Propositional anaphora and alternatives in the semantics of *in which case* *

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Abstract

Recent decades have seen a wealth of research on appositive relative clauses. In this paper, we look at a closely related construction: parentheticals introduced by *in which case* (IWCs). We show that IWCs share many major properties with appositives, but also one major difference: they impose a requirement for epistemic alternatives to the content of their anchor. We develop a formal account of IWCs extending AnderBois, Brasoveanu & Henderson (2015)'s formalism and show how together with a suitable alternative requirement, this derives their similarities and differences. Finally, we turn to examine the compositional source of this requirement, building on Moltmann (2021)'s proposal for other instances of the English noun *case* in other constructions and arguing that this is the source of the requirement.

Keywords: Alternatives, Appositives, Cases, Conditionals, Discourse reference, Dynamic Semantics, Propositional anaphora

1 Introduction

Much has been written in the last 20 years about the semantics and pragmatics of appositive/non-restrictive relative clauses. Specifically, much of that focus as been on appositives with an individual "anchor", (1). However, it has also long been known that appositive RCs can have anchors of various other semantic types, including propositions, (2).

(1)   Bettina might have talked to Leydi, who is the director of the institute.

(2)   Zhang San might be stuck in traffic, which would be surprising.

At first blush, sequences with *in which case* appear to function quite similarly to (2):

(3)   Zhang San might be stuck in traffic, in which case I would be surprised.

Looking more broadly at other examples, however, we see that the construction with *in which case* is significantly more restricted. For example, removing the possibility modal from (2-3), as in (4-5), yields a clear contrast:

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(4)   Zhang San got stuck in traffic, which was surprising.

(5)   # Zhang San got stuck in traffic, in which case I {was/will be/would be} surprised.

In this paper, we explore the semantics of *in which case*, including the restriction on its anchors we have just illustrated. Concretely, we will propose that *in which case* requires that there be epistemic alternatives to its anchor. After exploring the nature of this requirement and formalizing the dynamic update semantics involving it, we turn to examine the source of this requirement, considering two main options:

  i. The alternative requirement is due to this use of *which* exhibiting D-linking, similar to interrogative *which* (Pesetsky (1987) et seq)

  ii. The alternative requirement is due to the noun *case* exhibiting an requirement for alternatives (something Moltmann (2021) has proposed for other uses of the noun *case*)

We find that neither option proves straightforward. The kinds of alternatives needed for *in which case* differ in key ways from both of these potential sources as characterized in previous literature. We propose an analysis that builds on Moltmann (2021)'s claims about *case*, refining her claims about *case* (though we leave a full revisiting of all of the various uses of *case* to future work). From there, we develop a formal account of *in which case* constructions, building on AnderBois et al. (2015), a dynamic semantic framework making use of individual and propositional discourse referents (and which we extend to event predicate drefs to handle certain cases).

The paper is structured as follows: §2 presents the major properties of *in which case*, including its requirement for alternatives; §3 develops the core account of the dynamic semantic analysis; §4 shows how the alternative requirement combined with the semantics in §3 account for the core data; §5 examines the compositional source of the requirement for alternatives, comparing *in which case* with *in that case*; and §6 concludes.

2   Semantic/pragmatic properties of *in which case*

In this section, we introduce some basic terminology to talk about the components of *in-which-case* construction (henceforth **IWCs**) and establish some basic generalizations about them. We can schematically characterize IWCs as in (6). We will be somewhat loose and use these terms for either the syntactic objects or their corresponding denotations.

(6)   **Schema for an IWC of the form:** $Op(p)$, in which case, q
        Matrix/main clause: $Op(p)$
        in-which-case clause (IWC clause): *in which case, q*
        Anchor: p, the clause on which the IWC-clause comments
        Consequent: q

For a simple example like (7a), the components are as in (7b)

(7)   a. It might rain, in which case we will get wet
        b. **Components of (7a):**

> **Main clause:**, "It might rain"
> **IWC clause:**, ", in which case, we will get wet"
> **Anchor:**,"It rains"
> **Consequent:**, "we will get wet"

Now we move on to present various possible anchors (and impossible anchors) for *in which case*[1]. Consider first the case of modal anchors:

Modals

(8) a. That report **might** have been prepared before the fare increases, in which case Portland would indeed miss the cut. **COCA**

   b. * The prisoner **must** have escaped, in which case could you go look for him?

(9) a. You **may** leave now, in which case, you will still be marked present.

   b. * You **must** save the kid, in which case you can get to heaven.

(10) a. Context: John wants to travel to Boston from Providence. He wants to know what transportation method he should use. So he asks Bill. Bill says:
   Take the MBTA train, in which case, you will see great scenery along the way.

   (Weak imperative)

   b. * Put your hand in the air! In which case, I won't shoot you. (Strong imperative)

In (8a-8b), we see that "in which case" can be felicitously used with an epistemic possibility modal but cannot be readily used with a necessity one. The intuition is that using a possibility modal $\Diamond p$, the speaker is merely suggesting that p is possible and leaves open the alternative $\neg p$. However, using a necessity modal $\Box p$, assuming that the speaker is speaking seriously and truthfully, the speaker is suggesting that he is certain of p and has ruled out the alternative $\neg p$. "in which case" can pick up p in $\Diamond p$ because p is left open and has alternatives, but not in $\Box p$.[2] We return to the case of deontic modals and imperatives in §4.3 below, but the main intuition is similar.

Looking beyond modals, we see that the same basic intuition can be found with disjunctions, embedding verbs, questions, and tense. We return to the more interesting cases in subsequent sections, but merely present the data here.

Disjunction

(11) Either it will be raining tomorrow, in which case I will bring an umbrella, or it will be sunny tomorrow, in which case I will wear a big hat.

(12) * [I will either get an A or I will get a B], in which case, I will make it to the Dean's List.

Reportatives vs. factive verbs

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1 Data here are a mix of constructed examples confirmed informally with speakers of American English and corpus examples from Davies (2008-) (marked with **COCA**).

2 We will of course make precise and elaborate on this intuition further in §4. Right now, we are just motivating our analysis with this intuition, which should hopefully be clear.

(13)   I heard that the match will be popular, in which case I better buy tickets now.

(14)   * The professors know that some students will cheat in the exam, in which case they will punish them.

Question-related constructions

(15)   **Was he talking about shrubbery** because I don't think I would like eating shrubbery no matter how it was prepared or how often I tried it **or was he referring to the band Bush** in which case I agree, they are an acquired taste.   **COCA**

(16)   I wonder whether John went to the party, in which case I will talk to him later.

Tense and mood

(17)   * It will rain tomorrow, in which case, I will bring an umbrella.   (Simple future)

(18)   * It was sunny yesterday, in which case, I will regret not going out for a walk.   (Past)

(19)   * It is raining, in which case, I will bring an umbrella.   (Present imperfective)

The intuition here is the same as the case of epistemic modals. For example, a reportative "heard" does not entail its prejacent at all (leaving $\neg p$ open), while a factive like "know" entails p and so certainly rules out $\neg p$, given that the speaker is semantically competent. Thus, the above data seems to motivate the following generalization on the distribution of IWCs:

(20)   **Epistemic alternative requirement (discussed further in §5)**

   a. A proposition p has epistemic alternatives iff p is not entailed (semantically or pragmatically) by the speaker's discourse commitments.

   b. Anchors of IWC clauses need to have epistemic alternatives.

All the cases in which IWC is licensed thus far involve uncertainty: "might", questions, reportatives, disjunction. Each of them suggests some kind of uncertainty about whether their prejacents are actually true. In contrast, for example, factive verbs entail their prejacents, present/past tense seems to express definite facts about the present and the past. We will see some complications to this picture in §5, but for the moment we will preliminarily assume this generalization to be right and turn now to analyze *in which case* clauses in light of it.

3   Analysis

In this section, we will develop our analysis by laying it out for the following sentence:

(21)   It might be raining, in which case I will stay inside.

3.1 Component I: Conditional semantics for *in case*

Following Declerck & Reed (2001: pp.21-25), Mackenzie (2024), we take the semantic contribution of "in case" here to be a conditional one. The semantic contribution of (21) can therefore be broken down informally into: (i) *it might be raining*, and (ii) *if it is raining, I will stay inside*. This conditional semantics corresponds quite directly to the forms that are possible in IWC clause, including modals like *will* as above, as well as *would* in counterfactual cases like (22) where the main clause occurs in past tense (or more precisely, the anaphorically retrieved conditional antecedent as interpreted in the IWC, see §3.3).

(22) It might have rained, in which case we would have become all wet.

This also explain the contrasts in (23-24) since the materials in the (a) examples can independently serve as conditional consequents.

(23) a. It might be raining, in which case, can you bring me an umbrella?

b. #It might be raining, which can you bring me an umbrella?

(24) a. Or maybe you're the one getting married, in which case, mazel tov! **COCA**

b. # Or maybe you're the one getting married, which mazel tov!

3.2 Component II: *which* comments on a discourse referent

Since the anchor, "It is raining", is notably not the matrix clause itself, we need some apparatus to model and explain how the anchor compositionally factors into the IWC. Drawing inspiration to other parentheticals with *which* (e.g. del Gobbo (2003) et seq.), we take this relationship to be an anaphoric one. Specifically, here it is a propositional discourse referent (dref) that *which* picks up, with the IWC commenting on the propositional dref. This approach makes a clear prediction: the range of licit main clauses should be all and only those that introduce a propositional dref for the anchor. N.B. as we will see in §4.3, this generalization ends up being slightly too restrictive in the case of deontic modals and imperatives.

In light of prior research on propositional drefs (Asher (1993), Snider (2017), and references therein), this in turn means that the operators in the main clause must be ones that introduce propositional drefs for their scopes. We follow Snider (2017)'s account of what propositional drefs are present at the time of uttering the IWC clause. To use (21) as the example: The matrix clause of (21) introduces two propositional drefs: (i) "it might be raining" (automatically introduced), and (ii) It is raining (set up by "might"). The semantics of IWC as we proposed above allows it to pick up (ii). That (i) cannot serve as the anchor is explained by the Epistemic Alternative requirement motivated earlier. Another nice consequence of this simple semantics is that the negation of the prejacent, "it is not raining", is not introduced as a dref despite its salience. It is therefore correctly predicted to be unavailable for IWCs:

(25)   ? It might be raining, in which case the ground outside will be quite dry.

3.3 Component III: The anchor requires epistemic alternatives

As discussed at the end of §2, valid IWC anchors impose the requirement in (20) that there be an epistemic alternative to the proposition to which the IWC refers. We leave it to §5 to discuss the compostional source of this requirement, but focus here on clarifying the precise nature of the generalization. It is important that this requirement is pragmatic, which means that it can be met through pragmatic reasoning as well as semantic encoding by the matrix operator, in contrast to the commenting-on-dref of "which", which is part of the semantics of "which". We will say more about the pragmatic nature in §4.

We can consider again example (21) to see how this requirement works. The first dref, "it might be raining", does not have epistemic alternatives because (21) is asserting that it might be raining, thereby removing alternatives such as "it is not the case that it might be raining." This is in virtue of the tense and mood of (21). In contrast, the prejacent "it is raining" has an epistemically possible alternative, "it is not raining." This follows from the semantics of the epistemic possibility modal. "Might" does not rule out a world where it does not rain.

3.4 Component IV: the non-at-issueness of IWC

Finally, we propose that the IWC clause contributes non-at-issue content just like appositive relative clauses, and hence is not targeted by bare response particles:

(26)   A: Either John got his UTRA award, in which case he will have $1500 to spend for his travel, or he didn't, in which case he will have to pay for the plane tickets himself.
        B: #No, that's not true. If John got his UTRA award, he will receive $2500.

This also explains why IWCs cannot occur across speakers:

(27)   A: It might be raining.
        B: *In which case, we should stay inside.

The reason is that B's response in (27) makes the IWC clause trying to contribute at-issue content (see §5.2). There is a small caveat that is worth noting: medial and final appositives have been widely acknowledged to differ in how readily available they are to such discourse moves (e.g. AnderBois, Brasoveanu & Henderson (2011), AnderBois et al. (2015), Syrett & Koev (2015), Hunter & Asher (2016)). The large majority of IWCs appear in clause-final position, and thus may seem more susceptible to bare responses.[3]

3.5 Formalization

We adopt the formalism of AnderBois et al. (2015) (hence abbreviated as "ABH"), which in turn builds on Groenendijk & Stokhof (1991). ABH analyzes appositive relative clauses as updating the

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[3] However, the empirical distribution does not speak against the possibility of clause-medial IWCs. The fact that IWCs comments on a proposition means that it needs to occur after a full proposition being introduced, which usually means a clause final one. If one wants, however, one can easily use complex logical operators to put more propositions in the sentence to create clause-medial IWCs (e.g. the discussion of disjunction in §4.1).

Context Set directly, while at-issue content updates a proposal that may or may not be accepted by the addressee. Specifically, ABH enriches DPL with propositional variables and uses a designated variable p^{cs} to encode the Context Set. The at-issue content is modeled by introducing a new propositional dref p and updating it, whereas appositive content will directly update p^{cs} (N.B. this is not to say that all not-at-issue content has this same profile, e.g. AnderBois (2016)'s account of slifting-like constructions). The translation for (28) is then as in (29):

(28)   John might$_p^{p'}$ [fight$_{p'}$ Bill [who is a professional boxer$_{p^{cs}}$]$_{appos}$]$_{might}$

(29)   a. **New proposal**: $[p] \wedge p \subseteq p^{cs} \wedge$

b. **Issue**: $[x] \wedge x = \text{JOHN} \wedge [y] \wedge y = \text{BILL} \wedge$

c. **Modal (at-issue ctd.)**: $\text{MIGHT}_p^{p'}(\text{FIGHT}_{p'}(x,y) \wedge \ldots$

d. **Appositive**: $\ldots \text{PRO-BOXER}_{p^{cs}}(y)) \wedge$

e. **Acceptance**: $[p^{cs}] \wedge p^{cs} = p$

Some remarks on (29): "Might(ϕ)" is translated as $\text{MIGHT}_p^{p'}(\phi)$. Following ABH's formalism and supported by Snider (2017)'s claims about propositional drefs, "Might" introduces a propositional dref p' for its prejacent with all the worlds in which it is true. Then it requires that each world in p, which it is updating, must have some accessible world where p' is true.

ABH does not define a dynamic conditional, which is what we need to model IWC clauses. So we adopt the one from Groenendijk & Stokhof (1991). Intuitively, what a dynamic conditional $\alpha \rightarrow_p \beta$ says is that for every world w in p, if α is true in w, then β is true in w.[4] We can see how the account captures a simple example, (30), in (31).

(30)   John^x might visit Mary^y, in which case, he$_x$ will chat with her$_y$.

(31)   a. **New proposal:** $[p] \wedge p \subseteq p^{cs} \wedge$

b. **Issue:** $[x] \wedge x = \text{JOHN} \wedge [y] \wedge y = \text{MARY} \wedge$

c. **Modal (at-issue ctd.)**: $\text{MIGHT}_p^{p'}(\text{VISIT}_{p'}(x,y)) \wedge$

d. **Appositive:** $(p'_{p^{cs}} \rightarrow_{p^{cs}} \text{CHATWITH}_{p^{cs}}(x,y)) \wedge$

   i. **Presupposition:** The IWC clause, evaluated relative to $\langle g,h \rangle$, presupposes that $h(p) \not\subseteq h(p')$ and $h(p) \not\subseteq W - h(p')$.

e. **Acceptance:** $[p^{cs}] \wedge p^{cs} = p$

Some elaboration on (31): First, $p'_{p^{cs}}$ intuitively means that the proposition encoded by the dref p' is true at worlds in the context set. We will spell out a precise semantics for these new formulas in the appendix; Second, (31d-i) encodes (20). It says that at the point of IWC clause, neither the Context Set updated with the matrix clause entails the anchor, nor does it exclude the anchor (entailing its negation). This formalization is a mere approximation of (20), as this is a purely semantic condition. Below is a pictorial illustration (based on ABH):

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4 There is actually a technical problem in directly combining ABH semantics with DPL semantics of the conditional: the resulting conditions that rule out assignment functions are not right. We discuss this problem in more detail in the Appendix and propose a solution there. For present purposes, the intuition of what the conditional is doing to the context set should hopefully be clear.

(32) Suppose for concreteness that:
(i) John visited Mary in w_1 and w_2;
(ii) John chats with Mary in w_1;
(iii) $MB(w_1) = \{w_1, w_2\}$, $MB(w_2) = \{w_3\}$, $MB(w_3) = \{w_1, w_3\}$ where MB is *the modal base of* function.

(33)

p^{cs}
$\{\mathbf{w_1}, \mathbf{w_2}, \mathbf{w_3}\}$
$\{\mathbf{w_1}, \mathbf{w_2}\}$
$\{\mathbf{w_1}, \mathbf{w_3}\}$
$\{\mathbf{w_2}, \mathbf{w_3}\}$
$\{\mathbf{w_1}\}$
$\{\mathbf{w_2}\}$
$\{\mathbf{w_3}\}$

$\xrightarrow{\quad [p] \wedge p \subseteq p^{cs} \wedge [x] \wedge x = \text{JOHN} \wedge [y] \wedge y = \text{MARY} \quad}$
1:AT-ISSUE

p^{cs}	p	x	y
$\{\mathbf{w_1}, \mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}, \mathbf{w_3}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_3}\}$	*john*	*mary*
	$\cdots$		
$\{\mathbf{w_1}, \mathbf{w_2}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_2}\}$	$\{\mathbf{w_1}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_2}\}$	$\{\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_3}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_1}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	*john*	*mary*
$\{\mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_2}, \mathbf{w_3}\}$	*john*	*mary*
$\{\mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	*john*	*mary*
$\{\mathbf{w_1}\}$	$\{\mathbf{w_1}\}$	*john*	*mary*
$\{\mathbf{w_2}\}$	$\{\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	*john*	*mary*

$\xrightarrow{\quad \text{MIGHT}_p^{p'}(\text{VISIT}_{p'}(x,y)) \quad}$
2:MOD

p^{cs}	p	p'	x	y
$\{\mathbf{w_1}, \mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
	$\cdots$			
$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_1}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}, \mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_2}, \mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}\}$	$\{\mathbf{w_1}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	$\{\mathbf{w_1}, \mathbf{w_2}\}$	*john*	*mary*

$\xrightarrow{\quad (p'_{p^{cs}} \to_{p^{cs}} \text{CHATWITH}_{p^{cs}}(x,y)) \quad}$
3:APPOS

p^{cs}	p	p'	x	y
$\{\mathbf{w_1},\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1},\mathbf{w_3}\}$	$\{\mathbf{w_1}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1},\mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}\}$	$\{\mathbf{w_1}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*

$$\xrightarrow[\text{4:AT-ISSUE}]{[p^{cs}]\wedge p^{cs}=p}$$

p^{cs}	p	p'	x	y
$\{\mathbf{w_1},\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_1}\}$	$\{\mathbf{w_1}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*
$\{\mathbf{w_3}\}$	$\{\mathbf{w_3}\}$	$\{\mathbf{w_1},\mathbf{w_2}\}$	*john*	*mary*

Before **3:APPOS**, we check whether the presupposition requirement introduced by the IWC is satisfied. Of course, the Context Set updated with "John might visit Mary" does not entail "John visits Mary" nor does it rule out "John visits Mary". So, the presupposition is satisfied.

4 Explaining other data

In this section, we will use the analysis from §3 to explain key data points introduced in §2. Specifically, we will look into how the dref requirement and epistemic alternatives requirement correctly predict patterns of data, and that the epistemic alternatives requirement must be met pragmatically as well as semantically. We will also see that while the data with deontic modals fit the spirit of the account, they in fact motivate a slight revision to the account in §3.

4.1 Disjunction

Data on disjunction demonstrate how the availability of propositional drefs discussed in Snider (2017) restricts where IWC clauses can occur. Snider (2017) provides the following observations. First, the whole disjunctive clause is available as a dref after its utterance.

(34) **Context:** Nancy's birthday is approaching.
Jonathan will buy Nancy flowers or he'll buy chocolates. She doesn't know that, though.

Here "that" is referring to Jonathan buying Nancy a gift, regardless of the specific details provided by the disjunct (see Simons (2001) for detailed discussion of this process). The second disjunct is also available as a dref after the second disjunct:

(35) Steve cheated on the test, or he got really lucky. He told the whole class that, but I don't quite believe him.

On the other hand, the first disjunct is only available as a dref right after the first disjunct or within the second disjunct, but not after the second disjunct.

(36) Steve either cheated on the test, which his teacher hopes is not true, or he studied really hard.

(37)   * Steve either cheated on the test or he studied really hard. His teacher hopes that's not true.

IWC data with disjunction matrix clauses follow this same pattern as dref availability above. (11) is a positive data point showing that the IWC can pick up drefs of both the first and second disjuncts.

(11)   Either it will be raining tomorrow, in which case I will bring an umbrella, or it will be sunny tomorrow, in which case I will wear a big hat.

The infelicity of (12) shows that, after the second disjunct, the unavailability of the first disjunct dref prevents the occurrence of the IWC clause.

(12)   * I will either get an A or I will get a B, in which case, I will make it to the Dean's List.

In this instance, the example is simply infelicitous since world knowledge precludes a reading where the IWC picks up only the second disjunct. Note that although the entire disjunct is in principle available for propositional anaphora as a dref, it cannot host the IWC clause because it doesn't meet the epistemic alternative requirement.

4.2   Epistemic necessity modals

In §3 we have shown that epistemic possibility modals provide the epistemic alternatives needed for IWC clauses. In contrast, then, epistemic necessity modals do not necessarily provide the same epistemic uncertainty for the speaker, and hence we expect it not satisfy the requirement for IWC clauses to be felicitous.

(8b)   * The prisoner must have escaped, in which case could you go look for him?

There are two hypotheses that could potentially explain this contrast. The first is that the necessity modals semantically commit the speaker to the truth of their prejacents. The second is that this commitment is pragmatic in nature and therefore depends on the context. In this latter case, we would expect that there are contexts in which the epistemic alternative requirement could be met in the right kind of context. This latter hypothesis appears to be supported by data such as (38), where we see that despite the presence of *must* rather than *might*, there is intuitively still an open question about the location of the lost document.

(38)   **Context:** Yalitza is trying to find a lost document. They've looked all over the office and the kitchen. Having not found it, Yalitza says:
       Hmm, it must be in the car, in which case Betty should be able to see if it's there.

Notably, this is a context where the indirectness of *must* comes to the fore. Yalitza's inference is certain given a certain salient body of information, but the context makes clear that this information may be incomplete or inaccurate, and therefore in practice terms that the ultimate whereabouts of the document remains an open question. As we would expect, then, IWCs are felicitous precisely to the extent that they license these sorts of pragmatic inferences of uncertainty.

4.3 Deontic modals & imperatives

We have seen in §2 that the basic facts for deontic modals and imperatives parallel those for epistemic modals:

(9a) You may leave now, in which case you will still be marked present.

(9b)   * You must save the kid, in which case you can get to heaven.

(10a) Take the train, in which case, you will see great scenery.
(Weak imperative)

(10b)   * Put your hand in the air! In which case, I won't shoot you.
(Strong imperative)

And similar to the epistemic modal examples, the felicitous examples require epistemic uncertainty of whether the discussed activity will be performed. For (9a), the speaker is uncertain whether the given action of leaving will occur, whereas for (9b) the speaker is exhibiting certainty. Moreover, the different acceptability of weak and strong imperatives (whatever its semantic or pragmatic basis) follows from the pragmatic nature of the epistemic alternatives requirement.

However, when we turn to think about the dref requirement, things get a bit more complicated. Above, we have relied on propositional drefs to allow IWC clauses to pick up their anchors, but Snider (2017) argues that neither deontic modals nor imperatives introduce *propositional* drefs. He argues that they instead introduce *event* drefs. For (9a) the event dref would be an event of "You leaving now," and for (10a), it would be that of "(You) taking the train." Consider the following examples.

(39)   He may drink now, but I don't expect that to ever happen.

(40)   #He may drink now, but I don't expect that to ever be true.

Events can happen, but cannot be true or false. Hence, for (39), "that" refers to an event of "him drinking now," which can happen or not, but cannot be true or false. Notably in these examples here, the events in question are not in fact actual concrete events that exist in the world of evaluation. Rather, the examples assert that it is permissible/required/etc for there being an event of a given kind. The IWC, therefore, does not pick up a specific event introduced by the modal/imperative in these cases, but rather the description of a particular set of events or event type. What the IWC conveys, then, is that if an event of that kind in fact happens then the consequent will hold. We therefore analyze the dref being introduced as being anaphoric to an **event predicate/property** rather than an event per se. For instance, for (9a), we can say the following:

1. The deontic modal introduces an event predicate F for its scope, storing the set of events that are a "you leaving" event.

2. The at-issue content of the matrix clause asserts that there being an F event is compatible with a set of deontic rules/norms.

3. The IWC clause says that if there is an F event, then "you will be marked present."

With this tweak, deontic modals and imperatives are therefore predicted to be felicitous anchors for IWCs provided that they meet the alternative requirement.[5] As we have already seen above for epistemic modals, this will always be the case for possibility modals, while for necessity modals, it will depend on the context. The case of imperatives will of course pattern similarly, with the details depending on the semantics for imperatives one assumes (e.g. whether weak imperatives are due to a distinct semantics or pragmatics).

5   The source of the alternative requirement

5.1   The lexical source of the alternative requirement

Thus far, we have developed an account of IWCs that made us of the alternative requirement in (20), repeated here:

(20)   **Epistemic alternative requirement**

    a. Proposition p has epistemic alternatives iff p is not entailed (semantically or pragmatically) by the speaker's discourse commitment.

    b. Anchors of IWC clauses need to have epistemic alternatives.

In this section, we explore two candidates for the compositional source of the alternative requirement, namely:

    i. *which* contributes a requirement for alternatives

    ii. *case* itself contributes a requirement for alternatives

The first option, *which*, appears initially plausible since it can be motivated by the fact that interrogative uses of *which* exhibit D-linking (Pesetsky (1987) et seq), i.e. they presuppose a discourse-salient set of alternatives from which the answer is to be chosen:

(41)   Zhang San knows which book Betty read.
    ⤳ Presupposes a set of alternative books which Betty could have read (e.g. the books listed on the syllabus)

In the propositional case, *which* similarly seems to require a salient set of propositions rather than individuals, as in (42):

(42)   It might rain and it might not rain. In which situation would you bring an umbrella?

Despite the initial appeal of such an approach, we argue that the D-linking of *which* is not a viable source of the epistemic alternative requirement. First, the interrogative *which*'s requirements cannot be met by implicated or otherwise unstated alternatives, (43), whereas that of IWC can, (44).

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5 There is admittedly still a compositional issue to be resolved here regarding how *in which case* combines with kinds of events. IWC clauses that take event predicate drefs and those that take propositional drefs will be formulated slightly differently in terms of the alternative requirement and the conditional semantics. As we will see in §5, however, these differences arise generally in constructions with the noun *case*.

(43)   It might rain. #In which situation would you bring an umbrella?

(44)   It might rain, in which case I would bring an umbrella.

Second, focusing on propositional uses, we see that the set needed for D-linking is more flexible, not requiring the two alternatives to be true epistemic alternatives. For example, the conjunction in (45) satisfies the D-linking requirement of *which* since it provides two different alternative situations, either of which could serve as the answer to the question. In contrast, an IWC cannot make use of such a main clause as its anchor since it introduces no epistemic uncertainty.

(45)   Sanders fell to the 5th round and he was drafted by the Browns. Which was more surprising to you?

(46)   #Sanders fell to the 5th round and he was drafted by the Browns, in which case his career will be damaged.

We conclude, therefore, that the epistemic alternative requirement is not due to *which*, despite its well-known need for alternatives. They simply are not the same kind of alternatives.

Instead, we attribute the epistemic alternative requirement to the lexical item *case*. While this may seem less immediately intuitive, Moltmann (2021) has recently explored the meaning of the noun *case* in a wide range of other constructions and argued for a quite similar conclusion within the framework of truthmaker semantics. While she does not address IWCs specifically, her account nonetheless has important similarities.

We turn now to compare in more detail Moltmann 2021's claims about other uses of the noun *case* with our current findings regarding *in which case*. We leave to future work to assess Moltmann 2021's arguments regarding the need for truthmaker semantics and how/if IWC data bear on it. For present purposes, we are focused on the nature of the alternative requirement and integrating that within the dynamic account assumed here.

5.2   Moltmann (2021) on the semantics of the noun *case*

Moltmann (2021) does not discuss *in which case* specifically, but does discuss three different kinds of uses of *case*. As discussed in §3.3, since we analyze IWCs as anaphoric, they fit in the category of (48).

(47)   **Case with a modificational 'case clause'**

  a. the cases in which a student failed the exam

  b. the case in which it might rain tomorrow

(48)   **Anaphoric uses**

  a. John might go to the party. In that case, I will go too.

  b. John will interview or Mary will. In either case, we should be well prepared.

(49)   **Predicational uses w/ *to be the case***

  a. It is sometimes the case that a student fails the exam.

  b. That it is raining is not the case.

Moltmann (2021) observes that unlike similar-seeming expressions like *fact* or *situation*, the noun *case* imposes a requirement for alternatives. Therefore, whereas examples like (50) are felicitous, minimal pairs with *case* in place of *fact* are infelicitous since they do not meet this requirement.

(50) a. We discussed the fact that John returned yesterday.

   b. The fact that John has solved the problem was unexpected.

(51) a. ??? We discussed the case in which John returned yesterday.

   b. ??? The case in which John has solved the problem was unexpected.

The requirement for alternatives is called **Case Space Requirement**, which she describes as follows:

> "a situation or kind of situation can be a case only within a case space, a set of at least two alternatives. This Case Space Requirement, as I will call it, is part of the lexical meaning of the noun *case*"

This case space requirement seems very similar to our epistemic alternative requirement, but it is also broader in the ways it can be satisfied:

(52) **Kinds of case spaces according to Moltmann (2021):**

   a. **Case clauses that are true at different times or places:**
   There were two cases in which Jerry won the race.

   b. **Focus:**
   Mary remembered the only case in which JERRY$_F$ won the race.

   c. **Mathematical:**
   We didn't consider the case in which the number is a prime number.

   d. **Epistemic**
   We cannot exclude the case in which John returned yesterday.

On the face of this, then, these case spaces seem quite different from what we have seen for *in which case* thus far, where we have only encountered epistemic alternatives. However, after a closer comparison *in which case* and the anaphoric uses of *case* from Moltmann (2021) look less distinct.

5.3 Comparing *in that case* and *in which case*

To examine how similar Moltmann (2021)'s case space requirement is to our epistemic alternative requirement, we first compare *in that case* and *in which case* as this is the closest instance to consider since both are anaphoric. We begin by focusing on epistemic case spaces, before turning to (52a-52c) in §5.4.

In that case generally parallels the data we saw in §2 for *in which case*, in that it seems to require our notion of epistemic alternatives:

(53) **Epistemic alternatives for *in that case*:**

   a. * It is raining. In that case, I will bring an umbrella.

b. That report **might** have been prepared before the fare increases. In that case Portland would indeed miss the cut.

c. * The prisoner **must** have escaped, in which case could you go look for him?

d. I heard that the match will be popular. (And) in that case I better buy tickets now.

e. * The professors know that some students will cheat in the exam. In which case they will punish them.

The most major difference is that as observed by Moltmann (2021: pp.172-3), an unmodalized assertion can be the anchor across speakers, (55). In contrast, *in which case* does not allow for this possibility:

(54)   ??? John won the race. In that case, Mary will be happy.

(55)   **A:** John won the race.
       B: In that case, Mary will be happy.

Moltmann (2021)'s intuition (which we share) is that (55) works because speaker B has yet to accept or reject A's assertion, therefore creating the two corresponding alternatives. Our account of epistemic alternatives already captures this, since speaker A's assertion is not in speaker B's public discourse commitments yet at the time of B's utterance. Further support for this comes from the fact that B cannot felicitously include response particles indicating acceptance such *yes* or yeah:

(56)   **A:** John won the race.
       B: #Yes/#Yeah, in that case, Mary will be happy.

In contrast, for (54), no such option exists, since the speaker's commitment to the anchor contradicts the epistemic alternative requirement. For *in which case*, as discussed in §3.4, the parenthetical nature of the construction does not allow for a cross-speaker construction and thus is just as conflicting in (56) as in (54).

5.4   Unifying Moltmann (2021)'s non-epistemic case clauses

In this section, we return to the three types of non-epistemic case spaces introduced by Moltmann (2021). Crucially, we find that they are less diverse than meets the eye in certain respects, narrowing the gap between the Moltmann (2021)'s case space requirement and our account of the alternative requirement.

(52)   Non-Epistemic Case Clauses

(52a) **Case clauses that are true at different times or places:**
      There were two cases in which Jerry won the race.

(52b) **Focus case clauses:**
      Mary remembered the only case in which JERRY$_F$ won the race.

(52c) **Mathematical case clauses:**
      We didn't consider the case in which the number is a prime number.

First, looking at the "Focus case clauses" in (52b), we can see that focus itself does not satisfy the case space requirement. Consider a modified version of (52b):

(57)   *The case in which JOHN$_F$ won the only marathon ever held in our town came as a surprise when it happened.

(58)   The case in which JOHN$_F$ won a race always came as a surprise whenever it happened.

What the focus is doing is instead helping set up the right kinds of alternatives for another type of case clauses above, namely those that are true at *different times or places*. Focus indirectly helps facilitate the creation of a set of alternatives to consider one by one. But this is only indirectly by virtue of the noun *race* allowing for multiple instantiations for different occurrences of the event, say the 2025 race vs. the 2020 race, etc. When the example/context precludes this, as in (57), focus alone does not license the use of *case*.

We henceforth call these case clauses that generally involve multiple objects or events **quantificational case clauses**. These case clauses satisfy the **quantificational case space requirement** if only a proper subset of those objects or events satisfy a given predicate. With this generalization, the mathematical case clauses can be accounted for as well. For (52c), the set of objects includes the integers and the predicate is *being a prime number*. Indeed, only a proper subset of integers are prime. In sum, these case clauses all are ones that involve overt or covert quantification over events (or perhaps eventualities).

5.5   Quantificational case clauses involve event predicates

In this section we elicit quantificational case clauses within IWC clauses using quantificational adverbs (Q-Advs). We then show that they involve event predicates, parallel to the IWC constructions involving deontic modals and imperatives. Afterward we give a uniform treatment of those constructions with a quantificational version of the epistemic alternative requirement.

First, consider quantificational case clauses embedded in IWC clauses:

(59)   a. Sometimes a Mersenne number is a prime number, IWC it's called a Mersenne prime.

   b. Amir often takes the scenic highway, IWC he comes a bit late.

   c. *Amir always takes the scenic highway, IWC he comes a bit late.

It appears that Q-Advs introduce **event predicate drefs**, but not propositional drefs.

(60)   a. Sometimes a Mersenne number is a prime number, but that doesn't happen that often.

   b. *Sometimes a Mersenne number is a prime number, but that's often not true.

   c. Amir often takes the scenic highway, but it will happen less frequently once he moves closer to the city.

   d. *Amir often takes the scenic highway, but it sometimes won't be true once he moves closer to the city.

In contrast, constructions of similar meanings that allow for propositional drefs but not event predicate drefs do not allow for IWC clauses:

(61)   a. Some years have 366 days, which is true for roughly a fourth of all years.

        b. *Some years have 366 days, which happens roughly every 4 years.

        c. *Some years have 366 days, IWC the February of that year has 29 days.

We therefore hypothesize that IWCs take event predicate anaphors just in case they involve quantificational alternatives rather than epistemic ones. A test would be to see that deontic modals and imperatives discussed in §4.3 also have quantificational meanings, since they were shown to take event predicate drefs. Toward this, first note that deontic modals have a distributed meaning, which means, for the example below, the consequent of washing one's hands follows for each instance of an event satisfying the event predicate.

(62)   *Context: An elementary school teacher is announcing class policies.*
        You may go to the bathroom, in which case just make sure to wash your hands.

An alternative non-distributive meaning could be that the consequent is true once if there ever exists a bathroom going event. Now observe that the IWC clause is felicitous only if a proper subset of salient events (lab sessions) satisfy the event predicate (the student going there).

(63)   *Context: There are ten lab sessions throughout the semester.*
        You are required to go to at least two of them, in which case your TA will mark you present.

(64)   * You are required to go to all of them, in which case your TA will mark you present.

Hence they behave like quantificational case clauses, and we claim that this is generally true for all IWC clauses that take event predicate drefs, including imperatives. The examples also show that, as with epistemic alternatives, both the set of salient events and the satisfaction of quantificational alternatives may arise pragmatically.

What is left now is to translate the intuitive notion of quantificational case spaces we established to a version of the alternative requirement. We provide the following sketch:

(65)   **Quantificational/event alternative requirement**

        a. An event predicate P has quantificational alternatives iff for a salient set of events E, it is not entailed (semantically or pragmatically) by the speaker's discourse commitment that $\forall e \in E \ P(e)$.

        b. Anchors of IWC clauses that are event predicates need quantificational alternatives.

Now that we have two alternative requirements, we can predict that some sentences can have two readings. Consider the following.

(66)   *Context: There are ten volunteer opportunities.*
        You should go to at least two of them, in which case you will receive a free coupon ({ each time / at the end }).

This sentence has two readings. First, it has a reading based on quantificational alternatives one which the person will receive a coupon each time an event of the them volunteering occurs. Second,

it has a reading based on epistemic alternatives in which they will receive a single coupon if they meet the stated standard of volunteering twice.

We have thus far presented these two requirements as a disjunctive requirement of sorts between quantificational and epistemic alternatives. We leave it to future work to formally unify them, but we note that given the free event variable inside the IWC, there is intuitively genuine epistemic uncertainty about any individual instance.[6] And this remains so, even in a case like (67) where all of the facts about leap years are fully known to all. If we randomly assign a value corresponding to the year, then there will be epistemic uncertainty about whether the year has 366 days or not. With universal quantification, as in (59c), no matter how the value of the variable is fixed (i.e. which trip we're talking about), we know that it will be an event of Amir taking the scenic highway.

(67)   As you all know, sometimes a year has 366 days, IWC your calendars need to adjust accordingly.

6   Conclusions and future directions

In this paper, we have examined the semantics of parenthetical modifiers in English with *in which case*. We have proposed an account with three key components:

   i. *in case* contributes a conditional semantics.

   ii. Similar to appositives with propositional anchors, *which* acts as a propositional/event predicate anaphor, requiring a propositional/event predicate dref in the matrix to serve as antecedent of the conditional.

   iii. *case* contributes a pragmatic requirement for epistemic alternatives.

Taken together, we have shown that these three components explain a range of positive and negative data for *in which case*. For the study of parenthetical constructions, IWCs introduce a new empirical case study, one that in some ways conforms to what is known about other cases (e.g. the anaphoric relationship with the main clause). At the same time, however, IWCs present some unique puzzles in terms of the semantic categories of the dref they comment on, and the fact that their parenthetical content is necessarily conditional.

Beyond this, we have seen that IWCs' requirement for alternatives poses an interesting puzzle for the study of alternatives broadly. Although other uses of *which* exhibit a need for alternatives in the form of D-linking, we have argued that the kind of alternative that IWCs require is quite different. Instead, we have proposed that the noun *case* is the source of these alternatives, following Moltmann (2021)'s work on its uses outside of IWCs. Contra Moltmann, we have narrowed down the types of alternatives to only epistemic and quantificational alternatives, while giving a formal dynamic semantics account for one, and a sketch for the other.

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6 A further parallel is that event predicates are set of events and propositions are set of worlds. The propositional version of the epistemic uncertainty requirement also requires the speaker's discourse commitment not to entail $\forall w \in W, P(w)$, where W is given by the context.

References

AnderBois, Scott. 2016. Semantics and pragmatics of (not-)at-issueness in Yucatec Maya attitude reports. *Semantics & Pragmatics* 9(19).

AnderBois, Scott, Adrian Brasoveanu & Robert Henderson. 2011. Crossing the appositive/at-issue meaning boundary. In *Proceedings of Semantics And Linguistic Theory (SALT) 20*, 328–346. eLanguage.

AnderBois, Scott, Adrian Brasoveanu & Robert Henderson. 2015. At-issue proposals and appositive impositions in discourse. *Journal of Semantics* 32(1). 93–138.

Asher, Nicholas. 1993. *Reference to abstract objects in English: a philosophical semantics for natural language metaphysics*, vol. 50. Studies in Linguistics and Philosophy.

Davies, Mark. 2008-. The corpus of contemporary american english (coca): 400+ million words, 1990-present. Available online at http://www.americancorpus.org.

Declerck, Renaat & Susan Reed. 2001. *Conditionals: A comprehensive empirical analysis*. Mouton de Gruyter. https://doi.org/10.1515/9783110851748.

del Gobbo, Francesca. 2003. *Appositives at the interface*: UC Irvine PhD dissertation.

Groenendijk, Jeroen & Martin Stokhof. 1991. Dynamic predicate logic. *Linguistics and Philosophy* 14. 39–100.

Hunter, Julie & Nicholas Asher. 2016. Shapes of conversation and at-issue content. In *Proceedings of SALT 26*, 1022–1042. doi:10.3765/salt.v26i0.3946.

Mackenzie, J. Lachlan. 2024. In case for Kees. *Linguistics in Amsterdam* 15(2). 81–88.

Moltmann, Frederike. 2021. Situations, alternatives, and the semantics of 'cases'. *Linguistics & Philosophy* 44. 153–193. doi:10.1007/s10988-019-09282-7.

Pesetsky, David. 1987. Wh-in-situ: Movement and unselective binding. In Eric Reuland & Alice ter Meulen (eds.), *The Representation of (In)definiteness*, MIT Press.

Simons, Mandy. 2001. Disjunction and alternativeness. *Linguistics and Philosophy* 24. 597–619.

Snider, Todd. 2017. *Anaphoric reference to propositions*: Cornell University PhD dissertation.

Syrett, Kristen & Todor Koev. 2015. Experimental evidence for the truth conditional contribution and shifting information status of appositives. *Journal of Semantics* 32(3). 525–577. doi:10.1093/jos/ffu007.

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Appendix: Revising AnderBois et al. (2015) to cover non-atomic appositives

This appendix deals with the problem that we pointed out in the main body of the paper and left only sketchy remarks. It has two parts: the first part exposits the problem in full detail with respect to the conditional; the second part presents a revised formalism based on AnderBois et al. (2015) that deals with the problem.

The problem

The basic problem is that directly combining the DPL semantics for the conditional and ABH way of treating appositive update yields the wrong truth conditions. For exposition purposes, we provide the two below, where M is a model, g, h variable assignment functions:

DPL semantics for conditionals:
$M, \langle g, h \rangle \models \phi \to \psi \Leftrightarrow g = h \land \forall g' \colon \langle g, g' \rangle \models \phi \Rightarrow \exists k \colon \langle g', k \rangle \models \psi$

ABH semantics for atomic formulas:
$M, \langle g, h \rangle \models P_q x \Leftrightarrow g = h \land \forall w \in h(q) \colon h(x)(w) \in M(P)(w)$

Now consider for concreteness the following conditional formula:

(68) $P_{p^{cs}} a \to_{p^{cs}} Q_{p^{cs}} a$ where P, Q are two predicates and a a constant.

We try to use this formula to directly update p^{cs}. For concreteness and simplicity, suppose that the Context Set includes $\{w_1, w_2, w_3\}$. So possible assignments to p^{cs} include:
$\{w_1, w_2, w_3\}, \{w_1, w_2\}, \{w_1, w_3\}, \{w_2, w_3\}, \{w_1\}, \{w_2\}, \{w_3\}$.

Suppose in addition that a is P at w_1, w_2 only, and a is Q at w_1 only.

Intuitively, using (68) to update p^{cs} will rule out any p^{cs} with w_2 in it since at w_2 the conditional is not true: a is P but is not Q. So we are left with $\{w_1, w_3\}, \{w_1\}, \{w_3\}$.

However, if we directly combine the DPL semantics for the conditional and the ABH formalism for the atomic predicates, we got the wrong result. Here is the illustration. First, we work out what assignments will be crossed out under (68). We omit M in the following to improve readability, but all $\models$ should be understood as relative to a model M:

$\langle g, h \rangle \models P_{p^{cs}} a \to Q_{p^{cs}} a$
$\Leftrightarrow g = h \land \forall g' \colon \langle h, g' \rangle \models P_{p^{cs}} a \Rightarrow \exists k \colon \langle g', k \rangle \models Q_{p^{cs}} a$
$\Leftrightarrow g = h \land \forall g' \colon h = g' \land \forall w \in g'(p^{cs}) \colon g'(a) \in M(P)(w) \Rightarrow \exists k \colon g' = k \land \forall w \in k(p^{cs}) \colon k(a) \in M(Q)(w)$
$\Leftrightarrow g = h \land \forall g' \colon h = g' \land \forall w \in g'(p^{cs}) \colon g'(a) \in M(P)(w) \Rightarrow \exists k \colon g' = k \land \forall w \in k(p^{cs}) \colon k(a) \in M(Q)(w)$
$\Leftrightarrow g = h \land \forall g' \colon h = g' \land \forall w \in g'(p^{cs}) \colon g'(a) \in M(P)(w) \Rightarrow \forall w \in g'(p^{cs}) \colon g'(a) \in M(Q)(w)$
$\Leftrightarrow g = h \land \forall w \in h(p^{cs}) \colon h(a) \in M(P)(w) \Rightarrow \forall w \in h(p^{cs}) \colon h(a) \in M(Q)(w)$
This says that an assignment g will be crossed out if at every world of $g(p^{cs})$ a is P, but at some world of $g(p^{cs})$ a is not Q.

Thus, the assignments that survive the update will include:
$\{w_1, w_2, w_3\}, \{w_1, w_3\}, \{w_2, w_3\}, \{w_1\}, \{w_3\}$.

Crucially, the assignment $\{w_1, w_2, w_3\}$ and the assignment $\{w_2, w_3\}$ will survive the update because both assignments verify the right-hand side of the semantic clause, although they verify it by falsifying the antecedent of the semantic clause: since w_3 is a world where a is not P, then for $\{w_1, w_2, w_3\}$ for example, it is not the case that for every world in it, a is P in that world. Thus, the semantic clause will be vacuously verified. Consequently, this semantic clause will not rule out what we want to rule out intuitively (and correctly).

The upshot is that directly combining the DPL semantics for conditionals and the ABH semantics for atomic sentences yields too weak conditions. Intuitively, what the conditional clause updating p^{cs} should end up saying something like:
$$\forall w \in h(p^{cs}): h(a) \in M(P)(w) \Rightarrow h(a) \in M(Q)(w)$$

A similar problem arises for disjunction. The problem there is that directly combining the two yields too strong conditions on the Context Set.

A solution

Essentially, the problem with directly smooshing together the ABH formalism and DPL-style semantics for the conditional is that we cannot get right subscripts at the right places to ensure that the treatment of the conditional yields the right conditions on p^{cs}. The following presents a formal solution that deals with this in a relatively systematic way. This solution has several components to which we will turn to now.

Before getting into the main components, it is worth laying out explicitly the syntax of the extended ABH language for the conditional:
(i) If p, q are propositional variables or constants, then p_q is a formula.
Note: This is the simple step that we need to be able to use propositional drefs to comment on the context set.
(ii) If α and β are formulas and p a propositional constant/variable, $\alpha \to_p \beta$ is a formula.
Note: In effect, this indexing will specify what set of worlds the conditional is updating, the proposal p of the context set p^{cs}. Now we can move on to the main components.

First, define recursively a syntactic replacing mechanism $[p \, sub/q]$, intuitively replacing all *subscript* instances of p with q:
$$(P_p x_1, \cdots, x_n)[p \, sub/q] := P_q x_1, \cdots, x_n$$
$$\alpha \wedge \beta [p \, sub/q] := \alpha[p \, sub/q] \wedge \beta[p \, sub/q]$$
$$\alpha \to_p \beta [p \, sub/q] := \alpha[p \, sub/q] \to_q \beta[p \, sub/q]$$

Second, define the semantics of new formulas as:
(i) $M, \langle f, g \rangle \models p_q \Leftrightarrow f = g \wedge \forall w \in h(g): w \in h(p)$
The semantics here parallels that of atomic formulas indexed with propositional variables like $P_q x$. This formula intuitively says that for all world in q, p is true there.
(ii) $M, \langle f, g \rangle \models \alpha \to_p \beta \Leftrightarrow$
$f = g \wedge \forall w \in g(p): \forall h: M_w^q, \langle g, h \rangle \models \alpha[p \, sub/q] \Rightarrow \exists h' M_w^q, \langle h, h' \rangle \models \beta[p \, sub/q])$
M_w^q is the model that is exactly like M but extends the language with a new propositional constant q and extends M to assigns q the singleton set $\{w\}$.
The intuition above is that the conditional when updating p says that for every world w in p, if the

antecedent is true at w, then the consequent is true at w. The original propositional indices carried by α and β will be overridden to be evaluated at each of the ws.

Now take the simple example we used to illustrate the problem:

$$P_{p^{cs}}a \rightarrow_{p^{cs}} Q_{p^{cs}}a$$

We can show that this revised semantics for the conditional yields the right truth conditions:

$M, \langle g, h \rangle \models P_{p^{cs}}a \rightarrow_{p^{cs}} Q_{p^{cs}}a$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): \forall h': M_w^q, \langle h, h' \rangle \models (P_{p^{cs}}a)[p^{cs}\ sub/q] \Rightarrow \exists h'' M_w^q, \langle h', h'' \rangle \models (Q_{p^{cs}}a)[p^{cs}\ sub/q]$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): \forall h': M_w^q, \langle h, h' \rangle \models P_q a \Rightarrow \exists h'' M_w^q, \langle h', h'' \rangle \models Q_q a$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): \forall h': h = h' \wedge \forall w \in M_w^q(q)h'(a) \in M(P)(w) \Rightarrow \exists h''h' = h'' \wedge \forall w \in M_w^q(q)h''(a) \in M(Q)(w)$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): \forall h': h = h' \wedge \forall w \in \{w\}h'(a) \in M(P)(w) \Rightarrow \exists h''h' = h'' \wedge \forall w \in \{w\}h''(a) \in M(Q)(w)$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): \forall h': h = h' \wedge \forall w \in \{w\}h'(a) \in M(P)(w) \Rightarrow \forall w \in \{w\}h'(a) \in M(Q)(w)$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): \forall w \in \{w\}h(a) \in M(P)(w) \Rightarrow \forall w \in \{w\}h(a) \in M(Q)(w)$

$\Leftrightarrow g = h \wedge \forall w \in h(p^{cs}): h(a) \in M(P)(w) \Rightarrow h(a) \in M(Q)(w)$

This is exactly the right semantics we intuitively want, which rules out any h s.t. $h(p^{cs})$ includes w_2.

So we can formalize the appositive in (30) as:

$$p'_{p^{cs}} \rightarrow_{p^{cs}} Chatwith_{p^{cs}}(y)(x)$$

This intuitively says that for *every world in the Context Set*, if p' (which is the proposition that John visits Mary) is true, then x (John) will chat with y (Mary).

Note that this rewrite algorithm is defined generally so as to cover more complex cases of update. For example, one might have the following appositives with their rough formalisation:

(69)   John might visit Mary, in which case, if she is not well, he will buy her some medicine.

(70) $p'_{p^{cs}} \rightarrow_{p^{cs}} (Notwell_{p^{cs}}(\mathbf{m}) \rightarrow_{p^{cs}} Buy_{p^{cs}}(\mathbf{medicine})(\mathbf{j}))$

(71)   John might visit Mary, in which case, either they will have KFC or MacDonalds.

(72) $p'_{p^{cs}} \rightarrow_{p^{cs}} (EatKFC_{p^{cs}}(\mathbf{j},\mathbf{m}) \vee_{p^{cs}} EatMac_{p^{cs}}(\mathbf{j},\mathbf{m}))$

We leave it to future work to move fully develop this solution and to compare it to other possible formal solutions. The upshot is that we hope to have shown that the issue that arises with *in which case* clauses is a general issue regarding appositive content with internally dynamic contents. The conditional semantics of *in which case* necessarily brings this to the fore in a way appositive relative clauses only sometimes do. Despite the generality of the problem, we hope to have demonstrated that there are principled solutions available given suitable revisions to the ABH system.