The *Complementizer-Trace* Effect from a Statistical Perspective*

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Abstract

This paper sheds a new light on the *Complementizer-Trace* (C-t) effect based on statistic data from English, Swedish and Finnish. We show that a smooth pitch lowering is disturbed in the presence of an overt complementizer for speakers who do not accept the C-t construction, which is shown with insufficient ratio of downstep. This observation applies to an individual speaker, not to an individual language. The more speakers whose pitch is difficult to lower in the presence of an overt complementizer a language contains, that language is more likely to show the C-t effect, which provides a unified account not only for why the C-t effect occurs in languages but also for why the acceptability of the C-t construction differs between the native speakers of a language. We claim that the C-t effect does not arise from syntactic ill-formedness: *wh*-subject extraction should be derived by the same syntactic operations for all languages, with the difference in the acceptability of *wh*-subject extraction attributed to whether the complementizer has phonological features or not.

1. Introduction

The *Complementizer-trace* (C-t) effect (Perlmutter 1971) illustrates one of the differences in the acceptability between the extraction of a subject and that of other sentential elements from embedded clauses. The extraction, e.g. of a *wh*-object, from an embedded clause is acceptable, regardless of whether the complementizer *that* is present or not; see (1a-b). In contrast, the extraction of a *wh*-subject from an embedded clause is not acceptable when the complementizer *that* appears as illustrated in (2a), but it is acceptable when the complementizer is not overt as illustrated in (2b).

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(1) a. What do you think [that Bill wrote __]?
b. What do you think [Ø Bill wrote __]?
(from Kandybowicz 2006: 220, (1b))

(2) a. *Who do you think [that __ wrote the book]?
b. Who do you think [Ø __ wrote the book]?
(from Kandybowicz 2006: 220, (1c))

In generative syntax, the unacceptability of *wh*-subject extraction has long been attributed to a syntactic ill-formedness. Chomsky (1981, 1986) proposed a representational account of the C-t effect, claiming that the trace of a *wh*-subject is illicit due to the violation of the *Empty Category Principle* (ECP). Since Chomsky (1995), an extraordinary amount of derivational accounts of the C-t effect has been proposed. According to Chomsky's (2015) latest account within the framework of *Labeling Algorithm*, when the overt complementizer appears as illustrated in (2a), the boundary of the embedded CP phase is present, which prevents movement of a *wh*-subject; see (3a). When the overt complementizer is deleted, as illustrated in (2b), the phase boundary disappears, which enables a *wh*-subject to be involved in further syntactic operations; see (3b).[1]

(3) a. * … who … **[$_{CP}$ that** [~~who~~ [T [$_{v*P}$ who [wrote [the book]]]]]]

b. ^{OK} … who … [$_{CP}$ that [~~who~~ [T [$_{v*P}$ who [wrote [the book]]]]]]

It has been assumed that not only the semantic component but also the syntactic component are uniform for all languages with the surface difference confined to phonology (the *Uniformity Principle*, Chomsky 2001). If the C-t effect occurred from syntactic ill-formedness, (2a) – which I refer to the C-t construction – should be unacceptable in all languages, contrary to fact. In some languages, the overt complementizer can be optional in *wh*-(subject) extraction; in others it is even obligatory. Even within the same language, the C-t construction may be accepted by some speakers but not accepted by others; see the references given in Kandybowicz (2006). As long as the C-t construction is accepted, it is plausible, contrary to the traditional claim, that the C-t effect is caused by a factor that is outside the syntactic component.

In this paper, I argue that the C-t effect does not arise from syntactic ill-formedness. This

[1] Chomsky claims that after the overt complementizer is deleted, T, instead of C, acts as a phase head. See his paper for the details of his argument. So many other syntactic accounts of the C-t effect have been proposed that I do not review them here. See Pesetsky (2017) for a good summary of the theoretical accounts of the C-t effect in the history of Chomskyan generative syntax, and the references therein.

claim is based on statistic data from English, Swedish and Finnish, involving speakers who accept, and those who do not accept, the C-t construction. The results show that a smooth pitch lowering is disturbed in the presence of an overt complementizer for speakers who do not accept the C-t construction, which is shown with insufficient ratio of downstep. The paper is organized as follows. Section 2 discusses the validity of investigating sound properties of ungrammatical sentences. Section 3 introduces the details of the experimental methods. Section 4 shows the results, and Section 5 analyzes and discusses them. Section 6 discusses how to derive the C-t construction. Section 7 concludes this paper.

2. On investigating sound properties of ungrammatical sentences

Some non-syntactic accounts of the C-t effect have been proposed (Cowart 1997, 2003; Kandybowicz 2006; Sato and Dobashi 2016, among others).[2] Ritchart et al. (2016) conduct a perception study of the C-t effect, concluding that the prosodic approach to the C-t effect is not given any support. They take the following sentence patterns in which, according to Kandybowicz (2006), the C-t effect is ameliorated:

(4) a. ?Who do you think that __ WROTE Barriers?

b. ?Who do you suppose that'll leave early?

In (4a), the embedded verb *wrote* is focused; in (4b), the complementizer *that* is contracted with the Aux(iliary verb) *will*. They claim that since the syntactic structure is the same as the patterns that are judged ungrammatical, i.e. *who do you think that __ wrote Barriers?* (without the focus on the embedded verb) for (4a) and *who do you suppose that __ will leave early?* (without the contraction of the complementizer with the Aux) for (4b), the prosodic approach could be supported if (4a-b) were actually ameliorated. Their stimuli consisted of four patterns, both those with and those without *that*, and the informants were asked to judge the acceptability of them. Their statistic data shows, firstly, that (4a) is judged better than its counterpart without the focus on the embedded verb, regardless of whether the complementizer is overt or not, and secondly, that (4b) and its counterpart without the contraction of the complementizer with the

[2] Cowart (1997, 2003) is the first who conducts an extensive native judgments survey on the C-t effect. Kandybowicz (2006) proposes a phonological account based on Nupe, which shows the C-t effect in the conditions similar to English. Sato and Dobashi (2016) argue that the C-t effect occurs as the overt complementizer cannot make a prosodic phrase with the *wh*-subject trace adjacent to it. See also Bošković (2011) for another PF-based account of the C-t effect and Sato and Dobashi's (2016: 342, ft.3) argument against his claim. McFadden and Sundaresan (2018) attempt to provide an account of the C-t effect in terms of prosodic phrasing, but crucially, their alignment of the English complementizer, i.e. … *that*][… , is wrong.

Aux are both judged worse than the construction without *that*. With these results, they conclude that the prosodic approach is not supported.

There are several methodogical problems in Ritchart et al.'s (2016) experiment. They compare the judgments of sentences that do not have the same meaning. (4a) expresses not only focus on the sentence-initial *wh*-phrase but also contrastive focus on the embedded verb, whereas its counterpart expresses focus on the sentence-initial *wh*-phrase only. Hearing two sentences that have different meanings, the informants could react to them differently to begin with, regardless of whether the complementizer is overt or not. The sound property on the embedded verb, in association with the meaning imposed on it, affects the judgment of the acceptability. They recorded their stimuli by putting a L+H* pitch on the focused embedded verb (Ritchart et al. 2016:322), which could further induce the informants to judge (4a) better than its counterpart.

Crucially, Ritchart et al. (2016) ignore the fact that the complementizer is a function word which is reduced under various phonological/phonetic conditions (cf. Selkirk 1996b). They state that '*[t]hat'll* and *that will* were consistently pronounced as [ðæɾl] and [ðæʔwɪl], respectively' (Ritchart et al. 2016: 324). It is obvious that the complementizer *that* was pronounced as a full form as indicated by the presence of the vowel [æ], which could lead their informants to judge the stimuli with the complementizer *that* as odd and even ungrammatical. The judgment of whether and to what extent it is reduced depends on each speaker. It is highly likely that a complementizer form that a speaker uttered in the certainty that it is reduced may not be accepted as reduced by another speaker. The perception study in which a speaker judges the acceptability by listening to the stimuli that were produced by another speaker thus does not clarify the facts on the C-t effect.

The C-t effect is a particular property of languages that have speech sound. According to Lillo-Martin (1991), American Sign Language does not have an overt marking of the complementizer; it lacks the C-t effect, along with strict constraints on *wh*-extraction. Imagine how we do native judgments: we read test sentences silently to ourselves. To judge whether (2a-b) are grammatical, we silently read both (2a) *who do you think wrote the book?* and (2b) *who do you think that wrote the book?* to ourselves. We are likely to subvocalize both sentences; we may actually utter them in a very small voice. The credibility of native judgments on (the sentences relevant to) the C-t construction is thus owed to our (external or internal) speech sound with which we read test sentences. To clarify the facts on the C-t effect, it is promising to investigate sound properties of the sentences relevant to the C-t construction that are actually produced by speakers.

This means, however, that sound properties not only of grammatical but also of ungrammatical sentences are investigated. In the tradition of phonology and experimental

phonetics (cf. Ladd 2008, Féry 2017), researchers try to describe phonological/phonetic rules and seek principles that will govern all rule systems by studying sound properties of grammatical sentences. A good case is the *wh*-question. It has a general intonation pattern: the focal accent and the pitch peak occur on the *wh*-phrase, whether it is located in sentence-initial position as in English or in a sentence-medial position as in Japanese; after the pitch peak on the *wh*-phrase, the pitch successively lowers. These sound properties have been extensively studied in association with the syntactic and semantic properties of the *wh*-question (cf. Bolinger 1978, Bartels 1999, Ishihara 2007, Richards 2010, Gordon 2016, among others).

In investigating sound properties of ungrammatical sentences, some concerns might occur at the psychological and performance levels. At the psychological level, ungrammatical sentences are negative data and do not exist in a speaker's grammar. It might be questioned whether such sentences can explain their own ungrammaticality. At the performance level, a speaker may read out ungrammatical sentences which she has never uttered before with some disfluency such as pauses and a stammer. Alternatively, a speaker may produce ungrammatical sentences with an intonational contour that is grammatical for her native language, adjusting with her native phonology. Either way, it might be questioned how the production of ungrammatical sentences can be evaluated.

When a sentence is judged odd and even ungrammatical, there are two ways to account for its oddity. One way is that it is not constructed in the syntactic component in a licit way, and it is ungrammatical in a literal sense. The other way is that it is licitly constructed in the syntactic component, but some problem occurs on it during the process of *externalization* (Chomsky 2015) or after it is sent to the morphophonological component (*Distributed Morphology*; cf. Embick and Noyer 2007). As stated in section 1, if the C-t effect occurred from syntactic ill-formedness, the C-t construction should be unacceptable in all languages. But as long as it is accepted by some speakers, it is plausible to think that the C-t construction is built in syntax in a licit way and exists in the grammar. The oddity comes from factors outside the syntactic component, possibly from some morphophonological/sound properties.

In reading out the C-t construction, speakers are likely to adjust its intonational contour with their native phonology, since most of them accept *wh*-object extraction with the overt complementizer. It is predicted that regardless of whether the complementizer is overt or not, *wh*-subject extraction will be produced with the general intonation pattern of *wh*-questions in which the focal accent and the pitch peak occur on the *wh*-phrase, after which the pitch successively lowers. Since the *wh*-subject extraction with the overt complementizer is judged odd, however, it is expected that there will be some difference in sound properties between the *wh*-subject extraction with the overt complementizer that is judged odd and the other extraction sentences that are judged grammatical. Note that our aim is neither to find a specific intonation

pattern of the C-t construction nor to evaluate which is right and wrong between the intonation pattern of the *wh*-subject extraction with an overt complementizer and that of the *wh*-subject extraction without an overt complementizer. We aim to show, with statistic data, whether and to what extent the sound properties of an "ungrammatical" C-t construction differ from other grammatical *wh*-extraction sentences.

3. Methods

3.1. Languages and informants

The study involved 20 informants in total. 11 informants were native speakers of English (7 female, 4 male), 6 native speakers of Swedish (2 female, 4 male) and 3 native speakers of Finnish (3 male). The age ranged from 22 to 65 years old. The interviews and recordings were conducted twice at Newcastle University, UK, once at the University of Turku, Finland, once at Lund University, Sweden, and once at Leiden University, The Netherlands. The informants were staff and students who belonged to one of the four universities.

3.2.Test sentences

The test sentences are given in Appendix I, with the numbering of (i-vi). The sentence types are (i) *wh*-object extraction without an overt complementizer, (ii) *wh*-object extraction with an overt complementizer, (iii) *wh*-subject extraction without an overt complementizer, and (iv) *wh*-subject extraction with an overt complementizer. In addition, there were two other types of extraction tested: (v) *wh*-subject extraction with a reduced complementizer (, which is shown by a subscript, e.g. $_{that}$) and (vi) *wh*-subject extraction with an overt complementizer and a following adverbial phrase. The last two structures were included as it has been reported that the C-t effect is mitigated in those patterns (cf. Bresnan 1977, Kandybowicz 2006).[3] Sentence type (v) was not presented to the Finnish informants. The test sentences used in the first survey at Newcastle University were made with words different from the ones given in Appendix I, but the sentence types were the same as those given there.

3.3. Procedures

The interviews and recordings were carried out by the author in quiet places, such as a small lecture room. Before the recordings, the informants were asked to do native judgments of the test sentences. This study aimed to investigate whether an overt complementizer is accepted

[3] In the traditional Finnish grammar, *kirjoittaneen* in (i) and (iii) is a past participle form, and *kirjoitti* in (ii) and (iv) is a past tense form. Following Huhmarniemi (2012: 202), who claims that the participial form has tense, I assume that the *että* 'that' -clauses in the test sentences are all finite.

when the meaning of relevant *wh*-extraction sentences does not differ, i.e. between (i-ii) and between (iii-v). No additional contexts were provided for the judgments of (i-v). No contexts were provided for the judgment of (vi) either, since it is already known that the overt complementizer can be accepted in this sentence type, as stated above. The results of the native judgments are presented in section 4.

After doing the native judgments, the informants were asked to read out each of the test sentences three times in an appropriately rapid speech. When they stopped with disfluencies such as pauses and stammers, they read out the same sentence again. The informants who accepted neither (iv) nor (v) were asked to read out all the test sentences except (v). The informants who accepted (iv) were also asked to read out all the test sentences except (v). The informants who did not accept (iv) but accepted (v) were asked to read out all the test sentences.[4] The voice of the informants was directly recorded into the author's laptop (LENOVO S21e), into which PRAAT speech processing software (Boersma and Weenink 1996) had been downloaded. 315 tokens were recorded.

3.4. Statistic analyses

The statistic data is shown by computing the ratio of *downstep* (cf. Pierrehumbert 1980, Pierrehumbert and Beckman 1988, Gussenhoven 2004, among others). In this paper, the term *downstep* is used to refer to the pitch lowering between two specified pitch points in a spoken utterance, with the first point taken early and the second point taken somewhere that follows the first point. Downstep is defined as the pitch difference between the first and the second points. The pitch difference is referred to as the downstep size.

First, two pitch points are taken from a) the highest pitch point and b) the lowest pitch point. As stated previously, *wh*-questions have a general intonation pattern in which the focal accent and the pitch peak occur on the *wh*-phrase, after which the pitch successively lowers. The highest peak occurs on the *wh*-phrase (or quite near to it), and it was taken as the highest pitch point. The pitch falls at the end of a *wh*-question in the unmarked case, but depending on speakers, the pitch sightly rises sentence-finally. In the former, the sentence-final position was taken as the lowest pitch point. In the latter, the lowest point before the pitch begins to rise was taken. The downstep ratio from a) to b) was computed.

Secondly, two pitch points are taken from c) the first accentable word preceding the complementizer and d) the first accentable word following the complementizer. In English, the first accentable word preceding the complementizer is the main verb *think* in all the sentence types, and the first accentable word(/phrase) following the complementizer is either the

[4] The Finnish informants, to whom Sentence type (v) was not presented, read out all the test sentences, (i-iv) and (vi).

embedded subject *Bill* in (i-ii), the embedded verb *painted* in (iii-v), or the adverbial phrase located in the embedded subject position *under no circumstances* in (vi). In Swedish, c) corresponds to the main verb *tror* in all the sentence types; d) corresponds to either the embedded subject *Benno* (i-ii), the embedded verb *målade* (iii-v), or the adverbial phrase *under inga omständigheter* (vi). In Finnish, c) corresponds to the main verb *luulet* in all the sentence types; d) corresponds to either the embedded subject *Bill(in)* (i-ii), the embedded verb *kirjoittaneen/kirjoitti* (iii-iv), or the adverbial phrase *ei missään olosuhteissa* (vi); see Appendix I. The downstep ratio from c) to d) was computed. One word of caution, however: the pitch properties of the overt complementizer itself are different in different languages and speakers. Being a function word, it is produced with a high tone in some cases and with a low tone in others. In my recordings, it can also be produced with a creaky voice, and its pitch contour often does not appear.

The fundamental frequency (F0) was extracted and computed for each utterance by using the autocorrelation method implemented in the PRAAT software, with reasonable upper and lower frequency bounds set depending on the gender and vocal characteristics of the speaker. The F0 values extracted at four pitch points a-d), which the PRAAT software measures in hertz (Hz), were converted to *semitones* (st).[5] The interval between any two pitch points measured in Hz can be converted to semitones by the following formula (P1 stands for the first point and P2 for the second point):

(5) 12 * [log(P1/P2) / log(2)]

When the pitch falls in a spoken utterance, the value of the downstep size is positive. The higher the value is, the larger the downstep size is.[6] In my recordings, the time interval between a) and b) is shorter than 3 seconds in most cases, and the time interval between c) and d) does not normally exceed the duration of one second. It can be estimated that the pitch lowering in the sentence types here should be roughly 2 semitones.[7] Thus, a proper instance of downstep in my materials is defined as a pitch decrement between two points larger than 2 semitones: the difference in semitones between two points must be larger than 2 to confirm that downstep actually occurs.

[5] For traditional works, see, e.g. Liberman and Pierrehumbert (1984), who propose to compute the downstep size by exponential decay.

[6] The negative value indicates that downstep does not occur – in fact, upstep occurs.

[7] The estimate here is based on the formula, $D = -11 / t + 1.5$, to compute the *declination* (cf. Gussenhoven 2004) in semitones per second (= D) for utterances shorter than 5 seconds, where t is the duration of the utterance (t' Hart et al. 1990:128; Rietveld and Van Heuven, 2009:311).

4. Results

The result of the native judgments is presented on the next page. The first column shows the information of the speakers, which includes the language, i.e. Eng(lish)., Swe(dish)., and Fin(nish)., the sex, i.e. F(emale) and M(ale), and the informant number, i.e. 1, 2, etc. The second column shows the information of their birthplace, which includes the city name, e.g. Hartlepool, and the country name, e.g. UK. The judgment grade is evaluated as follows: *OK* – grammatical; *?* – acceptable, but slightly degraded; * – ungrammatical. The number codes (i)-(vi) above the judgment grades correspond to the test sentence types, which was introduced in section 3.2: (i) *wh*-object extraction without an overt complementizer, (ii) *wh*-object extraction with an overt complementizer, (iii) *wh*-subject extraction without an overt complementizer, (iv) *wh*-subject extraction with an overt complementizer, (v) *wh*-subject extraction with a reduced complementizer (, which is shown by a subscript, e.g. $_{that}$), and (vi) *wh*-subject extraction with an overt complementizer and a following adverbial phrase. A few cells are blank due to some accidental missing of judgment.

It is shown that *wh*-subject/-object extraction is acceptable for all the speakers when the complementizer does not appear overtly; see columns (i) and (iii). Not all the speakers accept the overt complementizer in *wh*-object extraction. Especially, the British English speakers tend to reject it; see column (ii). For all the languages investigated, there are speakers who reject the C-t construction and those who accept it; see column (iv). Among the speakers who reject the C-t construction, the C-t effect can be mitigated in English when the complementizer is reduced, though such a mitigating effect does not occur in Swedish; see columns (iv) and (v). As reported by the literature given in section 3.2, the C-t effect can be mitigated among the speakers who reject the C-t construction when an adverbial phrase follows the complementizer; see columns (iv) and (vi).

Table 1: Native judgment data

Speakers	Birthplace	(i)	(ii)	(iii)	(iv)	(v)	(vi)
Eng. F1	Hartlepool, UK	OK	*	OK	*	*	OK
Eng. F2	Bolton, UK	OK	*	OK	*	OK	OK
Eng. F3	Frimley-Hampshire, UK	OK	*	OK	OK	*	OK
Eng. F4	Manchester, UK	OK	OK/?	OK	*	OK/?	OK
Eng. F5	Cambridge, UK	OK	*	OK	*	*	?
Eng. F6	Seattle, USA	OK	OK	OK	?	OK	OK
Eng. F7	New Hampshire, USA	OK	OK/?	OK	OK		OK
Eng. M1	Hertfordshire, UK	OK	*	OK	*	OK	*
Eng. M2	Ashington, UK	OK	*	OK	*	OK	*
Eng. M3	Washington DC, USA	OK	OK	OK	*	*	OK/?
Eng. M4	Essex, UK	OK	OK	OK	*	*	OK

Swe. F1	Göteborg, Sweden	OK	OK	OK	*	*	?
Swe. F2	Stockholm, Sweden	OK	OK	OK	*	*	*
Swe. M1	Lund, Sweden	OK	OK	OK	*	*	?
Swe. M2	Ystad, Sweden	OK	OK	OK	*	*	OK
Swe. M3	Göteborg, Sweden	OK	OK	OK	*	*	OK
Swe. M4	Turku, Finland	OK	OK	OK	OK		OK
Fin. M1	Jyväskylä, Finland	OK	*	OK	*		*
Fin. M2	Jämijärvi, Finland	OK	OK	OK	?/*		?
Fin. M3	Turku, Finland	OK	OK	OK	OK		?

Among the informants investigated, though composing a small data set, whether the C-t effect arises or not depends neither on the speakers' language nor on the countries and dialectal areas where they were born.[8]

Figures 1-2 illustrate the pitch properties of the C-t construction.[9] Figure 1 shows the F0 contour of speaker Eng. M4 (Essex, the UK), who does not accept the C-t construction. Figure 2 shows the F0 contour of speaker Eng. F7 (New Hampshire, the USA), who accepts it.[10]

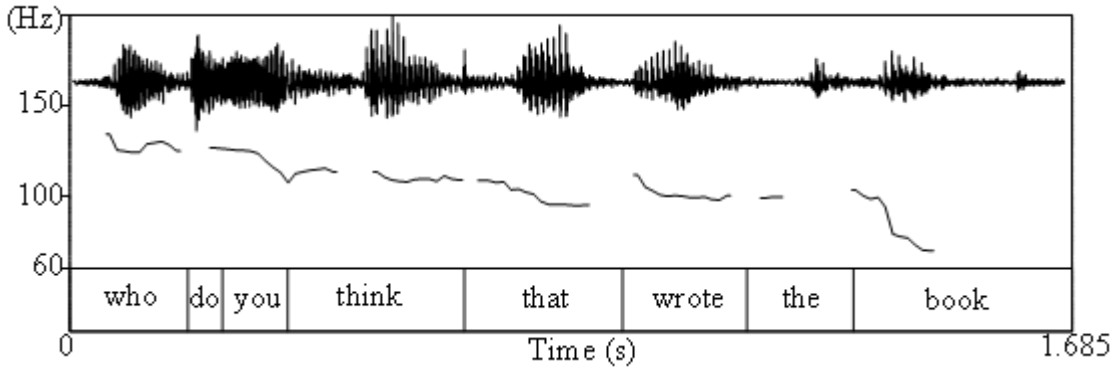


Fig. 1. The F0 contour of Eng. M4 (Essex, the UK), who does not accept the C-t construction.

[8] Unless far more data is collected, no definite conclusion can be drawn on this point, as pointed out by Johan Brandtler (p.c.).

[9] For the English intonational system, see Pierrehumbert (1980), Selkirk (1984, 1996a), Bolinger (1998), Hirst (1998), Gussenhoven (2004), Ladd (2008) and Féry (2017), among others. For the Swedish intonational system, see Bruce (1977, 2005, 2007), Gårding (1998), Gussenhoven (2004), Riad (2014) and Féry (2017), among others. For the Finnish intonational system, see Iivonen (1998), Suomi et al. (2008) and Nakai et al. (2009).

[10] Eng. M4 and Eng. F7 participated in the first survey at Newcastle University. The test sentences were made with words different from the ones given in Appendix I, as stated in section 3.2.

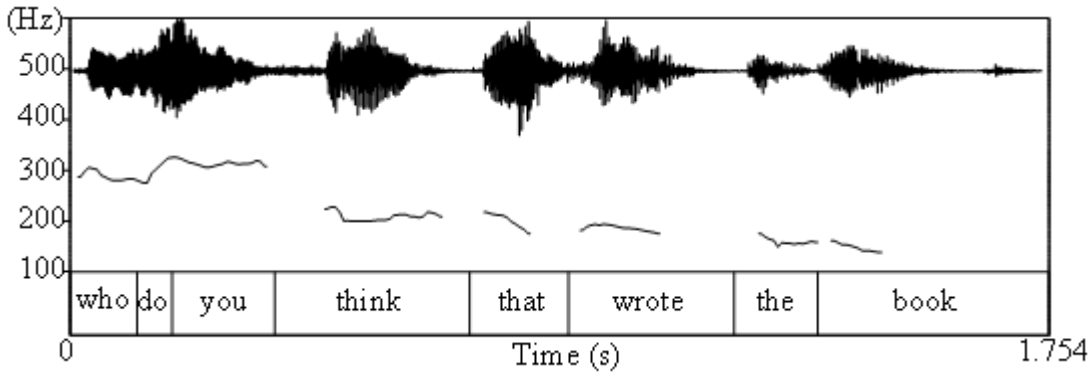


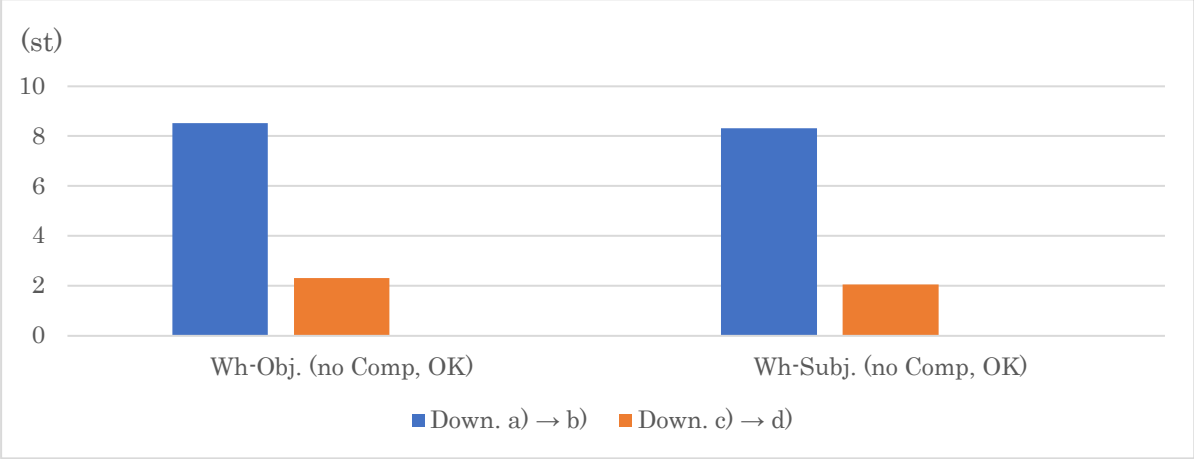
Fig. 2 The F0 contour of Eng. F7 (New Hampshire, the USA), who accepts the C-t construction.

As predicted in section 2, the C-t construction is produced with the general intonation pattern of a *wh*-question, regardless of whether it is judged ungrammatical or not. That is, in both cases above, the focal accent and pitch peak occur on the *wh*-subject *who* in sentence-initial position (or quite near to it); the pitch successively lowers and finally falls at the end of the sentence. This indicates that the speaker who does not accept the C-t construction actually adjusts the intonational contour with the native phonology in its production.

Below, Table 2 shows the mean values of the downstep size (which is abbreviated as Down.) from a) to b) and from c) to d); Graphs visually illustrate the difference in the mean values. In Tables, the data of *wh*-object extraction is firstly presented, since many speakers accept both the presence and absence of an overt complementizer in it. The data of *wh*-subject extraction, in which many speakers reject the presence of an overt complementizer, is then presented to make comparison easier. Table 2 and Graph 1 show the mean downstep size of (i) and that of (iii), both of which were judged grammatical by all the informants. The mean values are computed by taking the values of all the informants interviewed. The result of (i) is shown in *Wh-Obj. (no Comp, OK)*, and that of (iii) is shown in *Wh-Subj. (no Comp, OK)*.

	Down. a) → b) (st)	Down. c) → d) (st)
Wh-Obj. (no Comp, OK)	8.52	2.32
Wh-Subj. (no Comp, OK)	8.32	2.07

Table 2: The mean downstep size of *wh*-object extraction without an overt complementizer, (i), and that of *wh*-subject extraction without an overt complementizer, (iii).



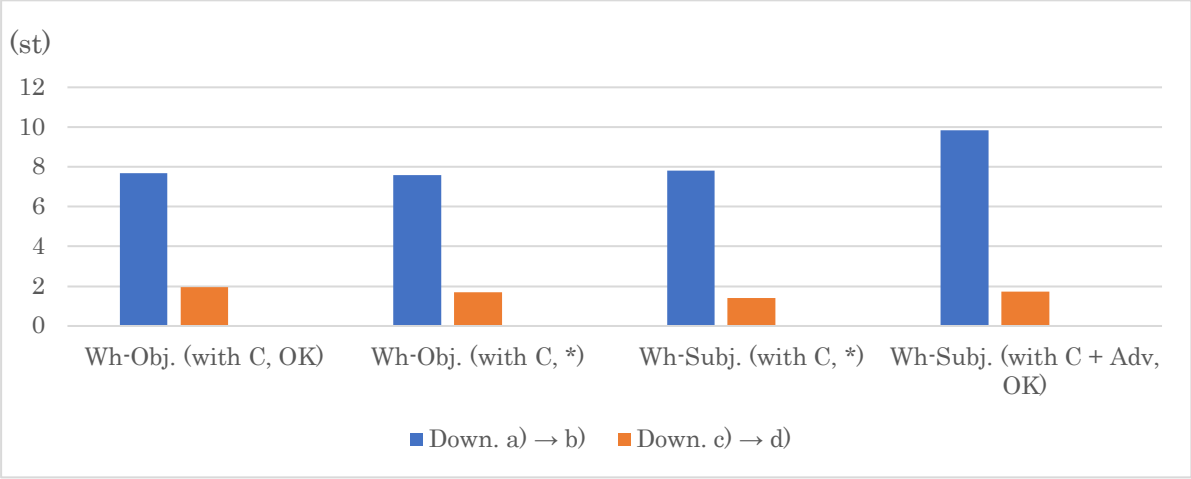
Graph 1: The mean downstep size of *wh*-object extraction without an overt complementizer, (i), and that of *wh*-subject extraction without an overt complementizer, (iii).

The mean value from a) to b) is 8.52 in *wh*-object extraction and 8.32 in *wh*-subject extraction, both of which exceed 2st; see column *Down. a) → b)*. The mean value from c) to d) is 2.32 in *wh*-object extraction and 2.07 in *wh*-subject extraction, both of which exceed 2st; see column *Down. c) → d)*.

Table 3 and Graph 2 show the mean downstep size which is computed by taking the values of the speakers who did not accept (iv), the C-t construction. The values of the speakers who accepted (iv), i.e. Eng. F3, F7, Swe. M4, and Fin. M3, are not included. The mean value of (ii) of those who accepted it is shown in *Wh-Obj. (with Comp, OK)*. The mean value of (ii) of those who rejected it is shown in *Wh-Obj. (with Comp, *)*. The mean value of (iv) is computed by taking the values of all the speakers who did not accept it, the result of which is shown in *Wh-Subj. (with Comp, *)*. The mean value of (vi) is computed by taking those who accepted it, result of which is shown in *Wh-Subj. (with Comp + Adv, OK)*. In all the cases, the mean value from a) to b) exceeds 2st; see *Down. a) → b)*. The mean value from c) to d) does not exceed 2st in any of the cases, however: the mean value of (ii) of those who accepted it is 1.95, the mean value of (ii) of those who did not accept it is 1.71, the mean value of (iv) is 1.41, and the mean value of (vi) is 1.73; see *Down. c) → d)*. The pitch of those who do not accept the C-t construction is difficult to lower in the presence of the overt complementizer.

	Down. a) → b) (st)	Down. c) → d) (st)
Wh-Obj. (with C, OK)	7.69	1.95
Wh-Obj. (with C, *)	7.59	1.71
Wh-Subj. (with C, *)	7.82	1.41
Wh-Subj. (with C + Adv, OK)	9.84	1.73

Table 3: The mean downstep size which is computed by taking the values of the speakers who did not accept (iv).

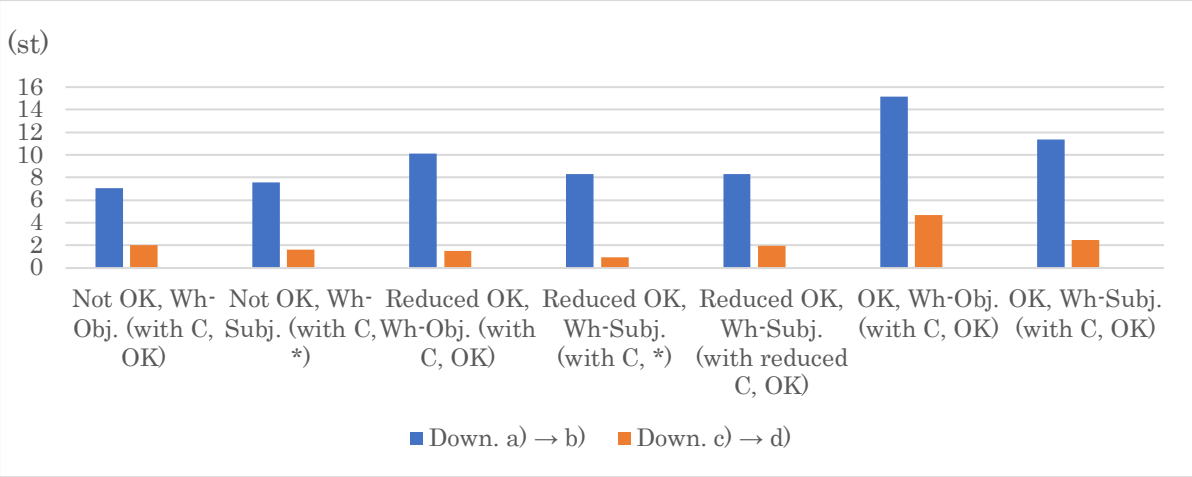


Graph 2: The mean downstep size which is computed by taking the values of the speakers who did not accept (iv).

Table 4 and Graph 3 show the difference in the mean downstep size between the speakers who reject the C-t construction, those who accept a reduced complementizer and those who accept the C-t construction. *Not OK* stands for the speakers who accepted neither (iv) nor (v): Eng. F1, F5, M3, M4, Swe. F1, F2, M1, M2, M3, including Fin. M1 and M2. *Not OK, Wh-Obj. (with Comp, OK)* shows the mean value of (ii) which is computed by taking the values of the speakers who accepted it among the eleven speakers. *Not OK, Wh-Subj. (with Comp, *)* shows the mean value of (iv) which is computed by taking the values of all the eleven speakers. *Reduced OK* stands for the speakers who did not accept (iv) but accepted (v): Eng. F2, F4, M6, M1, M2. *Reduced OK, Wh-Obj. (with Comp, OK)* shows the mean value of (ii) which is computed by taking the values of the speakers who accepted it among the five speakers. *Reduced OK, Wh-Subj. (with Comp, *)* shows the mean value of (iv) which is computed by taking the values of all the five speakers. *Reduced OK, Wh-Subj. (with* $_{Comp}$*, OK)* shows the mean value of (v) which is computed by taking the values of all the five speakers. *OK* stands for the speakers who accepted (iv): Eng. F3, F7, Swe. M4, and Fin. M3. *OK, Wh-Obj. (with Comp, OK)* and *OK, Wh-Subj. (with Comp, OK)* show the mean value of (ii) and that of (iv) respectively, which are computed by taking the values of all the four speakers.

	Down. a) → b) (st)	Down. c) → d) (st)
Not OK, *Wh*-Obj. (with Comp, OK)	7.09	2.05
Not OK, *Wh*-Subj. (with Comp, *)	7.59	1.62
Reduced OK, *Wh*-Obj. (with Comp, OK)	10.11	1.53[11]
Reduced OK, *Wh*-Subj. (with Comp, *)	8.30	0.93
Reduced OK, *Wh*-Subj. (with $_{\text{Comp}}$, OK)	8.29	1.96
OK, *Wh*-Obj. (with Comp, OK)	15.17	4.68
OK, *Wh*-Subj. (with Comp, OK)	11.35	2.50

Table 4: The mean downstep size which is computed on the basis of the difference in the acceptability of the overt complementizer between the informants.



Graph 3: The mean downstep size which is computed on the basis of the difference in the acceptability of the overt complementizer between the informants.

In all the cases above, the mean value from a) to b) exceeds 2st; see *Down. a) → b)*. The mean value from c) to d) of the speakers who accepted neither (iv) nor (v) is 2.05 in *wh*-object extraction and 1.62 in *wh*-subject extraction; the former barely reaches, and the latter does not exceed, 2st. For the speakers who did not accept a full complementizer but accepted a reduced complementizer, the mean value of (iv) is 0.93, which is far smaller than 2st. But the mean value of (v) is 1.96, which is quite closer to 2st. On the contrary, the mean value from c) to d) of the speakers who accepted the C-t construction is 4.68 in *wh*-object extraction and 2.50 in *wh*-subject extraction, both of which exceed 2st; see *Down. c) → d)*.

In sum, as shown in Tables 2-4/Graphs 1-3, the mean value from a) to b) exceeds 2st in all the cases. The pitch lowers throughout the entire sentence, conforming to the general intonation pattern of a *wh*-question, whether *wh*-extraction is judged acceptable or not and whether a complementizer appears overtly or not. Table 2/Graph 1 shows that the mean value

[11] As we saw in Table 2, the mean downstep size of all the grammatical sentences of *wh*-object extraction is 2.07; the mean downstep size of *wh*-object extraction of the speakers who did not accept the C-t construction is 1.95, as shown in Table 3. The computation here is done by taking the values of only two informants. With more informants, this value would be expected to be larger.

from c) to d) exceeds 2st both in *wh*-object extraction and in *wh*-subject extraction when the complementizer does not appear overtly. The pitch of all the speakers lowers smoothly from the main to the complementizer clause in the absence of an overt complementizer. Table 3/Graph 2 shows that the mean value from c) to d) of the speakers who do not accept (iv), the C-t construction, does not exceed 2st in any of the *wh*-extraction sentences with an overt complementizer. The pitch of those speakers does not lower smoothly in the presence of an overt complementizer. Table 4/Graph 3 shows that contrary to the speakers who did not accept (iv), the mean value from c) to d) of the speakers who accepted (iv) exceeds 2st in the presence of an overt complementizer. The pitch of those speakers lowers smoothly even when the complementizer appears overtly.

5. Analyses and discussion

An overall observation from the results above is that while downstep occurs in the entire *wh*-extraction sentence, a smooth pitch lowering is, in the presence of the overt complementizer, disturbed in the pitch contour of the speakers who do not accept (iv), the C-t construction, but is not disturbed in the pitch contour of those who accept it. Some of the speakers who do not accept (iv) do not accept the overt complementizer in *wh*-object extraction either; see the native judgment data given in the previous section.[12] As shown in Table 3/Graph 2, the mean value of (ii), *wh*-object extraction with an overt complementizer, of those who did not accept it is 1.71, contrary to 1.95 of those who accepted it. The pitch is more difficult to lower in the pitch contour of those who reject (ii) than in the pitch contour of those who accept it. For the speakers who did not accept an overt complementizer but accepted a reduced complementizer, the mean value from c) to d) of (iv) is 0.93, but that of (v), *wh*-subject extraction with a reduced complementizer, is 1.96, the latter of which is quite closer to 2st; see Table 4/Graph 3. The pitch of those speakers is difficult to lower when the complementizer is fully pronounced but can lower when it is reduced. These data even suggest that the overt complementizer (of a full form) can actually disturb a smooth pitch lowering in the pitch contour of the speakers who do not accept (iv).[13]

[12] Eng. F3 accepted the overt complementizer in *wh*-subject extraction but not in *wh*-object extraction, and she rejected a reduced complementizer in *wh*-subject extraction. Some individual differences should be taken into consideration to account for individual data.

[13] Whether and to what extent a smooth pitch lowering is disturbed in the presence of the overt complementizer is a physical matter that is not under the control of individual speakers. The speakers who feel the overt complementizer disturbs a smooth pitch lowering will always judge (iv) odd, whereas the speakers who do not feel so will always accept it. The judgments of speakers cannot be changed by their preference or intension. For this physical problem, we cannot answer the question why it is so, which is obviously a significant issue but beyond this paper.

The speakers who do not accept (iv) do accept the overt complementizer in *wh*-object extraction as well as in *wh*-subject extraction when an adverbial phrase follows it; see again the judgement data given in section 4. As shown in Table 3/Graph 2, the mean value of (ii) is 1.95 and that of (vi), *wh*-subject extraction with an overt complementizer and a following adverbial phrase, is 1.73. The downstep size does not exceed 2st, but these constructions are accepted. Recall that d) corresponds to the embedded subject in (ii) and an adverbial phrase located in the embedded subject position in (vi). The final pitch peak is likely to occur on them, and it is expected that the pitch will not lower before and on those sentential elements. But d) corresponds to the embedded verb in (iv). The verb is less prominent than the argument in the unmarked case (cf. Gundel 1988, Cinque 1993, Lambrecht 1994, Selkirk 1996a). It is expected that the pitch should lower on the embedded verb, but it does not in the presence of the overt complementizer, as shown by the mean value of (iv), 1.41; see Table 3/Graph 2. Therefore, the C-t effect arises not only from the difficulty in a smooth pitch lowering in the presence of the overt complementizer but also from an information-structural factor.[14]

The observation here applies to an individual speaker, not to an individual language. The language in which the pitch is difficult to lower in the presence of an overt complementizer for most of the speakers shows the C-t effect, but it can contain some exceptional speakers for whom such difficulty in the pitch lowering does not occur and who accept the C-t construction. The higher number of speakers whose pitch is difficult to lower in the presence of an overt complementizer a language contains, the more likely that language is to show the C-t effect. Thus here, a unified account is provided not only for why the C-t effect occurs in languages but also for why the acceptability of the C-t construction differs between the native speakers of a language.

6. Theoretical analysis

Based on the data of English, Swedish and Finnish, we have shown that some speakers have difficulty in the pitch lowering in sentences with an overt complementizer, due to which they judge such sentences ungrammatical. Our data thus indicate that the C-t effect does not arise from a syntactic ill-formedness. That is, the factor that distinguishes the difference in the acceptability between the *wh*-subject extraction with an overt complementizer and the *wh*-

[14] Sato and Dobashi (2016: 338) report that the construction *who do you think that according to the latest rumors is quitting politics?* sounds like parenthetical intonation of the adverbial phrase with a comma intonation inserted before and after the adverbial phrase and with an L-H% rising boundary tone on the final accentable syllable, i.e. *-mors* of *rumors*. None of my informants, whether he/she accepts the C-t construction or not, showed such intonational properties for (vi) as they describe. Depending on an inserted adverbial phrase, the parenthetical intonation may arise as they claim. But whether the parenthetical intonation arises or not is not crucial to account for (the avoidance of) the C-t effect from the intonational/phonological perspective.

subject extraction without an overt complementizer does not lie in the syntactic operations that derive them. *Wh*-subject extraction should be derived by the same syntactic operations for all languages, whether the *phase* theory (Chomsky 2001, 2004, 2008), *Labeling Algorithm* (Chomsky 2013, 2015), or the *workspace* framework (Chomsky 2019, 2020, 2021), is assumed. The difference in the acceptability of *wh*-subject extraction is attributed to whether the complementizer has phonological features or not.

Let us assume that a syntactic derivation proceeds only by (external and internal) *Merge*, which applies freely (Chomsky 2015), aside from theoretical issues such as Case/φ-feature agreement, feature inheritance (Richards 2007), labeling, etc.[15] A possible way to derive the C-t construction, e.g. *who do you think that built the house?*, is illustrated in (6). Below, verbs are written with a root form: e.g. *build(=R)*. The projections are represented with traditional notation, i.e. with VP, v*P, TP and CP. No functional features are represented, for the sake of simplicity.

(6) [$_{CP}$ who [do(=C) [$_{TP}$ you [T [$_{v*P}$ ~~who~~ [$_{v*P}$ ~~you~~ [think(=R)+v* [$_{VP}$ ~~think(=R)~~
[$_{CP}$ ~~who~~ [that(=C) [$_{TP}$ ~~who~~ [T [$_{v*P}$ ~~who~~ [build(=R)+v* [$_{VP}$ ~~build(=R)~~ [the
house]]]]]]]]]]]]]]]

The Merge operation proceeds step by step in a bottom-up manner, starting with merging *the* and *house*. The embedded verbal root *build(=R)* merges, and moves to the functional verbal head v*.[16] The *wh*-subject *who* merges, which completes the embedded v*P. The embedded T merges, and *who* moves to its Spec. The complementizer *that* merges as the embedded C head, and *who* moves to its Spec. The matrix verbal root *think(=R)* merges to the embedded CP and moves to the functional verbal head v*. The matrix subject *you* merges, which completes the matrix v*P. The *wh*-subject *who* moves from the embedded [Spec,CP] to the outer Spec of the matrix v*P. After the matrix T merges, *you* moves to its Spec. The Aux *do* merges as the matrix C head;[17] *who* moves to its Spec.[18] Due to the *Phase Impenetrability Condition* (Chomsky 2000), which defends the locality of derivation, syntactic units such as VP, v*P, TP, CP are transferred at various points of derivation, depending on the definition of the timing of *Transfer*

[15] In External Merge, a new item merges to another new item or to an existing structure. In Internal Merge, an item merges several times and appears in different positions at the same time, which corresponds to a movement operation.

[16] After which v* is deleted due to its affixal nature, according to Chomsky (2015). Here, I represent v* without a deletion line.

[17] Alternatively, the Aux *do* will merge in a lower head position and move to C, which details I leave aside here.

[18] This is the traditional way of raising a *wh*-subject. Chomsky (2008) claims that a *wh*-subject moves from [Spec,v*P] to [Spec,TP] on one hand, and it also moves from [Spec,v*P] directly to [Spec,CP] on the other, in a parallel manner.

(Chomsky 2015).

A transferred syntactic object cannot be involved in further syntactic operations, but it is not the case that it is immediately sent to phonology (cf. Chomsky 2015). In the derivation illustrated in (6), the complementizer is not assigned phonological features immediately after the embedded CP is transferred. After the structure built by the syntactic operations illustrated in (6) is sent to phonology, it is determined whether the complementizer appears overtly or not. The pitch gesture of the speakers whose pitch always lowers smoothly does not yield any problems in phonology. The complementizer inserted in syntax can appear overtly, as illustrated in (7a). But the speakers whose pitch is difficult to lower in the presence of the overt complementizer do not pronounce it; the phonological features of the complementizer are eliminated in phonology, as illustrated by *that* in (7b).

(7) a. The C-t construction acceptable:
[$_{CP}$ who [do+C [$_{TP}$ you … [think(=R)+v* … [$_{CP}$ ~~who~~ [**that(=C)** [$_{TP}$ ~~who~~ … [build(=R)+v* …

b. The C-t construction unacceptable:
[$_{CP}$ who [do+C [$_{TP}$ you … [think(=R)+v* … [$_{CP}$ ~~who~~ [**that(=C)** [$_{TP}$ ~~who~~ … [build(=R)+v* …

In *Distributed Morphology* (Embick and Noyer 2007, Bobaljik 2017), syntactic operations proceed with syntactic and semantic features only; in the morphophonological component, phonological features that correspond to each of the syntactic and semantic features are inserted. Assuming this framework, the C-t construction will be built in syntax as illustrated in (6), but only with syntactic and semantic features; the phonological features that correspond to each of the sentential elements are inserted in morphophonology. For the speakers who accept the C-t construction, the phonological features which correspond to the complementizer are optionally inserted, but for those who do not accept the C-t construction, the phonological features corresponding to the complementizer are not inserted.

Richards (2016) claims that many syntactic operations occur to satisfy some phonological requirement; sound properties can thus affect the process of syntactic operations. Following his claim, the derivation of the C-t construction will proceed as illustrated in (6), but a condition like below applies in the course of the derivation:

(8) Do not merge an overt complementizer when it prevents a smooth pitch lowering.

(8) does not apply to the speakers who accept the C-t construction. After the embedded TP is built, either the overt complementizer *that* or the phonologically null complementizer C is optionally merged; see (9a). (8) applies to the speakers who do not accept the C-t construction. After the embedded TP is built, only the phonologically null complementizer C can merge; see (9b).

(9) a. The C-t construction acceptable:
[$_{CP}$ who [do+C [$_{TP}$ you … [think(=R)+v* … [$_{CP}$ ~~who~~ [**that/C** [$_{TP}$ ~~who~~ …
[build(=R)+v* …

b. The C-t construction unacceptable:
[$_{CP}$ who [do+C [$_{TP}$ you … [think(=R)+v* … [$_{CP}$ ~~who~~ [**C** [$_{TP}$ ~~who~~ …
[build(=R)+v* …

In the Merge-based derivations illustrated above, neither the trace of the *wh*-subject in the embedded [Spec,TP] nor the complementizer in the embedded C violates any principles or constraints. There is no reason to assume that the operation of merging the complementizer *that*, instead of the null C head, to the embedded TP is problematic. There is no reason either to assume that any problems arise in the entire derivation illustrated above. The syntactic uniformity is maintained, with the difference in the appearance of the overt complementizer confined to morphophonology.[19]

7. Conclusion

Based on the data of English, Swedish and Finnish, all of which contain both speakers who accept, and those who do not accept, the C-t construction, we have shown that in the pitch gesture of the speakers who do not accept the C-t construction, a smooth pitch lowering is disturbed in the presence of the overt complementizer, which has been shown with insufficient ratio of downstep. We have argued that the C-t effect arises not only from the difficulty in a smooth pitch lowering in the presence of the overt complementizer but also from an

[19] The derivation illustrated in (6) cannot avoid the problem of the 'look-ahead' in phonology: the assumption that an overt complementizer merges in syntax and can be eliminated in phonology indicates that the decision to eliminate it depends on the phonological component. The Distributed Morphology-based account avoids the look-ahead problem, but the insertion of an overt complementizer is arbitrarily decided. The phonological constraint-based account avoids the look-ahead problem and decides the condition on the insertion of an overt complementizer, but the proposed constraint is not universal; in addition, phonology would have to know that the overt complementizer will prevent a smooth pitch lowering even before the complementizer merges, as suggested by Johan Brandtler (p.c.). No perfect derivational mechanism exists, actually.

information-structural factor: in *wh*-subject extraction, the pitch should lower on an (embedded) verb which is non-prominent in the unmarked case compared with arguments, but it does not when an overt complementizer appears. The observation here applies to an individual speaker, not to an individual language. The higher number of speakers whose pitch is difficult to lower in the presence of an overt complementizer a language contains, the more likely that language is to show the C-t effect. We have thus provided a unified account not only for why the C-t effect occurs in languages but also for why the acceptability of the C-t construction differs between the native speakers of a language. Our data indicate that the C-t effect does not arise from a syntactic ill-formedness: *wh*-subject extraction should be derived by the same syntactic operations for all languages, regardless of which derivational theory is assumed. With the demonstration of the Merge-based derivation, the difference in the acceptability of *wh*-subject extraction is, we have claimed, attributed to whether the complementizer has phonological features or not.

This paper has dealt with a small data set of 20 informants from English, Swedish and Finnish; more data is necessary to make a definite conclusion on whether the C-t effect is a matter of syntax or phonology. There are also many questions to be solved. An interesting, and important, question is whether the pitch of the speakers who do not accept the C-t construction is difficult to lower in the presence of the overt complementizer in all languages which show the C-t effect, the answer to which is beyond this paper. [20] Another question is how to account for the difference in the acceptability of the overt complementizer between languages. Contrary to the languages discussed here that show the C-t effect, the presence of the overt complementizer is optional, e.g. in Italian (Rizzi 1982); its presence is obligatory, e.g. in Dutch (Perlmutter 1971, Maling and Zaenen 1978). To answer these questions, more detailed study is required, which is left for future research. Despite these problems, it seems to be clear that phonological/phonetic factors are involved in the C-t effect to a significant extent.

[20] I would like to thank Anders Holmberg (p.c.) for letting me notice the importance of this question. Among languages that are reported to show the C-t effect are, for instance, Russian (Pesetsky 1982, 2017), Nupe (Kandybowicz 2006) and French (Rizzi and Shlonsky 2007).

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Appendix I: Test sentences

English:

(i) What do you think Bill painted?
(ii) What do you think that Bill painted?
(iii) Who do you think painted the wall?
(iv) Who do you think that painted the wall?
(v) Who do you think $_{\text{that}}$ painted the wall?
(vi) Who do you think that under no circumstances would betray you?

Swedish:

(i) Vad tror du Benno målade?
what think you Benno painted (‘what do you think Benno painted?’)
(ii) Vad tror du att Benno målade?
what think you that Benno painted (‘what do you think that Benno painted?’)
(iii) Vem tror du målade väggen?
who think you painted the-wall (‘who do you think painted the wall?’)
(iv) Vem tror du att målade väggen?
who think you that painted the-wall (‘who do you think that painted the wall?)
(v) Vem tror du $_{\text{att}}$ målade väggen?
who think you that painted the-wall (‘who do you think $_{\text{that}}$ painted the wall?’)
(vi) Vem tror du att under inga omständigheter skulle förråda dig?
who think you that under no circumstances would betray you
(‘who do you think that under no circumstances would betray you?’)

Finnish:

(i) Mitä luulet Billin kirjoittaneen?
what think-you Bill wrote (‘what do you think Bill wrote?’)
(ii) Mitä luulet että Bill kirjoitti?
what think-you that Bill wrote (‘what do you think that Bill wrote?’)
(iii) Kenen luulet kirjoittaneen kirjan?
who think-you wrote the-book (‘who do you think wrote the book?’)
(iv) Ketä sä luulet että kirjoitti kirjan?
who think-you that wrote the-book (‘who do you think that wrote the book?)
(vi) Kenen luulet, että ei missään olosuhteissa petä sinua?
who think-you that under no circumstances betray you
(‘who do you think that under no circumstances would betray you?’)