An experimental investigation of interrogative syntax/semantics*

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Abstract

Current theories of interrogative syntax/semantics adopt two strategies for the interpretation of in-situ *wh*-phrases: covert movement and in-situ interpretation. The covert movement strategy is traditionally assumed to be all-or-nothing: the in-situ *wh*-phrase covertly moves to C or else stays in-situ and is interpreted in its base-generated position at LF. In this paper we argue that neither approach to *wh*-in-situ can be maintained as is. We present evidence from real-time processing of English multiple *wh*-questions that in-situ *wh*-phrases require *both* covert movement and in-situ interpretation for their computation: an "in-situ" *wh*-phrase undergoes a short movement step, parallel to the behavior of traditional quantifiers such as *every*, immediately upon integration into the structure. Following that step, the *wh*-phrase *can* but *need not* move any further unless independent factors are at play. To account for this pattern we propose the partial movement approach to *wh*-in-situ: A *wh*-phrase must be interpreted at a position with propositional type at LF. *Wh*-phrases in object position are thus never interpreted in their base-generated position; instead some covert movement is always required.

1 Introduction and background

The goal of this paper is to investigate the possible position(s) of in-situ *wh*-phrases at LF. We will argue that both current approaches to *wh*-in-situ—the covert movement approach and the in-situ approach—are insufficient to derive the correct syntax-semantics of *wh*-questions, leading us to propose a new *partial movement* approach to interrogative syntax/semantics, where *wh*-in-situ may be interpreted at any node with propositional type at LF.

In this section we introduce the two traditional approaches to the interpretation of in-situ *wh*-phrases: covert movement and in-situ interpretation and the predictions they make for the position of in-situ *wh*-phrases at LF. We then briefly discuss the experimental methodology that we will use in our experiments to probe for the LF-position of in-situ *wh*-phrases.

1.1 Two approaches to *wh*-in-situ

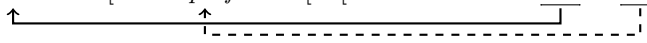
1.1.1 The covert movement approach

Under the covert movement approach to questions, *wh*-phrases must be adjacent to C in order to be able to make their contribution to the meaning of the question. Consequently, no

*For helpful comments, discussions and support, we would like to thank Danny Fox, Irene Heim, Shigeru Miyagawa, David Pesetsky, Micha Breakstone, Alexandre Cremers, Michael Yoshitaka Erlewine, Yasutada Sudo, and the audiences of NELS 44 and MIT Ling-Lunch. This material is based upon work supported by the National Science Foundation under Grant No. 1251717.

wh-phrase may remain in situ at LF; instead, all *wh*-phrases occur syntactically next to the complementizer, regardless of where they are pronounced (Karttunen, 1977; Huang, 1982; Lasnik and Saito, 1992; Hornstein, 1995; Pesetsky, 2000; Richards, 2001; Cable, 2007, a.o.).[1]

(1) **The covert movement approach to *wh*-in-situ**
[*Which student* [*which professor* [C [Fred introduced ___ to ___]]]]



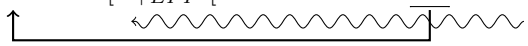
The covert movement approach thus predicts pervasive covert movement in multiple *wh*-questions. Moreover, movement is always triggered for one and the same reason—the semantic needs of the *wh*-phrases themselves, and it always targets the same syntactic position at LF—C. This approach makes the prediction in (2).

(2) **A prediction of the covert movement approach**
All *wh*-phrases in a question must (overtly or covertly) move to C for interpretation.

1.1.2 The *in-situ* approach

Under the *in-situ* approach to questions, no (overt or covert) movement is required in order to assign interrogative meaning to a structure containing *wh*-elements (Hamblin, 1973; É Kiss, 1986; Cheng, 1991; Chomsky, 1995; Reinhart, 1998; Kratzer and Shimoyama, 2002, a.o.). The meaning of in-situ *wh*-phrases can be calculated through a mechanism that passes the meanings of *wh*-words up the structure until they reach C, where they can be interpreted. From this perspective, there is no reason to expect any instances of *wh*-movement that are caused by the semantic needs of the *wh*-words themselves. Even the fact that English questions require overt fronting of one *wh*-phrase is unexpected. To explain this fact, a purely syntactic mechanism must be invoked, unrelated to interrogative semantics, for example an 'EPP' feature requiring C to have a filled specifier (Chomsky, 1981).

(3) **The in-situ approach to *wh*-in-situ**
[*Which student* [C_{+EPP} [Fred introduced ___ to *which professor*]]]



The in-situ approach to questions thus makes no predictions about the position of *wh*-phrases at LF. Following common assumptions in the theoretical literature that the simplest syntactic structure for a sentence is always preferred to a less simple one (Epstein, 1992; Chomsky, 1995; Kitahara, 1997; Collins, 2001; Fox, 2000; Reinhart, 2006, a.o.), it is predicted that *wh*-phrases occupy the position at which they were merged into the syntactic structure. No covert movement occurs for semantic interpretation of *wh*-phrases, (4).

(4) **A prediction of the in-situ approach**
Wh-phrases in a question can be interpreted in situ and do not require any movement.

1.2 Self-paced reading and the Hackl et al. (2012) paradigm

Hackl et al. (2012) develop a paradigm that is able to detect the presence and extent of covert movement in a structure by examining the interaction between quantifiers in object position and Antecedent Contained Ellipsis (ACE). Quantifiers in object position must QR locally to

[1] Straight arrows indicate overt movement, dashed arrows indicate covert movement, and squiggly arrows indicate areas of in-situ interpretation.

the first node of propositional type in the structure to resolve a type mismatch (May, 1977; Heim and Kratzer, 1998, a.o.). ACE requires a constituent containing the ACE-site to QR at least as high as the antecedent (Williams, 1974, 1977; Sag, 1976, a.o.). ACE can be hosted both by quantifiers such as *every* and by non-quantificational determiners such as *the*.

In example (5), ACE can be either ellipsis of a local VP_2 (<treat...>) or non-local VP_1 (<BE reluctant to treat...>). The auxiliary verb unambiguously determines which VP is a possible antecedent: the lower VP_2 with *did*, and the higher VP_1 with *was*. To undo antecedent containment in the structure and resolve the ellipsis, the object relative clause containing the gap site must QR at least as high as its antecedent. Therefore, we expect movement above VP_2 in (5a) and above VP_1 in (5b). In online sentence processing, ACE resolution requires *reanalysis* of the structure assumed by the parser. This operation causes difficulty detectable as a slowdown in Reading Times (RTs) following the detection of ACE by the parser.

(5) The doctor $[_{VP1}$ was reluctant to $[_{VP2}$ treat ...
  a. **the/every** patient that the recently hired nurse ***did*** — local ACE
  b. **the/every** patient that the recently hired nurse ***was*** — non-local ACE
  ... after looking over the test results. — (Hackl et al., 2012)

In sentences with *every*, but crucially not in sentences with *the*, we expect the quantifier to QR immediately upon integration into the structure. We expect this movement to be *local*, and therefore target a position above VP_2 and no higher. As a consequence, local ACE (but not non-local ACE) should be facilitated: movement of the quantifier in object position preemptively undoes antecedent containment in the case of local ACE (5a), and therefore an antecedent is easy to retrieve when the parser reaches *did*. With non-local ACE (5b), however, the parse must be reanalyzed upon encountering *was*. The *every*-DP must move above the higher VP_1 to create an appropriate antecedent, resulting in increased processing cost compared to (5a).

Hackl et al. (2012) tested paradigms as in (5) in a self-paced reading study: participants read sentences that appeared on the screen one word at a time in a moving window display. Residual Reading Times (RRTs) were analyzed for each word in the sentence. Results support the predictions made by QR-based theories of quantifier integration: resolution of local ACE with *every* is facilitated compared to parallel sentences with *the*. Furthermore this effect does not extend to cases with non-local ACE, where *every* no longer has an advantage over *the*.

2 Experiments 1 and 2

In addition to *the* and *every*, *wh*-phrases such as *which* can also host ACE. We can thus use the methodology in Hackl et al. (2012) to experimentally test whether the processing of *wh*-in-situ involves covert movement. All three experiments we present in this paper contained 28 target sentences and 48 filler sentences. Each sentence was followed by a comprehension question. All experiments were conducted online and hosted on IBEX.[2] Participants were recruited through Amazon Mechanical Turk and were paid $1.5 for their participation. Participants were asked about their native language but were told that payment was not contingent on their response. To further ensure that only native speakers of English participated in the experiments, IP addresses of participants were restricted to the US using Amazon Mechanical Turks user interface.

Experiment 1 presented participants with (embedded) *wh*-questions headed by a subject *wh*-phrase. Two factors were crossed: (a) DETERMINER: whether the embedded question contained the quantificational determiner every, yielding a simplex wh-question, or a second *wh*-phrase,

[2] IBEX: Internet Based Experiments, created and maintained by Alex Drummond, accessible at `http://spellout.net/ibexfarm/`.

yielding a multiple *wh*-question; and (b) ELLIPSIS SIZE: whether the sentence contained a small ellipsis marked by *did*, where the antecedent of the ACE site is the embedded VP_2, or large ellipsis marked by *was*, where the antecedent of the ACE site is the higher VP_1. A sample item is given in (6) below:

(6) The conductor asked $[_{CP}$ **which** soloist $[_{VP1}$ was willing to $[_{VP2}$ perform ...
   a. **which/every** concerto that the brilliant protégé ***did*** local ACE
   b. **which/every** concerto that the brilliant protégé ***was*** non-local ACE
   ... and restructured the rehearsal accordingly.

The two approaches to *wh*-in-situ make the following predictions:

(7) a. **Covert movement:** The *which*-DP (with the relative clause, including the ACE-site) moves non-locally to C when *wh* is encountered. Ellipsis resolution is relatively easy for both local and non-local ACE compared to *every*.

   b. **In-situ interpretation:** No movement. The structure must be reanalyzed when the parser encounters the ACE-site. Both local and non-local ACE incur relatively high processing costs compared to *every*.

61 native speakers of English participated in this study. Twenty participants were excluded from the analysis for various reasons.[3] In addition, two target sentences and no filler sentences were excluded from the analysis because of low accuracy (<60% across participants). Questions across the full experiment (targets and fillers) were answered correctly 87.5% of the time across participants; questions for experimental items were answered correctly on 83.3% of trials. Less than 1% of the data was trimmed using a criterion trimming.[4] Figure 1 shows the mean residual reading times (RRTs) for the two regions of interest for the four target conditions.

Results: A linear mixed effects model with random intercepts for subjects and items was fit to the data using R and the R package lme4. The model predicted logRT from the two factors of interest: DETERMINER (every vs. which) and ELLIPSIS SIZE (small ellipsis marked by *did*, vs. large ellipsis marked by *was*). Results show a main effect of determiner at the slot at which the determiner appeared in the sentence (log likelihood tests, p<0.05). This result is driven by the fact that reaction times in the *which* condition were slower than the reaction times in the *every* condition, across both ellipsis conditions. The results additionally show a main effect of ellipsis size two words and three words after the auxiliary site (log likelihood tests, ps<0.05).

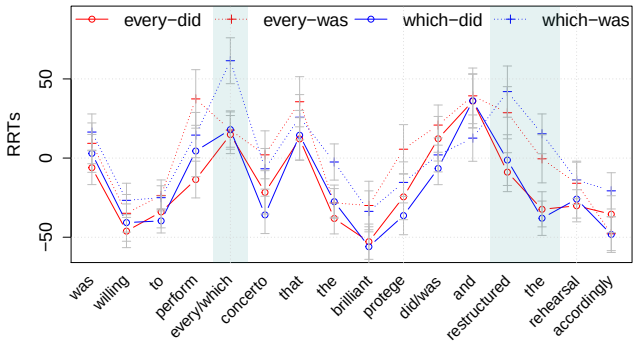


Figure 1: RRTs in target items in Experiment 1

[3]Participants who held the spacebar continuously pressed instead of reading the sentences one word at a time as instructed, who participated in the study more than once, who submitted the entire survey in less than 10 minutes, with an average reaction time of over 700ms, and with low accuracy rates in response to comprehension questions (<75% on filler trials and <75% on target trials) were excluded from the analysis.

[4]RTs from the first and last words of all items, RTs faster than 90ms or slower than 2000ms, and any RTs that were more than 2 standard deviations faster or slower than the average RTs for each subject (calculated per condition) were excluded from the analysis.

This result is driven by the fact that the resolution of small ellipsis is faster than the resolution of large ellipsis for both *every* and *which*. There were no differences between the two determiners at these slots, and there were no other significant effects in the results.

This result is not predicted by both the covert movement approach and the in-situ approach to *wh*-in-situ. Recall that the covert movement approach predicts facilitation of both small and large ellipsis, because the in-situ *wh*-phrase must move to C for interpretation, preemptively undoing antecedent containment in both ellipsis conditions. We would thus expect that RTs for both which conditions, irrespective of whether they involve local or non-local ACE, would be lower than those for the *every* conditions. The in-situ approach, on the other hand, assumes that the *wh*-phrase can be interpreted without any movement at all, and hence predicts no facilitation by an upstream *which* for either the small or large ellipsis conditions. However, the results of Experiment 1 show an effect of ellipsis size but no effect of determiner, which is not explained under both approaches to *wh*-in-situ.

Based on the results of Hackl et al. (2012), we may take the fact that there is no difference between *every-did* and *which-did* to indicate that local ACE resolution is facilitated in both cases. More specifically, if *which* where a determiner that could be interpreted in situ like *the* we should have seen relatively longer RTs for *which-did*, just like Hackl et al. (2012) did for *every-did*. The fact that we didn't shows that *wh*-phrases behave like traditional quantificational determiners such as *every* with regard to ACE resolution in real time.

In Experiment 2, we compare the behavior of *which* and *every* against *the* in the environment of Experiment 1. **Results.** Figure 2 shows the comparison of RRTs following the ACE site for *the* and *which* on the left and *the* and *every* on the right. For both comparisons, we find a significant main effect of ELLIPSIS SIZE two and three words after the auxiliary verb site and a main effect of DETERMINER two words after the auxiliary verb site (log likelihood tests, all $p<0.05$). This effect is driven by the fact that *the* is slower than *which* and *every* for all ellipsis conditions. The results for *every* and *the* are in line with the results of Hackl et al. (2012) in that they show that ACE resolution is more difficult when the ACE site is hosted by a definite DP. Importantly, this is also true when *the* is compared with *which*.

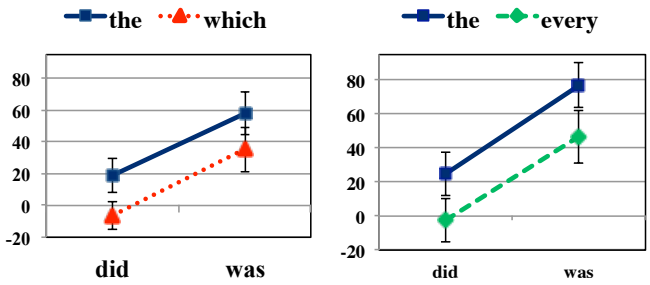


Figure 2: RRTs after the ACE site in Experiment 2

3 Proposal

We have seen in both Experiments 1 and 2 that *which* patterns with *every* in its effects on the resolution of ACE. This is not predicted by either approach to *wh*-in-situ. We propose that the results of Experiments 1 and 2 are explained if *wh*-phrases are quantifiers that must QR locally just like conventional quantifiers such as *every*. Similar proposals have been previously made by several researchers for a variety of languages (Baker, 1970; Dornisch, 2000; Huang, 1995; Kim, 1991; Rullmann and Beck, 1998, a.o.). We propose that once the *wh*-phrase has been integrated into the structure, it does not require any further movement: it is interpreted at the first position where it is interpretable. We propose that the movement step assumed by the parser is the smallest that can produce an interpretable structure:

(8) **The status of *wh*-phrases**
Wh-phrases are existential quantifiers.

(9) **The partial movement approach**
A *wh*-phrase must be interpreted at a position with propositional type at LF.

There is a possible alternative interpretation of Experiments 1–2: the difference between *the* on the one hand and *every* and *which* on the other hand is perhaps not the result of a difference in QR assumed for the interpretation of these determiners, but instead is contributed by some property of *the*, unrelated to its structural integration, which makes definite DPs relatively poor hosts for ACE. If this is true, we can no longer infer from the differences between *every* (and *which*) and *the* that upstream QR has occurred with *every* (and *which*) but not with *the*. The main effect of ELLIPSIS SIZE could be explained as an effect of the *complexity of the antecedent*: integrating a smaller, simpler antecedent into the structure is easier than integrating a larger, more complex one. The main effect of *determiner* would be a consequence of the as yet to be identified property of *the* that makes ACE resolution with it difficult.

Experiment 3 will address this alternative explanation by considering a prediction of the *partial movement* approach: that although *wh*-phrases, in principle, need not move any further than the closest node with propositional type, they may be forced to move higher on independent grounds. This prediction allows us to distinguish between the behavior of *every* and *which* in certain environments, where long-distance *wh*-movement may be necessary, leading us to expect a larger region in the question in which ACE facilitation effects are expected with *which* but not with *every*. If the alternative explanation of the results sketched above is on the right track–that is, if all Experiments 1 and 2 are showing is a complexity effect, then we should not see an increased domain of ACE facilitation effects, because no long-distance QR is assumed when the parser reaches *which*. However, if the *partial movement* approach is on the right track, then additional covert movement may occur in a question and we expect to find facilitation effects of ACE resolution for any ellipsis that is smaller than the landing site of this extended covert movement step. This prediction is summarized below and tested in Experiment 3.

(10) **Predictions of the partial movement approach:** *Wh*-phrases are quantifiers that QR to the nearest propositional node for interpretation. No additional movement is required for the interpretation of a *wh*-phrase, but movement may be forced by external interpretability considerations. *Wh*-movement may target other positions beside C.

4 Intervention effects and Experiment 3

Our proposal implies that longer-distance covert movement of a *wh*-phrase can be caused by material that triggers so called *intervention effects* (Beck, 2006, a.o.). The term intervention effect describes a situation in which a question is rendered ungrammatical because an in-situ *wh*-phrase is c-commanded at LF by an *intervener*, for instance a focus sensitive operator such as *only* or negation. Beck argues that in-situ interpretation of a *wh*-phrase is impossible when an intervener occurs above the *wh*-phrase: in that case, the *wh*-phrase must move above the intervener for interpretation.

(11) **The configuration of an intervention effect (Beck 2006)**:

a. $[_{CP}$ C ... *wh* ... **intervener** ...t_{wh} ...]

b. * $[_{CP}$ C ... **intervener** *wh* ...]

In Experiment 3 we exploit intervention effects to force long-distance covert movement, using *also* as an intervener in the items of Experiment 1. We place *also* in one of two positions: above the lower VP ('was willing to also perform...') or above the higher VP ('was also willing to perform...'). We expect *also* to force covert *wh*-movement above it because *wh*-phrases are uninterpretable when they are in-situ below an intervener. Hence, for the lower placement we expect movement to a position above the lower VP and for the high placement we expect movement above the higher VP. We furthermore expect ACE resolution to be facilitated in the entire domain of movement because the movement will preemptively undo antecedent containment in the structure, making an appropriate antecedent easier to retrieve.

As in Experiment 2, DETERMINER was a between-subject factor: in Experiment 3a participants only saw target items with *every*, and in Experiment 3b they only saw items with *which*. For Experiment 3a we expect to find no sensitivity to the presence and position of *also* because regular quantifiers are not sensitive to intervention effects. Hence, we expect to find a main effect of ELLIPSIS SIZE and nothing else. For Experiment 3b we expect to find an effect of the POSITION OF ALSO: for the high placement of *also*, we expect to find facilitation effects for the resolution of both local and non-local ACE; for the low *also*, we predict that only the resolution of local ACE is facilitated.

Results. Figure 3 shows a comparison of RRTs following the ACE site for *every* on the left and *which* on the right, for the two *also* conditions. We find a significant main effect of ELLIPSIS SIZE for *every*, but a significant interaction of ELLIPSIS SIZE and POSITION OF ALSO for *which* (p's<0.05).

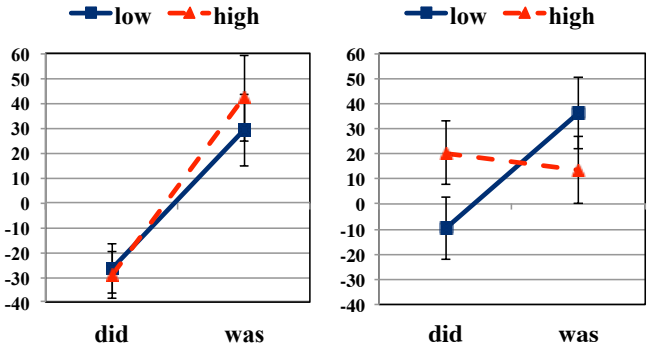


Figure 3: RRTs after the ACE site in Experiment 3

The results partially confirm the predictions of the *partial movement* approach: the *wh*-phrase is interpreted in the lowest position at which it is interpretable. If an intervener forces long-distance movement, ACE resolution is facilitated in the entire domain of movement. That is, when *also* is placed above the higher VP with *which*, the resolution of non-local ACE is facilitated. For *every* and for the low placement of *also* with *which*, only the resolution of local ACE is facilitated, as expected, because movement will only have targeted a position above the lower VP but below the higher VP.

What is unexpected under the *partial movement* approach is that local-ACE is relatively more difficult when *also* is attached high and thus forces non-local movement of the *wh*-phrase. We propose that the relative difficulty of local ACE resolution in this case is the result of a *scope-matching preference effect* observed in both off-line judgments (Hardt and Romero, 2004) and real-time sentence processing (Breakstone et al., 2011): there is a preference for the scope of an expression that hosts an ACE gap to match the size of an elided constituent in the same sentence. The resolution of local ACE is relatively difficult in the case of which-high *also* because more movement has happened than is necessary in order to resolve the local ACE.

5 Conclusion

The results of Experiments 1–3 shed light on the interaction between properties of in-situ wh-phrases and ACE resolution. Our findings suggest the following distribution of *wh*-phrases at

LF: in-situ *wh*-phrases cannot be interpreted in their base position, but also do not necessarily move to C for interpretation. Instead, they can be interpreted at any propositional node in the structure, just like regular quantifiers. Unlike regular quantifiers, however, in-situ *wh*-phrases are subject to intervention effects. Thus, the presence of an element like *also*, which projects a domain of intervention, can force in-situ *wh*-phrases to move higher than a regular quantifier in order to escape the intervention effect.

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