

Intervention effects in relative pronoun pied-piping: experimental evidence*

Hadas KOTEK — *McGill University*

Michael Yoshitaka ERLEWINE — *National University of Singapore*

Abstract. This paper contributes experimental evidence regarding the question of how relative pronouns are interpreted in English non-restrictive relative clauses with relative pronoun pied-piping (RPPP). Kotek and Erlewine (2015) and Erlewine and Kotek (to appear b) claim that the *wh*-relative pronoun is sensitive to *intervention effects* inside its pied-piping constituent (cf Sauerland and Heck, 2003; Cable, 2010; Kotek and Erlewine, to appear). In this paper we present the results of a web-based grammaticality judgment survey which supports this claim. We discuss the nature of the intervention judgment, which is notoriously subtle, and how it might be modeled in grammar. The sensitivity of RPPP to intervention effects has important implications for the formal analysis of English non-restrictive relative clauses, supporting the view that relative pronouns are interpreted in-situ without covert movement out of its pied-piping.

Keywords: relative pronoun, pied-piping, non-restrictive relative clause, intervention effects, grammaticality judgment survey, gradience in grammar

1. Introduction

The literature of the past three decades on the syntax/semantics of *wh*-constructions has identified broadly two different strategies for the scope-taking of surface in-situ *wh*-words: covert movement and in-situ interpretation. See e.g. Pesetsky (1987); Tsai (1994); Reinhart (1998); Cheng (2009) for discussion of these two strategies. Although this literature has overwhelmingly focused on the interpretation of *wh*-in-situ in *wh*-questions, *wh*-words are also used for a range of other purposes and their scope-taking can also be investigated in similar terms. Against this backdrop, in this paper we investigate the interpretation of *wh*-words as relative pronouns in English non-restrictive relative clauses.

Relative pronouns in English relative clauses undergo obligatory fronting to the edge of the relative clause, as in (1). In this simple case, we can interpret the overt movement step as abstracting over the object position of *find*, resulting in the interpretation of the derived predicate “ λx . we found a copy of *x* in the archive” which must hold of the head noun (here, *this letter by Lincoln*). See Heim and Kratzer (1998) for one standard treatment, focusing on English restrictive relative clauses.

(1) **Obligatory relative pronoun fronting in English relative clauses:**

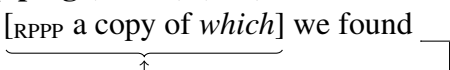
We read this letter by Lincoln, [_{RC} *which* we found a copy of ____ in the archive].

*For comments and discussion we would like to thank Amy Rose Deal, Danny Fox, Martin Hackl, Chris Kennedy, David Pesetsky, Gary Thoms, and audiences at Sinn und Bedeutung 20, CLS 51, and McGill University. The first author is supported by a Mellon fellowship at McGill University. Errors are each other's.

The interpretation of the relative clause is complicated by the availability of *relative pronoun pied-piping* (RPPP). Consider the variant of (1) with pied-piping in (2), which has the same interpretation as (1). In this case, there is not a straightforward way of retrieving the same predicate “ λx . we found a copy of x in the archive” which must hold of the head noun. Although overt *wh*-movement takes place in the derivation of the relative clause, the possibility of pied-piping forces us to consider the interpretation of the relative pronoun as an in-situ *wh*-word, inside its pied-piping.

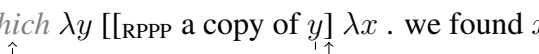
(2) **Optional relative pronoun pied-piping (RPPP) (cf 1):**

We read this letter by Lincoln, [RC [RPPP a copy of *which*] we found _____ in the archive].



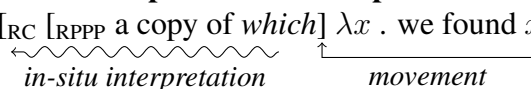
Following the literature on different interpretational strategies for *wh*-in-situ in *wh*-questions, we consider two approaches to the interpretation of relative clauses with RPPP, schematized in (3–4) below. Option 1 involves covertly moving the relative pronoun out of the RPPP to the edge of the relative clause at LF (3), which straightforwardly yields the same derived predicate for the relative clause as in the non-pied-piped variant in (1).¹ Option 2 involves interpreting the *wh*-relative pronoun in-situ within the pied-piping at LF (4). We indicate overt movement with solid arrows, covert movement with dashed arrows, and areas of in-situ interpretation with squiggly arrows.

(3) **Option 1: covertly move the relative pronoun out of the RPPP**

- a. LF: [RC *which* λy [[RPPP a copy of y] λx . we found x in the archive]]
- 
- b. [[RC]] = λy . (λx . we found x in the archive) (a copy of x)
 = λy . we found a copy of y in the archive

(4) **Option 2: interpret the relative pronoun in-situ within RPPP**

LF: [RC [RPPP a copy of *which*] λx . we found x in the archive]



These two options for the analysis of RPPP in non-restrictive relatives make different predictions for the region between the relative pronoun and the edge of the relative clause. The covert movement option (3) predicts that the relative pronoun cannot be inside a syntactic island, inside the pied-piping, whereas alternative computation (4) is not sensitive to islands (see e.g. Rooth, 1985). In contrast, the use of Rooth-Hamblin alternative computation to interpret relative pronouns in-situ (4) is susceptible to so-called *intervention effects*, which we introduce in the following section, but the covert movement option (3) predicts no such sensitivity.

This paper is structured as follows. In section 2 we present background on intervention effects and their use in diagnosing regions of in-situ interpretation. In section 3 we return to the problem of

¹Heim and Kratzer (1998: p. 106) presents Option 1 for pedagogical purposes. Option 1 here also stands in for other options which involve a movement relation between the overt position of the relative pronoun and the edge of the relative clause. For example, a derivation where the head NP (here, *letter by Lincoln*) is moved to its surface position from the position of the relative pronoun, as in the analyses of Kayne (1994); Bhatt (2002) a.o., would also yield a similar structure at LF.

relative pronoun pied-piping (RPPP) and the predictions of the intervention effect diagnostic. We present our experimental paradigm and results in section 4 and conclude in section 5.

2. Background: Detecting in-situ interpretation through intervention effects

2.1. Intervention effects in *wh*-questions

The term *intervention effect* is traditionally used to describe a situation in which a *wh*-question is rendered ungrammatical because an in-situ *wh*-phrase is c-commanded by an *intervener*—certain quantificational and negative elements, as well as focus-sensitive items—at LF (Beck, 2006; see also Beck, 1996; Kim, 2002, a.o.).

Intervention effects are most easily observed in *wh*-in-situ languages such as Japanese and Korean.² In the following paradigm from Beck and Kim (1997), example (5a) shows that Korean questions generally do not require *wh*-fronting. However, when the subject above the in-situ *wh*-word is changed from ‘Minsu’ to the focus-sensitive expression ‘only Minsu,’ the question becomes ungrammatical (5b). This problem can be avoided by scrambling the *wh*-word over ‘only Minsu’ as in (5c), so that the intervener no longer c-commands the *wh*-word. Interveners are bolded and *wh*-words are italicized throughout.

- (5) **Intervention effect in Korean *wh*-questions:** (Beck and Kim, 1997)
- a. Minsu-nun *nuku-lûl* po-ass-ni?
 Minsu-TOP who-ACC see-PAST-Q
 ‘Who did Minsu see?’
- b. * Minsu-**man** *nuku-lûl* po-ass-ni? c. *Nuku-lûl* Minsu-**man** ___ po-ass-ni?
 Minsu-only who-ACC see-PAST-Q who-ACC Minsu-only see-PAST-Q
 Intended: ‘Who did only [Minsu]_F see?’ ‘Who did only [Minsu]_F see?’

The intervention effect in (5b) and its amelioration through scrambling in (5c) motivate the idea that *intervention effects affect regions of in-situ interpretation, not movement* (Beck, 2006; Beck and Kim, 2006; Kotek, 2014). The authors cited here assume a theory of in-situ interpretation that is based on Rooth-Hamblin alternative computation (see Hamblin, 1973; Rooth, 1985: a.o.). Informally, interveners interrupt the projection of alternatives before they reach the interpreting operator—in this case, interrogative C.³ Interveners do not affect overt or covert movement possibilities. The schema in (6) from Beck (2006) reflects the contrast in (5b–c):

²Intervention effects can also be observed in *wh*-fronting languages such as English and German, under certain circumstances. See Pesetsky (2000) and Beck (2006) for details.

³Here we will concentrate on the distribution of intervention effects and be less concerned with the mechanism that causes intervention. See Beck (2006) for one prominent view.

- (6) **Intervention affects in-situ interpretation (alternative computation), not movement:**
- a. * [CP C ... **intervener** ... *wh*] (5b)
- b. ✓ [CP C ... *wh* ... **intervener** ... *t*] (5c)

Here we note that judgments concerning intervention effects are notoriously difficult.⁴ As a result, different authors studying intervention effects have reported the degradation of examples caused by intervention as “*”, “?*”, or “??”. We will simply indicate degraded examples throughout with a “*”. We return to this issue after presenting our experiment in section 4.

2.2. Intervention effects in interrogative pied-piping

Sauerland and Heck (2003), Cable (2007), and Kotek and Erlewine (to appear) show that intervention effects also occur inside pied-piped constituents triggered by interrogative *wh*-movement:⁵

- (7) **Intervention effect in English interrogative pied-piping:** (based on Cable, 2007: p. 262)
- a. ✓ [pied-piping A picture of *which* president] does Jim own ____?
- b. * [pied-piping **No** pictures of *which* president] does Jim own ____?
- c. * [pied-piping **Few** pictures of *which* president] does Jim own ____?
- d. * [pied-piping **Only** PICTURES of *which* president] does Jim own ____?

If an intervener is placed between the *wh*-word and the edge of pied-piping, the result is ungrammatical due to an intervention effect. This is explained by the view that interrogative *wh*-words are interpreted *in-situ* within pied-piping constituents, using Rooth-Hamblin alternative computation (Cable, 2010; Kotek and Erlewine, to appear), as schematized in (8). In (7), only example (7a) is grammatical, because (7b–d) involve an intervener occurring inside the region where alternatives must be projected for the interpretation of the question.

(8) **The pied-piping intervention schema:**

$$*_{[\text{pied-piping} \dots \text{intervener} \dots \text{wh} \dots]} \lambda x . \dots x \dots$$

We know that it is specifically this region within the pied-piping that is sensitive to intervention because different choices of pied-piping size can lead to structures where the intervener is stranded outside the pied-piped material. Such questions are grammatical, as seen in (9) in comparison with (7b) above. This reflects the fact that intervention effects affect Rooth-Hamblin alternative computation, here used to interpret the *wh*-word *in-situ* within the pied-piping constituent, but not structures that are derived through movement chains and interpreted through λ -abstraction.

⁴For example, see discussions in Pesetsky (2000), Tomioka (2007, 2009), and Kotek (2014), as well as Beck (1996: fn. 2) and Butler (2001: fn. 1).

⁵See also Erlewine and Kotek (2014) for parallel results from overt and covert focus movement in English.

(9) **Intervention avoided with smaller pied-piping (cf 7b):** (Cable, 2007)

- a. ✓ [_{pied-piping} Of *which* president] does Jim own **no** pictures ____?
- b. ✓ [_{pied-piping} Which president] does Jim own **no** pictures of ____?

3. Intervention effects in RPPP

We now return to the question of relative pronoun pied-piping (RPPP). Recall from the introduction that there are broadly two approaches to the interpretation of the relative pronoun inside RPPP: movement and in-situ interpretation. These options from (3–4) above are schematized here in (10). Following previous work on the interpretation of interrogative *wh* pied-piping, reviewed in §2.2 above, we take the mechanism of in-situ interpretation in Option 2 to be Rooth-Hamblin alternative computation.

(10) **Two options for the interpretation of relative pronouns with pied-piping:**

- a. Option 1: covertly move the relative pronoun out of the RPPP

LF: [_{RC} *wh*_{RP} λ*y* [[_{RPPP} ... *y* ...] λ*x* *x* ...]

- b. Option 2: interpret the relative pronoun in-situ within RPPP

LF: [_{RC} [_{RPPP} ... *wh*_{RP} ...] λ*x* *x* ...]
alt. computation *movement*

Previous work on the semantics of relative pronouns have largely favored Option 1, or similar movement derivations which yield a substantially equivalent LF representation (e.g. Kayne 1994; Bhatt 2002; see footnote 1), with some authors arguing that in fact a Rooth-Hamblin alternatives-based approach cannot be made to work for RPPP (Sternefeld, 2001; Sauerland and Heck, 2003; see discussion in Kotek and Erlewine 2015). Against this backdrop, in Kotek and Erlewine (2015) and Erlewine and Kotek (to appear b), we develop a semantics for non-restrictive relatives which interprets the relative pronoun in-situ through alternative computation within its RPPP (Option 2), solving the objections to this approach raised by previous authors.

Our proposal which interprets the relative pronoun in-situ using alternative computation (Option 2) was motivated by two new facts regarding RPPP. First, embedding a relative pronoun inside a syntactic island does not lead to ungrammaticality, as observed in (11), reproduced from our previous work. This is unexpected if the interpretation of RPPP necessarily involves movement (Option 1).

(11) **The relative pronoun can be inside an island, inside RPPP:**

This portrait,

- a. ✓ [_{RC} [_{RPPP} the background of *which*] is quite stunning],
- b. ✓ [_{RC} [_{RPPP} the background [_{RC} that was chosen for *which*]] is quite stunning],
 ...sold for a million dollars at auction.

The second fact is that the relative pronoun is sensitive to intervention effects inside its RPPP, in the same way that interrogative *wh*-pied-piping is sensitive to intervention (section 2.2 above). The motivating example for this fact is also reproduced here. Example (12a) provides a baseline. Examples (12b–d) contain interveners and judged as significantly degraded, whereas examples (12e–g) contain various non-intervening determiners and do not exhibit intervention effects.⁶ Note that the set of interveners presented in (12b–d) parallel the determiners shown to be interveners in English interrogative *wh* pied-piping, as in example (7) above.

(12) **Intervention effect in RPPP with known interveners *no, very few, only*:**

I want to try this recipe,

Baseline:

- a. ✓ [RC [RPPP the ingredients for *which*] I (already) have ____ at home].

Interveners:

- b. * [RC [RPPP **no** ingredient(s) for *which*] I have ____ at home].
 c. * [RC [RPPP **very few** ingredients for *which*] I have ____ at home].
 d. * [RC [RPPP **only** [one]_F ingredient for *which*] I have ____ at home].

Non-interveners:

- e. ✓ [RC [RPPP an ingredient for *which*] I'm missing ____].
 f. ✓ [RC [RPPP three ingredients for *which*] I (already) have ____ at home].
 g. ✓ [RC [RPPP many ingredients for *which*] I (already) have ____ at home].

Finally, as is also the case with interrogative *wh* pied-piping (9), intervention is avoided if a smaller pied-piping constituent is chosen which does not contain the intervener:

(13) **Intervention avoided with smaller RPPP:**

I want to try this recipe,

- a. * [RC [RPPP **no** ingredients for *which*] I have ____ at home]. (=12b)
 b. ✓ [RC [RPPP for *which*] I have **no** ingredients ____ at home].
 c. ✓ [RC [RP *which*] I have **no** ingredients for ____ at home].

That relative pronouns in RPPP are sensitive to intervention effects but not islands motivates the interpretation of relative pronouns in-situ through alternative computation (Option 2; 10b), as we argue in Kotek and Erlewine (2015) and Erlewine and Kotek (to appear b).

We note that we have also discovered a second, distinct pattern of judgments for some native speakers, thanks to a comment by Amy Rose Deal at the Sinn und Bedeutung 20 meeting. These speakers report that RPPP is subject to islands, detecting a contrast in pairs such as (11) but that

⁶We report examples (12c–d) with ?? in Erlewine and Kotek (to appear b) as a consensus judgment across various speakers in in-person elicitation. As noted in section 2.1 above, we simply annotate degraded examples with * here.

there is no sensitivity to intervention as in (12). We believe such speakers to represent a minority of the population who may in fact be interpreting RPPP through Option 1 (10a). For present purposes we will concentrate on the pattern of judgments presented above and we leave more careful documentation of this second pattern of judgments for future work.

4. Experiment

We now turn to the contribution of this paper, the results of a web-based grammaticality judgment survey which corroborates our claim that RPPP is sensitive to intervention effects. The experiment presented native speakers with sentences to be judged on a 7-point Likert scale.

4.1. Participants

64 participants were recruited for this experiment through Amazon Mechanical Turk. Participants were paid US\$0.40 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 Turk's user interface. The average time for completion of the survey was 8 minutes and 5 seconds. Two participants were excluded from the analysis because they did not indicate that they were native speakers of English.

4.2. Materials and design

The experiment had a 2×2 design, crossing the presence of an intervener (–intervener, +intervener) with the size of pied-piping (small pied-piping, large pied-piping). Two interveners were used: *no* and *only one*. For items without an intervener, the determiners *every*, *some*, and *a* were used. The small pied-piping option either included movement of the relative pronoun alone or pied-piping of a preposition along with the relative pronoun; the choice was made based on the option that sounded more natural to the authors. Large pied-piping was always of DP size. Eight sets of sentences were constructed, each with four different versions as in (14).⁷ The full set of target items can be found in the Appendix.

(14) **Sample target item:**

My student is studying this letter by Lincoln,

- a. [RC *which* we found a copy of ____ in the archive]. –int., small p.-p.
- b. [RC [RPPP a copy of *which*] we found ____ in the archive]. –int., large p.-p.
- c. [RC *which* we found **only** [one]_F copy of ____ in the archive]. +int., small p.-p.
- d. [RC [RPPP **only** [one]_F copy of *which*] we found ____ in the archive]. +int., large p.-p.

⁷In one item set, (19), an adverb was changed between the +/–intervener conditions, to make each item maximally plausible.

In addition, 24 fillers were included in this study, with the following structure. 6 grammatical sentences and 6 ungrammatical sentences were chosen from the materials in Sprouse et al. (2013). 6 items contained ungrammatical long-distance dependencies. The final 6 contained relative clauses of varying complexity, half appositive and half restrictive, with no pied-piping, which were all grammatical.

To these 32 items, 6 items from a second, separate experiment were added, all containing appositive relative clauses. The resulting 38 items were randomized, and 8 lists were created using a Latin Square design. Each two target items had at least one filler item between them, and there were at least two filler items at the beginning and end of each list. Randomization and list-creation was done using *turktools* (Erlewine and Kotek, to appear a).

Participants were instructed to rate the sentences on a 7-point Likert scale. They were reminded that they might not be uttering the sentences by themselves, but might nevertheless have an intuition as to how natural they are. The scale was marked with numbers 1–7, with 1 being the most unnatural and 7 being the most natural. All participants completed the entire experiment. A counter helped ensure that all sentences were rated.

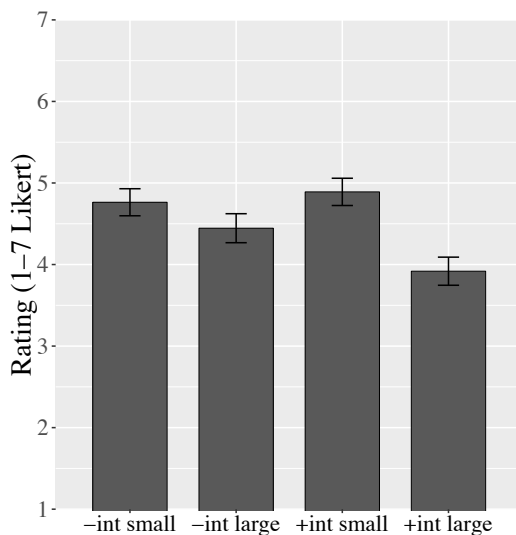
4.3. Results

Filler items were coded as grammatical or ungrammatical, with grammatical items expected to be rated as 5–7 and ungrammatical items expected to be rated as 1–3, on the 7-point Likert scale. The overall accuracy on filler items across participants in this experiment was 88.5%. One filler item was excluded from consideration because of low accuracy rates (54.8%). No other item had an average accuracy rate below 80%. Seven participants were excluded from the analysis because of low accuracy on the remaining 23 filler items (below 75%).⁸

The mean ratings of each condition in the target items are summarized in the table below and also represented in the graph at right. Error bars indicate standard errors. Recall that the crucial condition where an intervention effect is expected is *+intervener, large pied-piping*:

Condition	Mean score
<i>–intervener, small pied-piping</i>	4.74
<i>–intervener, large pied-piping</i>	4.89
<i>+intervener, small pied-piping</i>	4.41
<i>+intervener, large pied-piping</i>	3.92

Table 1: Ratings for each condition (1–7 Likert scale)



⁸Nine participants would be excluded if the accuracy cutoff were raised to 80%. The major results reported below remain unchanged in that case.

A linear mixed effects model was fit to the data using the *R* package *lme4* (Bates and Sarkar, 2007). The model predicted the mean rating of target sentences from the two factors of interest: *intervener* (–intervener vs. +intervener) and *pied-piping* (small vs. large). The model contained random intercepts and slopes for both predictors for subjects and items (Baayen, 2004; Barr et al., 2013).

The results show a main effect of *pied-piping* and a *intervener* × *pied-piping size* interaction. A log likelihood test comparing this model to one without the interaction term was significant, $p < 0.05$. This result is driven by the fact that items that contain interveners inside large pied-piping are degraded compared to items with no intervener, smaller pied-piping, or both. The results of the model are summarized in Table 2.

Predictor	Coefficient	Standard Error	<i>t</i> value
Intercept	4.8804	0.3421	14.264
<i>intervener</i>	−0.1194	0.2668	−0.447
<i>pied-piping size</i>	−0.9673	0.2684	−3.604
<i>intervener</i> × <i>pied-piping size</i>	0.6537	0.2744	2.382

Table 2: Results of the linear mixed effects model

4.4. Discussion

The experimental results reflect a statistically significant effect of intervention, specifically observed in the *intervener* × *pied-piping size* interaction term (Table 2). The interaction term shows that the particular combination of intervener presence and pied-piping size led to a greater effect on item ratings than would be predicted by the effects of intervener presence and pied-piping size alone. This confirms the prediction that RPPP is sensitive to intervention effects.

5. Discussion and conclusion

As we discussed in section 2.1, judgments concerning intervention effects are notoriously difficult across languages and constructions. This was reflected in speaker responses to our RPPP intervention paradigm in (12) as well; see footnote 6. The apparent subtlety of the contrasts in RPPP and potential speaker variation motivated the use of a larger-scale, controlled experiment, to determine whether such an intervention effect as in (12–13) can be established with statistical significance.

Our experiment finds a significant *intervener* × *pied-piping size* interaction, confirming the prediction of intervention effects inside RPPP. However, when examining the raw average ratings across conditions in our experiment, the effect of intervention appears small. The condition of interest (+*intervener*, *large pied-piping*) was judged with an average rating of 3.92, compared to an average rating of 4.68 across the other conditions, on a 7-point Likert scale. This appears to suggest that the intervention effect, while real, is not a strong contrast between categorically grammatical and categorically ungrammatical items.

We would like to offer two thoughts on this issue. First, we are weary of over-interpreting the absolute ratings. Experimental measures of grammaticality are affected by the relative grammaticality of other items presented, including other target items but also fillers. The fact that non-intervention conditions—which we believe to be fully grammatical—were judged with an average rating of 4.68 shows that these target items involving non-restrictive relative clauses were in general complex and difficult to judge. The lower rating of the condition of interest must be judged relative to this lower ceiling, instead of being evaluated over the full 1–7 scale.

Second, experimental research has motivated the existence of *soft constraints* in grammar which lead to gradient judgments of the form reported here (see e.g. Keller, 2000; Sorace and Keller, 2005; Featherston, 2005). The results here may indicate that intervention effects do not result in categorial ungrammaticality, but rather in a detectable degradation in acceptability. This accords with the responses to intervention effect items by native speakers in our in-person elicitation, which we noted above.

There is, however, a potential issue with this account of intervention as a soft constraint. The widely adopted Beck (2006) account for intervention effects, also adopted in our own previous work on intervention in English pied-piping, predicts intervention configurations to be completely uninterpretable, rather than resulting in a systematic minor degradation. We hypothesize that this reflects that there are *two strategies* for the interpretation of pied-piping in the grammar: one preferred strategy, susceptible to intervention, and another strategy which is dispreferred but unaffected by interveners.

There is a precedent for this approach in the domain of interrogative *wh*-intervention. Multiple *wh*-questions can have single-pair or pair-list readings. The addition of interveners in certain English multiple *wh* configurations leads to an intervention effect, which is detected differently by different speakers. Some speakers report that the resulting question is fully ungrammatical whereas others report the loss of the pair-list reading only, with a surviving single-pair interpretation (Petsky 2000: pp. 60–61, Beck 2006: fn. 4). The apparently gradient judgments for interrogative *wh* intervention, then, can be accounted for in this way, as the result of two strategies: a pair-list interpretation strategy which is sensitive to intervention and an alternative strategy which is immune to intervention but does not yield the pair-list reading.⁹

Extending this logic to RPPP, we take our results to indicate that a preferred strategy for relative pronoun interpretation is indeed the intervention-sensitive strategy of Rooth-Hamblin alternative computation (Option 2). However, the fact that our crucial intervention items are not strictly ungrammatical may reflect the existence of an alternative, generally dispreferred interpretational option available to at least some speakers, which may be a movement-based variant (Option 1). Further work is necessary, both empirically and theoretically, to understand this aspect of intervention effects.

⁹See Butler (2001) for a sketch of how this may be achieved within a dynamic semantic approach, and Kotek (2014) for the idea that the remaining interpretational mechanism is one that produces echo-questions.

References

- Baayen, R. H. (2004). Statistics in psycholinguistics: A critique of some current gold standards. In *Mental Lexicon Working Papers*, Edmonton, pp. 1–45.
- Barr, D. J., R. Levy, C. Scheepers, and H. Tily (2013). Random effects structure for confirmatory hypothesis testing: Keep it maximal. *Journal of Memory and Language* 68(3), 225–278.
- Bates, D. M. and D. Sarkar (2007). lme4: Linear mixed-effects models using S4 classes. R package version 0.9975-12, URL <http://CRAN.R-project.org/>.
- Beck, S. (1996). Quantified structures as barriers for LF movement. *Natural Language Semantics* 4, 1–56.
- Beck, S. (2006). Intervention effects follow from focus interpretation. *Natural Language Semantics* 14, 1–56.
- Beck, S. and S.-S. Kim (1997). On *wh*- and operator scope in Korean. *Journal of East Asian Linguistics* 6, 339–384.
- Beck, S. and S.-S. Kim (2006). Intervention effects in alternative questions. *Journal of Comparative German Linguistics* 9, 165–208.
- Bhatt, R. (2002). The raising analysis of relative clauses: evidence from adjectival modification. *Natural Language Semantics* 10, 43–90.
- Butler, A. (2001). Intervention effects in English questions. In *Proceedings of Szklarska Poreba Workshop 2*.
- Cable, S. (2007). *The Grammar of Q*. Ph. D. thesis, Massachusetts Institute of Technology.
- Cable, S. (2010). *The Grammar of Q: Q-particles, wh-movement, and pied-piping*. Oxford.
- Cheng, L. L.-S. (2009). *Wh*-in-situ, from the 1980s to now. *Language and Linguistics Compass* 3(3), 767–791.
- Erlewine, M. Y. and H. Kotek (2014). Intervention in focus pied-piping. In H.-L. Huang, E. Poole, and A. Rysling (Eds.), *Proceedings of NELS 43*, Volume 1, pp. 117–130.
- Erlewine, M. Y. and H. Kotek (to appear a). A streamlined approach to online linguistic surveys. *Natural Language & Linguistic Theory*.
- Erlewine, M. Y. and H. Kotek (to appear b). The structure and interpretation of non-restrictive relatives: Evidence from relative pronoun pied-piping. In *Proceedings of CLS 51*.
- Featherston, S. (2005). Magnitude estimation and what it can do for your syntax: some *wh*-constraints in German. *Lingua* 115, 1525–1550.

- Hamblin, C. (1973). Questions in Montague English. *Foundations of Language* 10(1), 41–53.
- Heim, I. and A. Kratzer (1998). *Semantics in Generative Grammar*. Blackwell.
- Kayne, R. (1994). *The Antisymmetry of Syntax*. MIT Press.
- Keller, F. (2000). *Gradience in grammar: Experimental and computational aspects of degrees of grammaticality*. Ph. D. thesis, University of Edinburgh.
- Kim, S.-S. (2002). Intervention effects are focus effects. In *Japanese/Korean Linguistics 10*, pp. 615–628.
- Kotek, H. (2014). *Composing Questions*. Ph. D. thesis, Massachusetts Institute of Technology.
- Kotek, H. and M. Y. Erlewine (2015). Relative pronoun pied-piping in English non-restrictive relatives. Manuscript, McGill University and National University of Singapore.
- Kotek, H. and M. Y. Erlewine (to appear). Covert pied-piping in English multiple *wh*-questions. *Linguistic Inquiry*.
- Pesetsky, D. (1987). Wh-in-situ: movement and unselective binding. In E. J. Reuland and A. G. B. ter Meulen (Eds.), *The representation of (in)definiteness*, pp. 98–129. MIT Press.
- Pesetsky, D. M. (2000). *Phrasal movement and its kin*. Number 37 in Linguistic Inquiry Monographs. MIT Press.
- Reinhart, T. (1998). Wh-in-situ in the framework of the Minimalist Program. *Natural Language Semantics* 6, 29–56.
- Rooth, M. (1985). *Association with Focus*. Ph. D. thesis, University of Massachusetts, Amherst.
- Sauerland, U. and F. Heck (2003). LF-intervention effects in pied-piping. In *Proceedings of NELS 33*, pp. 347–366.
- Sorace, A. and F. Keller (2005). Gradience in linguistic data. *Lingua* 115, 1497–1524.
- Sprouse, J., C. Schütze, and D. Almeida (2013). A comparison of informal and formal acceptability judgments using a random sample from linguistic inquiry 2001-2010. *Lingua* 134, 219–248.
- Sternefeld, W. (2001). Partial movement constructions, pied piping, and higher order choice functions. In *Audiatur Vox Sapientiae: A Festschrift for Arnim von Stechow*, pp. 473–486.
- Tomioka, S. (2007). Pragmatics of LF intervention effects: Japanese and Korean interrogatives. *Journal of Pragmatics* 39, 1570–1590.
- Tomioka, S. (2009). Why-questions, presuppositions, and intervention effects. *Journal of East Asian Linguistics* 18, 253–271.
- Tsai, W.-T. D. (1994). *On economizing the theory of A-bar dependencies*. Ph. D. thesis, Massachusetts Institute of Technology.

Appendix: experimental items

Below are the target items used in our experiment. Each item set is comprised of four conditions, presented here in this order:

- a. –intervener, small pied-piping
 - b. –intervener, large pied-piping
 - c. +intervener, small pied-piping
 - d. +intervener, large pied-piping
- (15) The detective solved the Willis murder,
- a. which the police had interviewed every witness to.
 - b. every witness to which the police had interviewed.
 - c. which the police had interviewed only one witness to.
 - d. only one witness to which the police had interviewed.
- (16) Susan is preparing a story on the Zika virus,
- a. which she's interviewed some researchers of.
 - b. some researchers of which she's interviewed.
 - c. which she's interviewed no researchers of.
 - d. no researchers of which she's interviewed.
- (17) Agent Sanders was assigned to investigate the use of marijuana,
- a. which she recognizes every slang term for.
 - b. every slang term for which she recognizes.
 - c. which she recognizes no slang term for.
 - d. no slang term for which she recognizes.
- (18) This is a very rare delicacy,
- a. for which a recipe has appeared in print.
 - b. a recipe for which has appeared in print.
 - c. for which no recipe has appeared in print.
 - d. no recipe for which has appeared in print.
- (19) Mathematicians love to discuss the Graph Isomorphism problem,
- a. for which a solution has now been found.
 - b. a solution for which has now been found.
 - c. for which no solution has ever been found.
 - d. no solution for which has ever been found.

- (20) I want to watch the new Kristovsky film,
- a. which I've seen a review of.
 - b. a review of which I've seen.
 - c. which I've seen only one review of.
 - d. only one review of which I've seen.
- (21) My student is studying this letter by Lincoln,
- a. which we found a copy of in the archive.
 - b. a copy of which we found in the archive.
 - c. which we found only one copy of in the archive.
 - d. only one copy of which we found in the archive.
- (22) Malcolm wrote his thesis on The Cartessan War,
- a. which he actually read every book about.
 - b. every book about which he actually read.
 - c. which he actually read no book about.
 - d. no book about which he actually read.

reproduced above as (14)