPLETION rule and the ELIMINATION rule, defined below, are applied in sequence. The COMPLETION rule is responsible for moving the pointer upward to the mother node and copying the information on the daughter nodes onto the mother node. The ELIMINATION rule is responsible for combining the semantic formulas on sister nodes through functional application as is usual in the λ-calculus.

COMPLETION

$$\frac{\{ \dots \{ Tn(n), \dots \}, \{ \langle \uparrow_i \rangle Tn(n), \dots \varphi, \dots, \diamond \} \dots \}}{\{ \dots \{ Tn(n), \dots, \langle \downarrow_i \rangle, \varphi, \dots, \diamond \}, \{ \langle \uparrow_i \rangle, Tn(n), \varphi \} \dots \}}$$

ELIMINATION

$$\frac{\{ \dots \{ Tn(n), ?X, \langle \downarrow_0 \rangle, \alpha : Y, \langle \downarrow_1 \rangle, \beta : Y \rightarrow X, \diamond \} \dots \}}{\{ \dots \{ Tn(n), \beta(\alpha) : X, \langle \downarrow_0 \rangle, \alpha : Y, \langle \downarrow_1 \rangle, \beta : Y \rightarrow X, \diamond \} \dots \}}$$

The result of repeated application of these rules to the semantic formulas on the sister nodes on the LINKed tree is shown in figure 5.

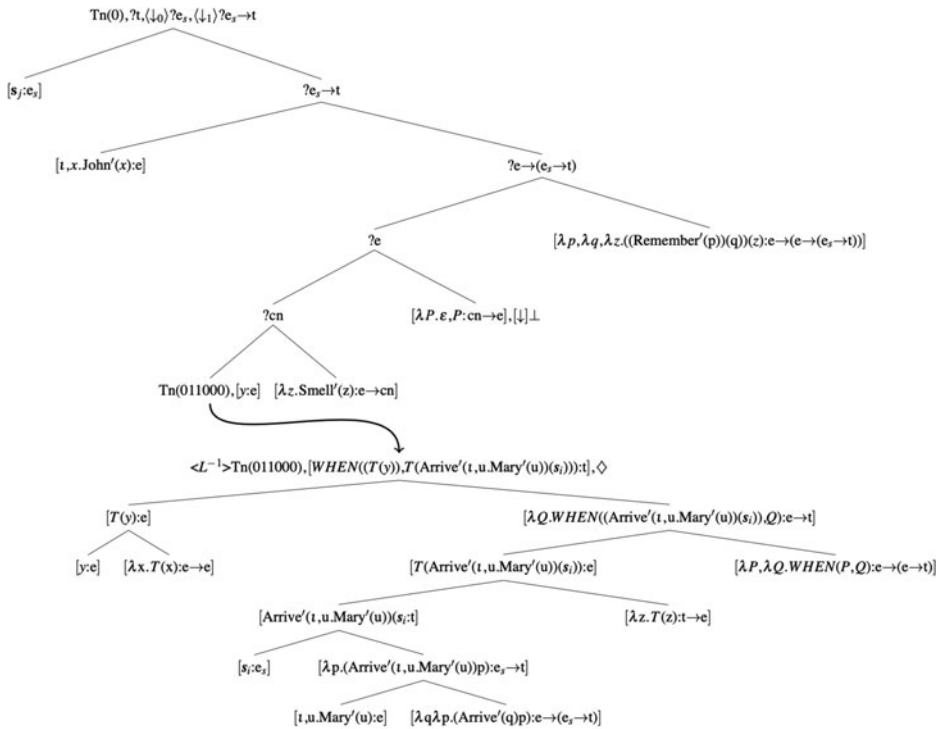


Figure 5. After parsing *John remembers the smell when Mary arrived*

As the LINKed tree is completed, the pointer goes back to the main tree through applying the LINK COMPLETION rule.

LINK COMPLETION

$$\frac{\{ \dots \{ Tn(n), \dots \}, \{ \langle L^{-1} \rangle Tn(n), \dots \varphi, \dots, \diamond \} \dots \}}{\{ \dots \{ Tn(n), \dots, \langle L \rangle, \varphi, \dots, \diamond \}, \{ \langle L^{-1} \rangle Tn(n), \dots \varphi \} \dots \}}$$

Subsequently, the COMPLETION and ELIMINATION rules are applied repeatedly to the main tree to complete it (see figure 6).

With the two trees both completed, i.e. involving no unachieved goals, the LINK EVALUATION rule, defined below, is applied, combining the semantic formulas on the root nodes of the two trees as the conjuncts in a composite propositional formula, as given in (47).

LINK EVALUATION

$$\frac{\{ \dots \{ Tn(n), \dots, \varphi: t, \diamond \}, \{ \langle L^{-1} \rangle Tn(n), \psi: t \} \dots \}}{\{ \dots \{ Tn(n), \dots, \varphi \wedge \psi: t \}, \{ \langle L^{-1} \rangle Tn(n), \psi: t \} \dots \}}$$

(47) ((Remember'(ε_s, y. Smell'(y))(t, x. John'(x)))(s_j)) ∧ (WHEN(T(y)), T((Arrive'(t, u. Mary'(u))(s_i))))

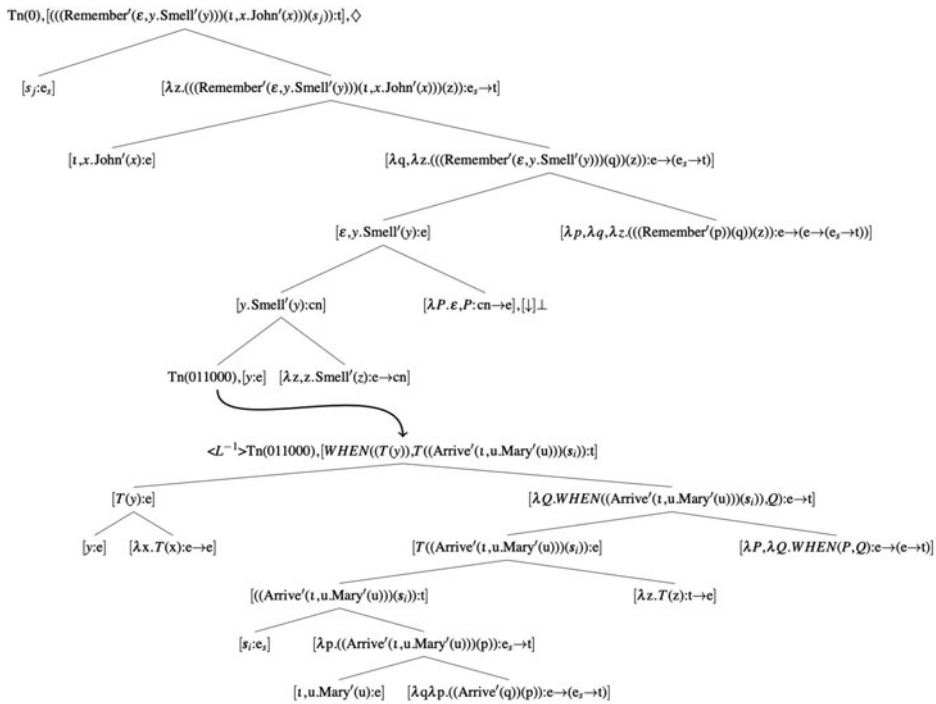


Figure 6. After applying COMPLETION and ELIMINATION several times

It should be noted that the triggering conditions in the lexical information of *when_p* strictly restrict the syntactic distribution of this word, excluding the possibility that a *when_p*-relative clause is fronted, as illustrated by the sentences in (29), (31), (32) and (33).

4.3.2 The dynamic syntax of familiar *when*-relative clauses

The process of parsing (44) follows the same principles of parsing as shown above; but it differs from the latter at some critical parsing stages; more specifically, it involves a different *when* lexical entry. To save space, we only demonstrate the parsing stages where a difference from the process of parsing (43) can be clearly observed.

Through parsing (44), two LINK relations are established. One is that between the two partial trees that respectively accommodate the semantic content obtained from parsing *John arrived* and that obtained from parsing *on the day*; the other is that between the partial trees that respectively accommodate the semantic content obtained from parsing *on the day* and that from parsing *when Mary arrived*. What is shared among the three trees is an event variable, which captures the fact that *on the day* and *when Mary arrived* both provide temporal specification of the event of *John arrived*. In terms of syntax, the lexical information of *when_f* is quite similar to that of *when_p* since they both occur in restrictive relative clauses; for this reason, the triggering conditions for lexical actions in *when_f* are the same as those in the lexical information of *when_p*. The only difference between them is that the former takes a temporal variable as its

argument while the latter takes a non-temporal variable as its argument. This difference is reflected in the semantic formulas that they contribute respectively. The result of parsing the sentence is shown in figure 7.

```

whenf
IF <L-1>[s:es],?t,<↓*>[v:e]
THEN MAKE(⟨↓0⟩); GO(⟨↓0⟩); PUT(?e);
  MAKE(⟨↓1⟩); GO(⟨↓1⟩); PUT(λ x.T (x): e→t); GO(⟨↑1⟩);
  MAKE(⟨↓0⟩); GO(⟨↓0⟩); PUT(?e); GO(⟨↑0⟩⟨↑0⟩);
  MAKE(⟨↓1⟩); GO(⟨↓1⟩); PUT(?e→t);
  MAKE(⟨↓1⟩); GO(⟨↓1⟩); PUT(λP, λQ. WHEN(P, Q): e→(e→t)); GO(⟨↑1⟩);
  MAKE(⟨↓0⟩); GO(⟨↓0⟩); PUT(?e);
  MAKE(⟨↓1⟩); GO(⟨↓1⟩); PUT(λz. T(z): t→e); GO(⟨↑1⟩);
  MAKE(⟨↓0⟩); GO(⟨↓0⟩); PUT(?t)
ELSE ABORT
    
```

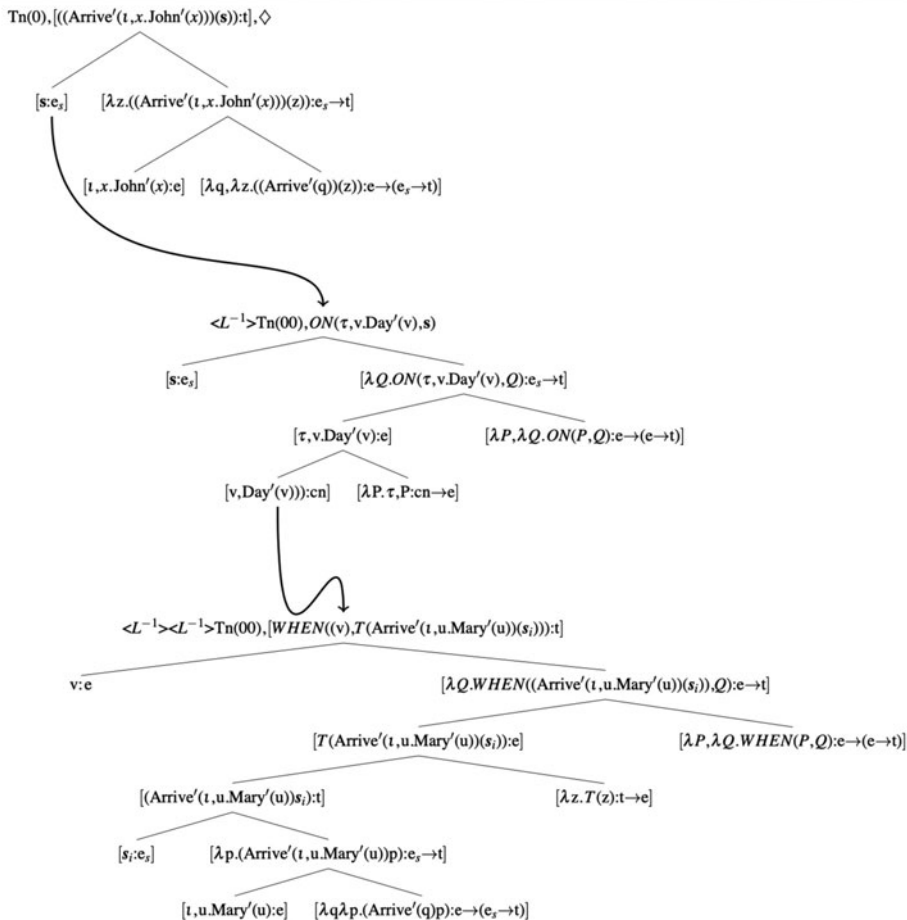


Figure 7. Parsing *John arrived on the day when Mary arrived*

After completing the three partial trees, the semantic formulas on the root nodes of the three trees are combined via applying the LINK EVALUATION rule to form a composite propositional formula. It should be reiterated that $when_f$ is distinct from $when_p$ because they have different though highly similar semantic content which restricts their syntactic distribution, one following a temporal expression, the other following a non-temporal expression.

4.3.3 The dynamic syntax of when-adverbial clauses

The *when*-clause in (45) is an adverbial clause. An important difference between the *when*-adverbial clauses and the previously mentioned two types of *when*-relatives is that the former can either precede or follow the main clause, while the latter two can only follow the head that they restrict. We still assume that the syntactic properties of $when_{ad}$ play a key role in determining the syntactic distribution of the *when*-adverbial clause. The lexical information of $when_{ad}$ involves alternative triggering conditions. One is that the pointer is located on a ?t node which does not have any fixed daughter nodes yet; this is a characterization of the case in which the *when*-adverbial clause precedes the main clause. The other is that the pointer is located on a node already annotated with a t-type node, which characterizes the case where the *when*-adverbial follows the main clause. The lexical information of $when_{ad}$ is defined as follows.

<i>When_{ad}</i>	<pre> IF ?t THEN IF ⟨↓⟩⊥ THEN PUT(⟨↓*⟩[U.∃x.x:t]); MAKE(⟨L⟩); GO(⟨L⟩); PUT(?t); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT([U.∃x.x:t]); GO(⟨↑⟩); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT([λ φ .T (φ): t→e]); GO(⟨↑⟩⟨↑⟩); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(?e→t); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λP, λQ.WHEN(P, Q): e→(e→t)); GO (⟨↑₁⟩); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λz.T(z):t→e); GO(⟨↑₁⟩); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?t) ELSE ABORT ELSE IF [α:t] THEN PUT(⟨↓*⟩[U.∃x.x:t]); MAKE(⟨L⟩); GO(⟨L⟩); PUT(?t); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT([U.∃x.x:t]); GO(⟨↑⟩); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT([λφ .T(φ): t→e]);GO(⟨↑⟩⟨↑⟩); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(?e→t); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λP, λQ.WHEN(P, Q): e→(e→t)); GO (⟨↑₁⟩); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?e); MAKE(⟨↓₁⟩); GO(⟨↓₁⟩); PUT(λz. T(z): t→e); GO(⟨↑₁⟩); MAKE(⟨↓₀⟩); GO(⟨↓₀⟩); PUT(?t) ELSE ABORT </pre>
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Parsing (45) yields the semantic trees shown in figure 8.

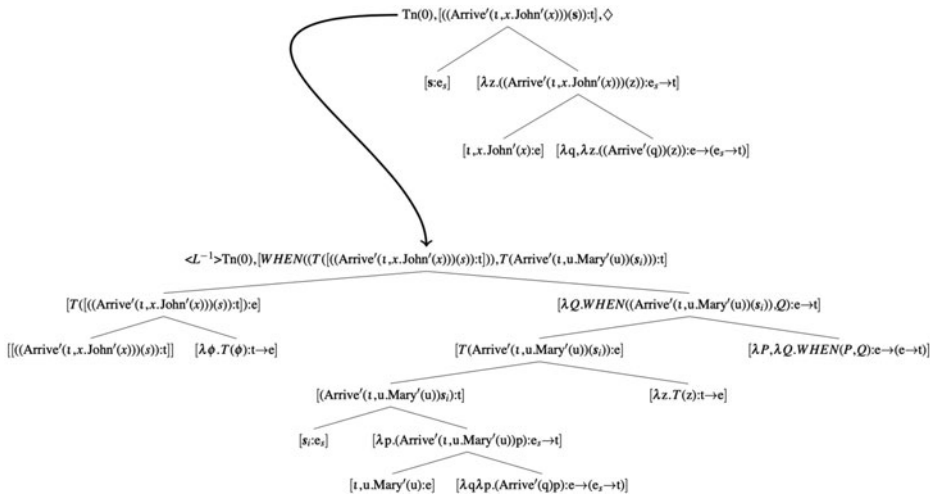


Figure 8. Parsing *John arrived when Mary arrived*

To reiterate, the *when*-adverbial clause is not syntactically restricted to the position following the main clause; it can also appear before the main clause, as illustrated by (48).

(48) When Marry arrived, John arrived.

But the process of parsing (48) is trivial theoretically because the only difference between (48) and (45) is that *when_{ad}* is parsed under the triggering conditions that are alternative to those in the case of (45), as shown in the definition of the lexical information of *when_{ad}*. What is shared between the two trees is initially a t-type metavariable, which is to be replaced by a contentful semantic formula of the same type, since the t-type formula is not available before the main clause is parsed. After the main clause is parsed, the formula that can be used to replace the metavariables, i.e. the placeholders for contentful formulas, is available and the substitution of the metavariables takes place, as a result of which the metavariables on the LINKed trees are replaced with the same semantic formula. Finally, the semantic formulas on the two trees get combined as was shown in the demonstration of the preceding two parsing processes.

What's more, the lexical information of *when_{ad}* allows the ambiguity that arises in (41a), repeated as (49a), and disallows ambiguous interpretation in the case of (41d), repeated below as (49b).

- (49) (a) I ate dinner when Mary thought that I should eat dinner.
- (b) I ate dinner when Mary made the suggestion that I should eat dinner.

(49a) can be parsed in two different ways. The t-type metavariable U which *when_{ad}* contributes has an unfixed node initially, as indicated by ⟨↓*⟩. It will merge with either the current t-type node or some t-type node dominated by the current node. In other words, the metavariable will take content either from *Mary thought ...* or just from *I*

should eat dinner. Ambiguity does not arise in the case of (49b) because the tree-structural modality $\langle \downarrow^* \rangle$ that marks the potential structural status of $[U: t]$ restricts the status of the formula within the current tree, while the semantics of the appositive clause, *that I should eat dinner* that follows *the suggestion*, different from that of an object clause, is, as can be assumed, accommodated on another partial tree that is connected to the current tree via the LINK relationship.

4.3.4 The dynamic syntax of free when-relative clauses

In this section, we consider *when_{free}* in free relatives. *When*-free relatives can appear as a subject or object complement of a verb, just like a noun phrase. To capture this fact formally, we assume that *when_{free}* contributes a temporal operator which takes a proposition to yield a temporal entity, i.e. an e-type formula in Dynamic Syntax terms. The lexical information of *when_{free}* is defined as follows.

<i>when_{free}</i>		IF ?e
		THEN MAKE($\langle \downarrow_1 \rangle$); GO($\langle \downarrow_1 \rangle$); PUT($\lambda P.T(P):t \rightarrow e$); GO($\langle \uparrow_1 \rangle$);
		MAKE($\langle \downarrow_0 \rangle$); GO($\langle \downarrow_0 \rangle$); PUT(?t)
		ELSE ABORT

To save space, we merely demonstrate the final stage of the parsing of (46), as shown in figure 9.

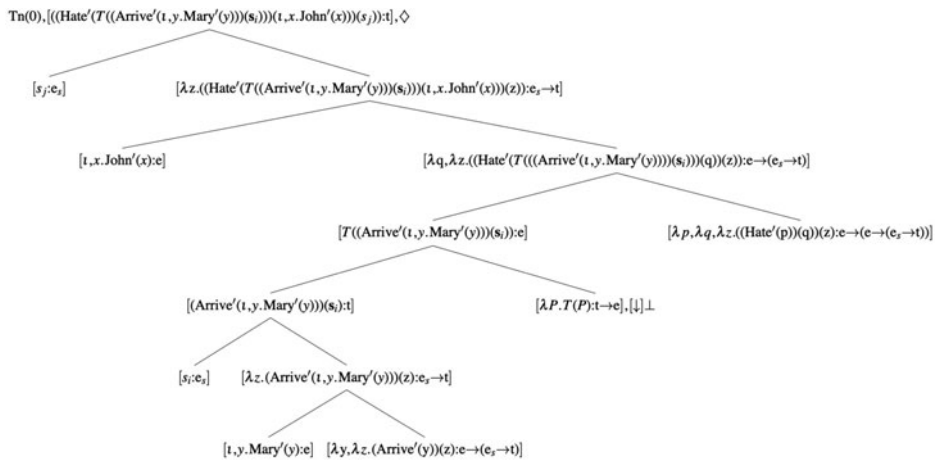


Figure 9. Parsing *John hates when Mary arrived*

This treatment of the *when*-free relative does not make the grammar of English more complex than the treatment of *when* having a single lexical entry with many assumed syntactic structures and unpronounced prepositions. Seen from the parsing perspective that we take, different *whens* parsed under different syntactic conditions make different, though similar to some extent, semantic contributions.

5 Theoretical implications: from *when*-relatives to all relatives

The current study of *when*-clauses reveals a peculiar kind of *when*-relative the head of which is not interpreted as an argument or adjunct of some verb but rather as an argument of the relative operator *when*. The discovery of this kind of relative clause enriches the typological inventory of relative clauses across languages. Although it is unfeasible to look into all types of relatives described in the literature and all existing theoretical accounts of relatives ever proposed, we will reflect on the general theoretical line of thought along which the structural diversity of relatives is characterized in a mainstream account, by briefly comparing the current account with the work contributed by Cinque (2020).⁴

Motivated by the existence of double-headed relative clauses in some languages such as Kombai (de Vries 1993), Cinque (2020) assumes that most, if not all, relatives across languages have a basic double-headed structure. Specifically, a relative clause that modifies a noun phrase has two heads: one is the modified head, dubbed ‘the external head’, and the other a head inside the relative clause itself, dubbed ‘the internal head’. By assuming the application of syntactic-computational operations such as internal head raising, anaphoric matching or the internal head or external head’s being unpronounced, Cinque (2020) is able to account for the generation of a variety of structurally different relative clauses, whether pre-nominal or post-nominal, whether externally headed, internally headed, double-headed, headless, correlative or adjoined (see Cinque 2020: 4). The spirit of this approach to the structural diversity of relative clauses is that assuming a complex underlying structure can also ensure the generation of a variety of surface structures once some modification is applied to the underlying structure because no surface structure is more complex than the assumed underlying structure. Take the English phrase *the two nice books that John wrote* as an example. Cinque’s account of its generation goes as shown in figures 10 and 11. In our view, one can raise doubts as to the theoretical parsimony and empirical tenability of this approach for the following reasons.

Theoretically, in Cinque’s double-head account, the relative clause includes an internal head, which is a repetition of the external head, which we take to be the real head of the relative clause. If a relative clause has an internal head inside itself, then it consists of two parts, the head and an (embedded) modifier clause; this implies that the embedded modifier clause still has its internal head. Along this line of thought, it can be inferred that a relative clause will involve an infinite number of hierarchically embedded modifier clauses, which, however, is short of an empirical foundation. This theoretical

⁴ An anonymous reviewer expresses puzzlement regarding the reason why we selected Cinque’s (2020) work to compare with our own account. We selected Cinque’s work on relatives for a comparison because, as far as we are aware, this is the most recent work (at the time we submitted the manuscript) and it constitutes the most comprehensive account of relatives in English and across languages. By selecting this work and comparing it with our own account, we aim to locate our account within the options available in the theoretical landscape of accounting for syntax–semantics interactions and, hopefully, highlight the merits of our account when compared with a widely accepted and representative account in a mainstream alternative theoretical framework.

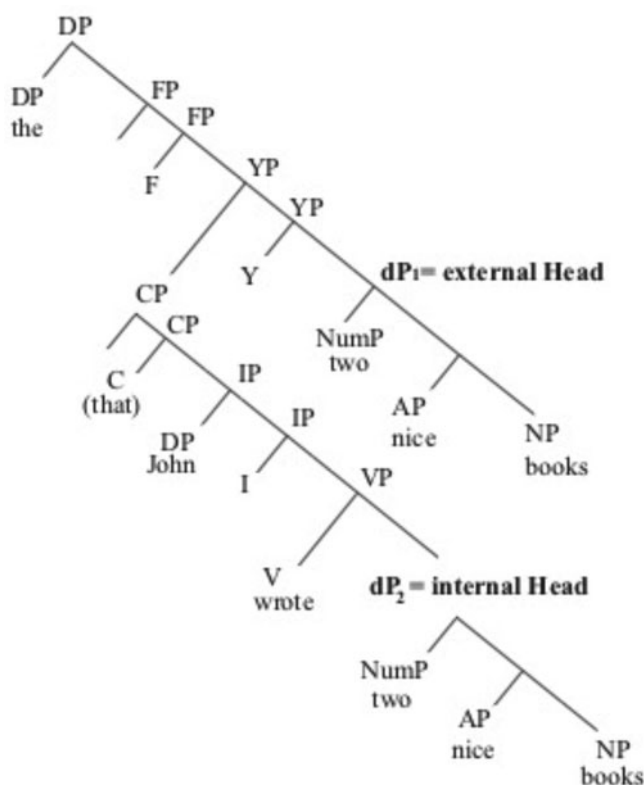


Figure 10. the base generation form (Cinque 2020: 15)

consequence cannot be avoided unless the term ‘internal head’ is not used seriously, in other words, simply meaning an expression that is referentially identical to the (external) head. Besides, the CP that dominates the syntactic structure of the relative clause is located on the specifier position of a phrase YP; but what the head of YP (see figures 10 and 11) accommodates is equivocal; in other words, it does not have a clear empirical foundation. The movement of the internal head to the higher position from its base-generation position is poorly motivated as well. In contrast, from our perspective, the fact that a relative clause and a main clause share some semantic content can be characterized as the sharing of a variable or a term which is restricted twice within the two clauses. The sharing of a variable can be achieved either through grammatical devices such as anaphors/relative pronouns, or by repeating an expression as in the case of double-headed relative clauses, or even by ungrammaticalized pragmatic inference as in the case where no relative pronoun is present, for example, *John hated the dog Mary liked*. Languages cannot be unified with respect to the formal means by which semantic sharing between the main clause and the relative clause is achieved.

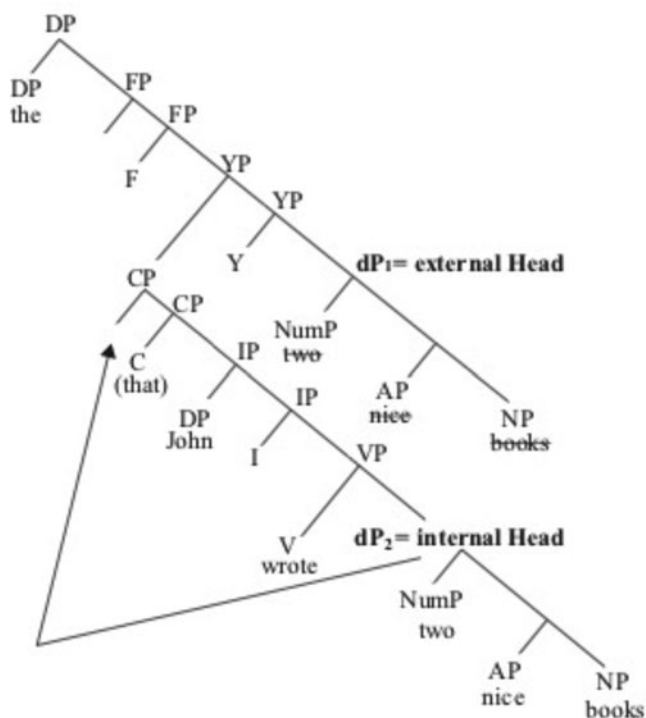


Figure 11. After internal head raising and deletion (Cinque 2020: 17)

Empirically, the double head theory is not sufficient to accommodate the varieties of relative clauses. Let's take the peculiar *when*-relative described in this article as an example. The head of such *when*-relatives can in no way appear inside the relative at all unless many unpronounced syntactic structures and syntactic categories are assumed, which are then faced with the question of how they are recovered. This fact, however, can be simply characterized as the sharing of a variable between two propositional formulas.

6 Conclusion

In this article, against the background of various *when*-clauses already investigated in the literature, we describe a new type of *when*-clause which restricts non-temporal noun phrases. It is argued that *when*-clauses of this new type are functionally similar to typical relative clauses. Based on the description of the new data and discussion of existing syntactic and semantic accounts of *when*-clauses, we propose a novel formal account of *when*, where four *when* lexical entries are recognized, having different syntactic properties and making different, though similar, semantic contributions. The descriptive work presented in this article is not only a classification of *whens* but a further illustration of the diversity of relatives, for the *when_p*-clause that modifies a non-temporal noun phrase, along with many other types of relatives described in the

literature, suggests that the semantic connection between a main clause and a relative clause can be established via various grammatical mechanisms. From a theoretical point of view, the syntactic and semantic properties of the clauses initiated by different *when* lexical items are characterized as lexical procedural information formulated within the framework of Dynamic Syntax. This approach explains the properties of both the syntactic distribution and interpretation of different types of *when*-clauses without assuming a separate syntactic structure over strings or any operations on a syntactic level of representation independently of semantics/pragmatics.

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