

COMPOSING COMMANDS

Composing Commands

an inferentialist semantics for subsententials and imperatives



(JAMES) KAI TANTER

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*Philosophy Department
School of Historical and Philosophical Studies
Faculty of Arts
The University of Melbourne
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For Rumo. The best of doggos.

Statement

This thesis is solely the work of its author. No part of it has previously been submitted for any degree, or is currently being submitted for any other degree. To the best of my knowledge, any help received in preparing this thesis, and all sources used, have been duly acknowledged. The thesis is fewer than the maximum word limit in length, exclusive of tables, maps, bibliographies and appendices.

KAI TANTER

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Abstract

Standard theories in philosophy of language tend to endorse three claims:

1. Representationalist notions such as truth and reference are semantic primitives;
2. Sentence level meaning is propositional;
3. The meaning of complex expressions is a function of the meaning of their constituents.

This thesis develops a semantics for languages with both imperative and declarative sentences, along with constituent names and predicates, and which rejects 1. and 2. above. The key features of this semantics are: inferentialism, compositionality, and content pluralism. It is inferentialist in the sense that, contra 1., meanings are treated as inferential roles, determined by norms of use in speech acts such as asserting and commanding. This is formalised as a proof-theoretic semantics in a cut-free sequent calculus system. It is compositional in the sense that the inference rules assigned to sentences are a function of those assigned to their constituents, names and predicates. In contrast to 2., it is a kind of content pluralism. This means that declarative and imperatives sentences express different sentence level semantic types, rather than just propositions. Despite this, sameness of word meaning is preserved across these different sentence types.

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CHAPTER ONE

Pragmatism, Content Pluralism, and Compositionality

1.1 Introduction

In this chapter we introduce the central positions, and the three arguments which drive the discussion in the following chapters. First, we discuss the divide in contemporary philosophy of language between pragmatists and representationalists. Here we present an argument due to Jasper Liptow (Liptow 2013), that pragmatist theories of meaning must fail due to their inability to explain the shared propositional content of different sentence types. In response to this, one might think that there need be no such shared propositional content. This would be a kind of content pluralism, rather than Liptow's content monism. However, we next present an argument of Michael Dummett's, purporting to show that there must be such shared propositional content (Dummett 1991). Dummett's argument rests on the claim that semantic theories must meet requirements of (1) compositionality, and (2) uniformity of word meaning across sentence types. The aim of the thesis is to present an inferentialist semantics for declaratives and imperatives which is a counter-example to Dummett's argument. A difficulty in doing so is that many believe that inferentialist theories of content cannot be compositional. The third argument introduced in this chapter is one due to Ernest Lepore & Jerry

Fodor (Lepore and Fodor 2001, 2007) which claims that the holistic nature of inferentialism prevents it from being compositional. We will later in the thesis show an inferentialist semantics can in fact be compositional. Lastly, we reconnect the above discussion to briefly give a positive case for pragmatism (inferentialism) and content pluralism.

1.2 Pragmatism

The divide between pragmatists and representationalists is one of, if not the most, important contemporary debates in philosophy of language (MacFarlane 2010; Wanderer 2010). The disagreements concerns the autonomy of linguistic meaning or content (semantics) from language use (pragmatics), which is respectively denied and affirmed by pragmatists and representationalists.

Wittgenstein's work can be used to motivate the distinction between pragmatist and representationalist theories of meaning. In the *Tractatus* Wittgenstein provides a paradigmatically representationalist theory (Wittgenstein 1922). Like many representationalists, he begins with a metaphysics, in this case of a world made up of states of affairs, and states of affairs as objects in relation to one another. Wittgenstein then explains the meaning of names and sentences through their relation to objects and states of affairs. Sentences express 'pictures' of states of affairs and grasping their meaning involves understanding what is the case if they are true. In case of names the object which they refer to is their meaning. The sentence pictures or represents the state of affairs, through the names of which it is composed standing in relations which correspond to the objects in the state of affairs. While many representationalist theories of meaning differ in the details, the three notions of reference, truth, and representation (picturing) all play a similar central role. Language use is not in the picture.

Wittgenstein famously changed his mind, swapping from representationalism to pragmatism. Two examples illustrate this. First, a description of a conversation with the Italian economist Piero Sraffa:

Wittgenstein was insisting that a proposition and that which it describes must have the same 'logical form', the same 'logical multiplicity'. Sraffa made a gesture, familiar to Neapolitans as meaning something like disgust or contempt, of brushing the underneath of his chin with an outward sweep of the fingertips of one hand. And he asked: 'What is the logical form of that?' (Malcolm 1958: p.55-58)

The gesture, while meaningful does not 'picture' anything, let alone a state of affairs. Yet it expresses something, namely disgust, and plays a role in a social practice. Second, Wittgenstein's observations about the relation between language and a game such as chess:

For Frege the alternative was so: Either we are dealing with ink strokes on paper or these ink strokes are signs for something, and that which they represent is their meaning. The game of chess shows precisely that this alternative is not right: here we are not dealing with the wooden figures, however the figures don't represent anything, they have not meaning in Frege's sense. There is yet a third option, the signs can be used as in a game (Waismann and Mcguinness 1967: p.105).¹

Here the significance of a chess piece is constituted by its role in the game rather than by standing for something else. Hence Wittgenstein's term 'language game' and the idea that the meaning of an expression is its role within such a game.

In moving away from representationalism Wittgenstein also abandoned systematic theories of meaning. We need not do so here. His game analogy can still be used as the basis for a systematic theory. Let us return to chess. At each move the player is constrained by two things:

1. the rules determining correct movement of each piece; and
2. the state of the game - the distribution of the pieces.

1. My translation.

Their move will alter 2., bringing the game into a new state. Think of each move as a function from one state to another. Language games work similarly. Speech acts are governed by norms determining their correct use and how they change the conversation state. They are “pieces” which we make linguistic “moves” with. The conversation state is determined by the speech acts made so far, which will require, permit, and prohibit further moves. On this model, think of the pragmatic force or significance of a speech act as a mapping from one conversation state to another (Brandom, 1994, 190). The pragmatist thesis can now be stated more clearly:

Pragmatism in this sense is the view that what attributions of semantic contentfulness are for is explaining the normative significance of intentional states such as beliefs and of speech acts such as assertions. Thus the criteria of adequacy to which semantic theory’s concept of content must answer are to be set by the pragmatic theory, which deals with contentful intentional states and the sentences used to express them in speech acts (Brandom 1994: p.143).

For pragmatists, pragmatics, the theory of force, determines the object of explanation for the semantic theory. Any semantics which makes no reference to pragmatics, such as that of the early Wittgenstein, has no grounds for its own justification.

One helpful feature of the score-keeping model is that it directly explains the meaning of non-declaratives sentences such as ‘Close the door’. Non-declaratives challenge representationalism because they appear not to have truth values and in as much as they “represent” the world, they do so differently from declaratives. The sentence types declarative, interrogative and imperative are paradigmatically used for acts of asserting, asking, and commanding respectively, which systematically alter the conversation score in different ways. For pragmatists, all that’s needed is the appropriate kind of content to explain each of their force. Despite the promise of this kind of explanation, Jasper Liptow (Liptow 2013) has argued against pragmatist theories of meaning, due to their tight connection between force and content. Consider the three

sentences:

1. Marlowe will peel an orange.
2. Marlowe, peel an orange!
3. Will Marlowe peel an orange?²

Liptow claims that any theory must explain the semantic commonality between these three sentences – most simply that “the meaning of ‘Marlowe’, ‘peel’, and ‘orange’ is the same in all three case”(Liptow 2013: p.7) But the three are connected in a further way: “In all three cases it is about the upcoming peeling of an orange by Marlowe”(Liptow 2013: p.7) This is typically explained by dividing the meaning of each sentence into two parts (Davidson 1979; McGinn 1977). First, a sentence-radical expressing the sentence’s propositional content, shared by different sentence types. The difference between the sentences is located in their ‘mood’, represented by a mood-operator applied to the sentence-radical. Thus determining the mood of the sentence as either declarative, imperative or interrogative. Liptow argues that pragmatists will have difficulty finding this structure in pragmatic significance. Speech acts of asserting, commanding, and asking have systematically different force, and the force of each does not neatly divide into parts expressing propositional content and mood respectively. Liptow claims that:

Generally speaking, the pragmatic significance of an utterance does not seem to be divided into parts in a simple way (Liptow 2013: p.7).

If Liptow’s argument is successful, it shows that pragmatists cannot explain the semantics of mood in terms of a shared sentence-radical coupled with a mood-operator. The clearest alternative is that they express genuinely different types of content rather than a shared propositional

2. All quotations from Liptow are my own translations.

(or other) core. This flows naturally from the above account of score-keeping pragmatics. Different speech act types systematically alter the conversation score in different ways and so it is no surprise that they express different content types. We will now examine why so many consider content pluralism a non-starter and show what needs to be done to overcome this prejudice.

1.3 Content Pluralism

Call a semantic theory *content monist* if it only has one content type. Most theories are *declarative monist* in taking the propositional content typically expressed by declaratives as this one content type. The alternative to content monism is content pluralism. Content Pluralists, following Nuel Belnap, name Declarative Monism the Declarative Fallacy. He sums it up so:

Strict avoidance of the Declarative Fallacy ... requires the recognition that interrogatives and imperatives are not just marked differently from declaratives, but possess fundamentally different underlying content structures (Belnap 1990: p.5).

Content pluralists argue that there are many rather than just one content types. Questions, imperatives and propositions would be equiprimordial semantic primitives, rather than the latter two being derivative of the former. Nuel Belnap (Belnap 1990) defended such a view and it has recently been advocated for imperatives by Rosja Mastop (Mastop 2005, 2011).

Why do Liptow and many others consider content pluralism a non-starter? One motivation comes from concerns about compositionality, seen through an argument of Dummett's against content pluralism. In his broadly Fregean theory Dummett distinguishes sense (*Sinn*) and force (*Kraft*). Sense is the part of the meaning of an expression 'which is relevant to the determination of a sentence in which it occurs as true or otherwise' (Dummett 1991: p.144). This is at least weakly compositional as

the truth-conditions of sentences are determined by the meanings of their parts. Dummett is committed to:

C₀ The meaning of a complex expression is a function of the meanings of its constituents and the way they are combined (Szabó 2012: p.64).

Force 'indicate[s] which type of speech act is being performed' (Dummett 1991: p.144). The fact that the sentence 'Is it raining?' is in the interrogative mood, according to Dummett, indicates that a question is being asked. Dummett is committed to sentences that differ in their force-indicator being able to share the same sense. E.g 1., 2., and 3. are all meant to express the same proposition:

1. Tim bakes a cake
2. Does Tim bake a cake?
3. Tim, bake a cake!

Because of this the force indicator applies 'to the sentence as a whole' (Dummett 1991: p.115) rather than to particular clauses. E.g 'Come on time or don't bother at all!' has a sense which includes the disjunction over which the imperative force indicator ranges rather than the force indicator being within the disjunction.

Dummett's argument for this position appeals not just to compositionality but also to the idea that word meaning is uniform across sentence-types. I quote him at length:

[I]f we do not observe that the content of a command, request, instruction, or piece of advice can coincide with that of an assertion or sentential question, we shall be perplexed to explain our compelling intuition that most words have the same sense in assertoric and imperative contexts: the words 'simmer' and 'twenty' do not change their sense from those they bore in the cookery book when the cook reports, 'I simmered it for twenty minutes'... They have identical sense: we therefore need a uniform account of what these senses are. Such an account is attainable only if we separate the content of an utterance from

the force attaching to it, regarding words like ‘simmer’, ‘four’, ‘plate’, and so on, as contributing to determining the content independently of the force (Dummett 1991: p.116).

Dummett’s argument is also based around concerns with compositionality. For him, the contents of words are what they contribute to the contents of wholes (sentences or clauses). The contents of wholes are composed out of that of their parts. Yet if there are many different kinds of wholes (propositions, questions, prescriptions etc), then that difference must come from their parts. It is the interaction between compositionality and uniformity of meaning that is doing the work.

Imagine Dummett was concerned about compositionality but not uniformity of meaning and wished to give a semantics for the sentences 1, 2, and 3 above. Unconcerned by uniformity of meaning, Dummett might say that the single orthographic word ‘bake’ is semantically ‘bake_d’, ‘bake_{in}’ and ‘bake_{im}’ – perhaps so for every word. Dummett could tell a story about how the content of each sentence type is composed out of the content of words with the corresponding subscript. Alternatively, imagine he rejected compositionality but maintained uniformity of word meaning. Then he would not be committed to the meanings of wholes being entirely made up of those of their parts. Words appearing in different sentence types could maintain sameness of meaning across types, because the different sentence level meanings could come from somewhere other than their parts. Thus it is only because uniformity of meaning and compositionality are combined that Dummett is so motivated to adopt Declarative Monism.

A similar point stands by considering truth-conditional semantics for logical connectives. Suppose in a conjunction, one of its conjuncts is a non-declarative and therefore not truth-evaluable. E.g, ‘Tim is always late & don’t worry about offending him!’. If this semantics is compositional, there must be some common feature of both conjuncts which can feature in the semantics of ‘&’. Dummett’s answer is that they both share (different) truth-evaluable senses. Again, the combination of uniformity of meaning and compositionality motivates declarative monism.

1.4 Compositionality

If correct, Dummett's argument shows that content pluralism will have difficulty accommodating both uniformity of word meaning and compositionality. Why think though, that Dummett is right in assuming these principles? Wittgenstein in the *Philosophical Investigations* (Wittgenstein 2010) is famously unsystematic and one might be tempted to follow him and reject compositionality. I will briefly explain why we ought to take compositionality seriously. A relatively "theory-neutral" way of stating the principle of compositionality is the earlier:

C_0 The meaning of a complex expression is a function of the meanings of its constituents and the way they are combined (Szabó 2012: p.64).

Why think that something like C_0 holds? The most common argument concerns how we understand expressions. Zoltán Gendler Szabó sums this up so:

the meanings of complexes must be determined by the meanings of their constituents and the way they are combined, since we in fact understand them by understanding their parts and their structure (Szabó 2012: p.14).

The idea is that we understand complex expressions through first understanding their parts and then combining our grasp of the meanings of the parts into that of the complex. That we understand complex expressions in this manner is often supported by two further arguments. First, the argument from productivity. This begins by observing that "competent speakers can understand complex expressions they never encountered before" (Szabó 2012: p.15). The best explanation, so the argument goes, is to posit the principle of compositionality. Speakers understand new complex expressions because they already understand the constituents and then use this to compute the meaning of the complex. The second argument is that from systematicity and is also "an argument to the best explanation" (Szabó 2012: p.17). The initial claim is that given a number of complex expressions, e.g. 'red car', 'long hair', 'cut grass', a speaker

who understands these can also understand “all other complex expressions that can be built up from the[ir] constituents... using syntactic rules employed in building up their structures” (Szabó 2012: p.17). As with productivity, compositionality is appealed to as the best explanation. The speaker understands the initial complex expressions through their parts and means of combination, which are recombined in the new expressions. It is open as to what extent it really is compositionality which best explains productivity and systematicity, and what other commitments are required to do so. Because of this, Szabó suggest that “What really does the job of constraining what lexical meanings might be... is not compositionality but rather whatever best explains productivity and systematicity” (Szabó 2004: p.343). The constraints required for this may be significantly stronger than just compositionality.

So far, the discussion has focused on the question of pragmatism and its viability. In contrasting pragmatism and its rival, representationalism, there has been some conflation between theories of the semantics-pragmatics relation and those of content. Semantic pragmatism here is strictly a thesis about the relationship between semantics and pragmatics, namely that the former is not autonomous from the latter. Representationalism, as a rival to pragmatism, is the assertion of the autonomy of semantics from pragmatics, whereas as a theory of content it is one that appeals to representational vocabulary such as truth and reference as its semantic primitives. Nothing in principle prevents one from being a representationalist about content and also a semantic pragmatist – Davidson may be an example of this (MacFarlane 2010). Representationalism about content is contrasted with inferential role semantics, of which Brandom’s inferentialism is an example. This particular theory of content fits well with the scorekeeping pragmatics introduced earlier on the basis of the chess analogy. There the pragmatic force of a speech act was the way it affected the conversation state. Inferentialists think of the content of a sentence as its inferential role, rather than the conditions under which it is true. The inferential roles of sentences map on to the conventional force of their utterances, thus meeting the pragmatist crite-

ria for a semantic theory. In what follows, the theory of content will be an inferentialist rather than representationalist one. It should not be thought though, that pragmatism *per se* requires this. Inferentialism rather follows from the scorekeeping pragmatics. Compositionality however presents a problem for inferentialists, and any other holistic semantics where the meaning of an expression is constituted by its relations to other expressions. As argued by Jerry Fodor & Ernest Lepore (Lepore and Fodor 2001, 2007), holism appears to violate compositionality because the meanings of complex expression may depend not only on the meanings of their constituents but also on the meanings of other expressions which are semantically related to these constituents. So, despite C_0 being a “weak” or “neutral” statement, it is strong enough to rule out some semantics, merely by attributing a function from the meanings of constituents to that of complexes (the *semantic subformula property*). C_0 requires *atomism* in this sense.

Brandom’s incompatibility semantics for a directly modal logic (Brandom 2008) is a concrete example of a semantics that does not meet C_0 . While the details don’t concern us, what matters is that the semantics is ‘projectable and systematic, in that semantic values are determined for all syntactically admissible compounds, of arbitrary degrees of complexity’ (Brandom 2008: p.135). E.g, the semantic value of ‘ $\neg p$ ’ is determined by p and other expressions of the same logical complexity. Brandom’s semantics however does not have the semantic subformula property (and is therefore holistic) because it is both the meaning of p and other expressions of the same complexity which determine the meaning of ‘ $\neg p$ ’. This vindicates Szabó’s above conclusion that what really matters is whatever can explain productivity (projectability) and systematicity. A semantics needn’t be compositional in an atomistic sense in order to do so. Brandom sums this up by saying that:

What semantic *projectability*, *systematicity*, and *learnability-in-principle* require, then, is not semantic *atomism* and *compositionality*, but semantic recursiveness with respect to complexity... Having compound expressions exhibit the semantic sub-

formula property is only *one* way of securing recursiveness. The standard arguments for semantic compositionality are fallacious (Brandom 2010: p.336).

This response removes worries that inferentialist semantics, favoured by many pragmatists, fail on the grounds of compositionality. A semantics may not be compositional but still recursive. Semantic recursiveness is also all that is required for Dummett's earlier argument. A recursive but non-compositional semantics still faces the problem of words with apparently uniform meanings combining in such a way to project different wholes. The problem has not disappeared but inferentialist-pragmatists can in principle address it rather than being ruled out by requirements of compositionality.

1.5 Conclusion

1.5.1 Reconnecting Pragmatism, Pluralism, and Compositionality

We can draw on compositionality ("recursiveness") to give positive arguments for content pluralism, through the difference between force and content. Take a declarative sentence 'A'. When uttered freestanding, the act conventionally has the force of an assertion. However, when embedded in the conditional 'A \supset B', the utterance is not an assertion of 'A'. Traditionally content is identified with that which is preserved under embedding. This can be used against varieties of the mood-setter sentence-radical theory. Suppose for the following sentences

1. Who shot Mr Burns?
2. Shoot Mr Burns!
3. Homer didn't shoot Mr Burns.

the content is in each case a proposition whereas being mooded is only part of the force. If so, then when non-declaratives are embedded what

they contribute as a constituent ought to be propositional. The following are *prima facie* counterexamples:

1. I wonder who shot Mr Burns?
2. If Homer didn't shoot Mr Burns, then who did?
3. Tell me who shot Mr Burns!
4. If he tries to steal Bobo, then shoot Mr Burns!

The embedded interrogative and imperative appear to contribute something non-truthy. Moreover, the interrogative can be embedded within the imperative. It is open to propositional theories to explain away these cases but they *prima facie* favour content pluralist accounts of meaning.

Compositionality also forms part of a negative argument against those who think that the mood-setter forms part of the content. David Lewis gives us a good summary of a representationalist and non-pragmatist theory:

In order to say what a meaning *is*, we may first ask what a meaning *does*, and then find something that does that.

A meaning for a sentence is something that determines the conditions under which the sentence is true or false. It determines the truth-value of the sentence in various possible states of affairs, at various times, at various places, for various speakers, and so on. (Lewis 1970: p.54)

Lewis intends this to cover all sentence types, not only declaratives, and treats non-declaratives as paraphrases of performative declaratives. E.g 'Shut the door!' paraphrases 'I hereby command you to shut the door!'. Though odd-sounding, it has an important advantage of over the mood-setter theory. For it places the semantics of non-declaratives within a general theory of meaning, one where meaning determines truth-conditions.

Where the mood setter is understood as merely indicating conventional force (Dummett (1991)) or is itself truth-conditional (Davidson (1979)) it stays consistent with the above Lewis quote. Where it fails

is that 'mood' appears to embed (contra Dummett) and moreover this embedded content appears to be non-propositional (contra Davidson). Some have proposed new semantic predicates such as 'answered' and 'obeyed' to go alongside 'truth' subsuming all under a general notion such as 'fulfilment' (e.g Boisvert and Ludwig (2006); Ludwig (1997)). There are two worries with this sort of theory. First, it may have strayed into pragmatist territory by tying the notion of content to how the expressions are used. Being answered, obeyed etc are aspects of use, which non-pragmatists deny are tied to content. Second, they may collapse into truth-conditions, as pointed out by Ernest Lepore & Sarah-Jane Leslie (Lepore and Leslie 2001). Each non-declarative is fulfilment-wise equivalent to some declarative which states the former's fulfilment conditions. Thus making all sentence types have the same content – all content can then be subsumed under propositional content. However the earlier examples of embedding point to the 'mood' as part of the content. So we are stuck at an impasse.

It may appear that inferentialists face a similar problem. They are, according to Belnap:

also miserably guilty of the Declarative Fallacy, for, to a first approximation, it is *only* declaratives that can figure in inference, and we are thereby given no purchase on interrogatives or imperatives (Belnap 1990: p.8).

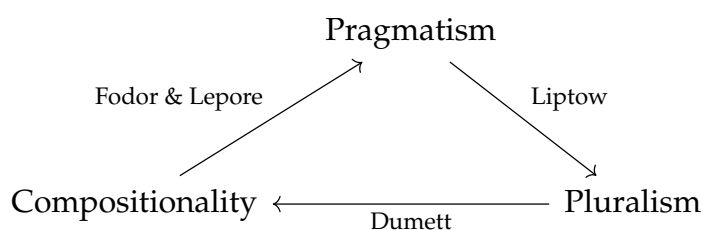
Brandom is happily guilty of this. He argues that in pragmatics assertion is *the* fundamental speech act, and that in semantics it is propositions, understood as inferential roles. Other speech acts and possible contents are parasitic:

It is only because some performances function as assertions that others deserve to be distinguished as *speech acts*. The class of questions, for instance, is recognizable in virtue of its relation to possible answers, and offering an answer is making an assertion... Orders or commands are not just performances that alter the boundaries of what is permissible or obligatory. They are performances that do so specifically by *saying* or *de-*

scribing what is and is not appropriate, and this sort of making explicit is parasitic on claiming (Brandom 1994: 172).

It is really only on first approximation however that inferentialism is a dead end for non-declaratives. The notion of inference used by Brandom piggybacks on the scorekeeping relations in the pragmatics. Given this the ‘inferential’ relations between non-declaratives, if we want to call it ‘inference’, will follow from the relevant scorekeeping relations in their pragmatics. The notion of ‘inference’ in this sense is far easier to generalise than that of truth. The remainder of the thesis will do just this.

1.5.2 Where to now?



We’ve gotten here by looking at three ideas - pragmatism, pluralism, and the principle of compositionality - each connected by an argument. We began by looking at *pragmatism*, the idea that

what attributions of semantic contentfulness are for is explaining the normative significance of intentional states such as beliefs and of speech acts such as assertions (Brandom 1994: p.143).

We then examined part of an argument of Jasper Liptow’s that a pragmatism theory of meaning could not account for a semantics of mood where the meaning of a sentence was divided into a propositional core and mood-setter. Rather than seeing this as a blow for pragmatism we suggested that a more natural account of mood was one where different sentence types shared no propositional core. We called this view *content pluralism*. Next, we asked why so many philosophers have considered content pluralism a non-starter. After looking at an argument of Michael

Dummett's we saw that one reason was its apparent inability to meet requirements of *uniformity of meaning* and *compositionality*. We then examined the principle of compositionality more closely, covering its use in explaining *productivity* and *systematicity*. We took on Szabó's suggestion that rather than compositionality *per se* it was the need to explain these two phenomena that puts constraints on our semantic theories. This posed an apparent problem for our original commitment to pragmatism, as Jerry Fodor & Ernest Lepore have argued that a holistic theory of content required by our brand of pragmatism could not be compositional, and thus explain neither productivity nor systematicity. We then drew on the work of Robert Brandom to show that it is possible for a semantics to be non-compositional but still *recursive* and thus projectable [productive] and systematic. This showed that Dummett's argument poses no in principle problem for a semantics which is both pluralist and pragmatist. If that is successful we would be then in a position to respond to Liptow by showing that pragmatists have a viable alternative explanation of the semantics of mood. The remaining chapters will follow through on these commitments.

CHAPTER TWO

Atomic and Subatomic Systems

2.1 Introduction

In the previous chapter three arguments were introduced which motivate the topic of the thesis. The first was Liptow's argument that semantic pragmatists cannot accommodate different sentence types which share the same propositional content. The second was Dummett's argument that all sentence level meaning must be propositional, and the third was Fodor & Lepore's argument that inferentialists cannot accommodate compositionality and are thus bound to fail. The thesis will respond to these arguments by setting out a theory where meaning is dependent on use, content is understood in terms of inferential roles, and sentence level meaning is plural. This will be done in reverse order, using the response to Fodor & Lepore to answer Dummett, and then the response to Dummett to answer Liptow. This chapter will respond to Fodor & Lepore by setting out a compositional, inferentialist semantics for atomic sentences, names and predicates. This semantics results in an analogous structure to a simple extensional semantics in the model-theoretic tradition, but which uses proof-theory as its basis. To do so I first sketch Greg Restall's bilateralist interpretation of the multiple conclusion sequent calculus. This declarative semantics for logic connectives will be expanded on in the thesis, first in this chapter to atomics and their constituents and then in the next chapter to imperatives. Second, I introduce Brandom's

notion of material inference and show how it can be formalised in an atomic system: a proof system for atomic sentences. The system is “well-behaved” and allows for cut-elimination. Third, I use Brandom’s distinction between names and predicates in terms of their inferential roles to extend the previous proof system to accommodate subsententials. This subatomic system allows for a compositional proof-theoretic semantics analogous to the standard model-theoretic one, but where classes of models are derivative of the basic inference rules. Lastly, I show how this semantics responds to Fodor & Lepore’s objection. On a narrow notion of meaning it is compositional and on a broader one is still recursive, in the sense discussed in Section 1.4 of the previous chapter.

2.2 Bilateralism

2.2.1 Assertion, Denial, and the Sequent Calculus

In this section I briefly sketch a bilateralist interpretation of the classical multiple conclusion sequent calculus, drawing on the work of Greg Restall (Restall 2005b, 2009, 2013). Later in this chapter, it is extended to atomic declarative sentences and their constituents, predicates and names, and in the last two chapters, to imperatives and their constituents.

Bilateralism is a kind of semantic pragmatism – the claim that meaning (semantics) depend on use (pragmatics), where the point of attributing meanings is to explain (or prescribe) aspects of use. Exemplifying this position Brandom says:

[I]t is pointless to attribute semantic structure or content that does no pragmatic explanatory work. It is only insofar as it is appealed to in explaining the circumstances under which judgments and inferences are properly made and the proper consequences of doing so that something associated by the theorist with interpreted states or expressions qualifies as a semantic interpretant, or deserves to be called a theoretical concept of content (Brandom 1994: p.144).

Importantly, this is a *normative* rather than *dispositional* pragmatism (e.g. Horwich (1998)) – meaning is determined by norms of correct use not patterns of actual use.

Bilateralism is an answer to the question ‘which norms of use?’. Unilateralists are those, such as Brandom and Dummett (Brandom 1994; Dummett 1991), who answer that the single speech act of assertion determines meaning. There are many kinds of bilateralism (Price 1990; Restall 2005b; Rumfitt 2000). What is shared between them is the view that norms of both assertion and denial determine meaning, where denials of p are not simply assertions of $\neg p$. Here I adopt Restall’s take on bilateralism as an interpretation of the multiple conclusion sequent calculus. He gives three main motivations for bilateralism:

1. Many speakers appear to (developmentally) be able to deny propositions, before being able to assert negations;
2. Assertion and denial provides a framework for both classical and some non-classical logics. Classical logicians treat the assertion [denial] of both a proposition and its negation as incoherent. In contrast, dialethists allow the coherent assertion of both a proposition and its negation, whereas supervaluationists treat the denial of both as a coherent option; and
3. It shows how consequence relations place cognitive constraints on us. Asserting p does not require one to assert all of its logical consequences nor actively form beliefs about them. Instead of focusing on what’s prescribed (ruled in), bilateralism focuses on what’s proscribed (ruled out) by performing a speech act. Asserting p rules out denying p ’s consequences. Doing so is “out of bounds”. Similarly, denying p rules out asserting (at least one of) p ’s possible antecedents (Restall 2005b).

To simplify talk about interactions between assertions and denials we introduce the notion of a declarative position

$X : Y$

made up of the possibly empty multisets³ of sentences asserted X and denied Y . These positions are bound by norms of coherence and incoherence. Incoherent, or “out of bounds”, positions and coherent, or “in bounds”, positions are written respectively as

$$X \vdash Y \quad X \not\vdash Y$$

We write

$$X, p : Y, q$$

for the position where the single sentence p is added to the speaker’s assertions and the single sentence q to the speaker’s denials.

This provides a natural reading of the classical multiple conclusion sequent calculus. Below are the standard rules for the logical connectives

$$\frac{X, A \vdash Y \quad X, B \vdash Y}{X, A \vee B \vdash Y} \vee L \quad \frac{X \vdash A, Y}{X \vdash A \vee B, Y} \vee R_1 \quad \frac{X \vdash B, Y}{X \vdash A \vee B, Y} \vee R_2$$

$$\frac{X, A \vdash Y}{X, A \wedge B \vdash Y} \wedge L_1 \quad \frac{X, B \vdash Y}{X, A \wedge B \vdash Y} \wedge L_2 \quad \frac{X \vdash A, Y \quad X \vdash B, Y}{X \vdash A \wedge B, Y} \wedge R$$

$$\frac{X \vdash A, Y}{X, \neg A \vdash Y} \neg L \quad \frac{X, A \vdash Y}{X \vdash \neg A, Y} \neg R$$

$$\frac{X \vdash A, Y \quad X, B \vdash Y}{X, A \supset B \vdash Y} \supset L \quad \frac{X, A \vdash B, Y}{X \vdash A \supset B, Y} \supset R$$

Read the turnstile as recording that it is incoherent to both assert all to the left of the turnstile and deny all to the right. The inference rules can be read top-to-bottom or bottom-to-top. Top-to-bottom they say that if the position(s) above the line are out of bounds then so is the one below the line. Bottom-to-top they say that if the position below the line is coherent then at least one of the positions above the line is also. The

3. A multiset is simply like a set but which tracks the number of instances of a member. E.g $\{a,b,c\}$ and $\{a,a,b,c\}$ would be the same sets but different multisets. Order however doesn’t matter. $\{a,b,c\}$ and $\{b,c,a\}$ are the same multisets.

sequent calculus has two types of rules, left [L] and right [R]. Top-to-bottom [bottom-to-top] the left rules say when it is incoherent [coherent] to assert a logically complex sentence, whereas the right rules govern coherence and incoherence of denials. E.g, $\neg L$ says that if it is incoherent to deny A , in the context of asserting all of X and denying all of Y , then it is also incoherent to assert $\neg A$ in the same context. Read the other way, it says that if it is coherent to assert $\neg A$ in some context, then it is coherent to deny A also. The two negation rules have the effect of making the assertion [denial] of a negation and the denial [assertion] of its negand have equivalent force. A “gappy” or “glutty” theory will modify these to remove one or both of these equivalences.⁴

Alongside rules governing specific connectives, there are also the following structural rules, governing assertions and denials in general

$$\frac{}{p \vdash p} Id \qquad \frac{X \vdash A, Y \quad X, A \vdash Y}{X \vdash Y} Cut$$

$$\frac{X \vdash Y}{X \vdash A, Y} KR \qquad \frac{X \vdash Y}{X, A \vdash Y} KL$$

$$\frac{X \vdash A, A, Y}{X \vdash A, Y} WR \qquad \frac{X, A, A \vdash Y}{X, A \vdash Y} WL$$

Id (for identity) is the only axiom and records the basic incoherency of asserting and denying the same thing. *Cut* is a kind of transitivity and is read top-to-bottom as saying that if it is incoherent to deny A (along with asserting X and denying Y) and also incoherent to assert A (along with asserting X and denying Y) then it is incoherent to jointly assert X and deny Y . Bottom-to-top it tells us that if asserting all of X and denying all of Y is coherent, then either asserting or denying A is coherent. Weakening (*K*) and contraction (*W*) will only play a minor role in the following and respectively record monotonicity and idempotency.⁵

4. The logics K_3 (Kleene 1952) and LP (Priest 1979) are examples of gappy and glutty theories respectively.

5. Sequent systems also sometimes include a rule of permutation (exchange) which

A derivation in the sequent calculus is a tree of sequents whose leaves are all instances of $[Id]$ and whose transitions are all either an instance of one of the structural or connective rules (Restall 2009: p.243). For example,

$$\frac{\frac{\frac{\overline{A \vdash A}^{Id}}{A, \neg A \vdash}^{-L}}{A, \neg A \wedge \neg B \vdash}^{\wedge L_1} \quad \frac{\frac{\overline{B \vdash B}^{Id}}{B, \neg B \vdash}^{-L}}{B, \neg A \wedge \neg B \vdash}^{\wedge L_1}}{\neg A \wedge \neg B, \neg A \wedge \neg B, A \vee B \vdash}^{\vee L}}{\neg A \wedge \neg B, A \vee B \vdash}^{WL}}{\neg A \wedge \neg B \vdash \neg(A \vee B)}^{-R}$$

This derivation shows that the clash between the complex sentences $\neg A \wedge \neg B$ and $\neg(A \vee B)$ is composed out of (or decomposes into) simple clashes between asserting and denying the same thing (Id). In this way, it is a compositional semantics because the inferential roles governing complex sentences are a function of those of their constituents and the way they combine.

2.2.2 Limit Positions and Models

We have so far identified semantic content with inferential roles rather than traditional model theoretic extensions. However, given inferential roles for sentences, the latter can be recovered. We do so by thinking of our coherent *positions* as models.

Definition [POSITION]: Given a collection of sentences, with a consequent relation \vdash satisfying the rules of the classical sequent calculus, a pair $[X : Y]$ of sets of sentences is a *position* when $X \not\vdash Y$ (Restall 2009: p.,246).⁶

Rather than a property of the sentences themselves, being asserted or

allows one to change the order of premises or conclusions. We are however working with multisets which make order irrelevant. See previous footnote.

6. For simplicity we here use sets rather than multisets. Take a multiset with multiple instance of some formula(s). Then apply contraction until there is only one.

denied is a function of being to the left or right in our representation of positions.

Definition: [LEFT AND RIGHT, IN A POSITION]: The LEFT COMPONENT of the position $[X : Y]$ is X . The RIGHT COMPONENT is Y . These are the formulas explicitly on the left and in the right, respectively. We say that A is to TO THE LEFT of $[X : Y]$ if and only if $X \vdash A, Y$. A is to THE RIGHT OF $[X : Y]$ if and only if $X, A \vdash Y$ (Restall 2009: p.,247).

As a conversation continues, its participants make further assertions and denials. When the new position is consistent with the old, we call this an *extension* of the old position:

DEFINITION [EXTENSION OF POSITIONS]: $[X' : Y']$ extends $[X : Y]$ if every formula in X is in X' , and every formula in Y is in Y' (Restall 2009: p.,248).

The more opinionated someone becomes, the more populated their position is on the left and the right. However, assuming their language is recursive they can never explicitly take a stance on every topic. “Taking a stance on everything” is a kind of maximally opinionated limit – an idealisation which can be approached but never reached. Each of these is a *limit position*:

DEFINITION [LIMIT POSITIONS]: Given a language \mathcal{L} , a LIMIT POSITION is a pair $[\mathfrak{X} : \mathfrak{Y}]$ of sets of sentences such that (a) whenever $X \subset \mathfrak{X}$ and $Y \subset \mathfrak{Y}$ are finite sets of formulas, $[X : Y]$ is a position, and (b) $\mathfrak{X} \cup \mathfrak{Y} = \mathcal{L}$ (Restall 2009: p.,249).

Limit positions act as Boolean evaluations for a language, with every sentence on the left assigned ‘true’ and every on the right assigned ‘false’. These assignments are compositional because whether a complex formula is on the left or right depends on whether its subformulae are on the left or right in one-to-one correspondence with truth-functional connectives:

FACT 5: For any limit position P (i) $A \wedge B$ is to the left of P iff A and B are both to the left of P . (i') $A \wedge B$ is to the right of P iff either A or B is to the right of P . (ii) $A \vee B$ is to the right of P iff A and B are both to the right of P . (ii') $A \vee B$ is to the left of P iff either A or B are to the left of P . (iii) $\neg A$ is to the left of P iff A is to the right of P . (iv) $\neg A$ is to the right of P iff A is to the left of P . (v) A is to the left of P iff A is not to the right of P (Restall 2009: p.,249).

This gives us a notion of ‘truth (or falsity) in a model’ as ‘being to the left (or the right)’ of a limit position and propositional content as ‘possible worlds at which it is true’ as ‘limit positions in which it is to the left’, for those who wish to define them so. These model theoretic (“representational”) notions here are idealisations, abstractions away from our concrete norms governing our assertions and denials. Later in Section 2.3.5 we will show how this same limit position approach can define corresponding classes of models for atomics, given basic inference rules, and the same for names and predicates in 2.4.4.

2.3 Material Inference and Atomic Systems

So far, we have focused on an inferentialist semantics for logical vocabulary, where the meanings of logical constants are their inferential roles, represented by rules in a proof system. What though, about non-logical expressions and logically simple sentences? This section shows how a notion of material rather than formal logical inference can accommodate these cases and be appropriately represented in a proof system.

2.3.1 Material Inference

Here we introduce the notion of *material inference*, taken from (Brandom 2000: Chapter 1, Section 5), which constitutes the meanings of non-logical expressions. We do so on via analogy with a notion of material rather than formal truth, showing that representationalists must also make a formal/material distinction.

Suppose you have a representationalist semantics for logical vocabulary. E.g

- $v(A \wedge B) = 1$ iff $v(A) = 1$ and $v(B) = 1$.
- $v(A \vee B) = 1$ iff $v(A) = 1$ or $v(B) = 1$.

What though, do the atomic sentences substituted for A and B mean? What are their truth conditions? Their semantics requires not just formal truth conditions, i.e truth conditions for logical vocabulary, but also *material* truth. This mustn't equate 'truth' with something like 'logical truth'. For 'Water is H_2O ' might (controversially!) be a semantic truth but is not one of logic. This often involves a story about how the meanings of atomic sentences are composed from those of their parts. For now however, we restrict ourselves to a merely propositional language with the three constants:

- p : Rumo is a dog
- q : Rumos is a cat
- r : Rumo is a mammal

and the following truth-conditions:

- $v(r) = 1$ iff $v(p) = 1$ or $v(q) = 1$.
- $v(p) = 1$ iff $v(r) = 1$ and $v(q) = 0$.
- $v(q) = 1$ iff $v(r) = 1$ and $v(p) = 0$.

We might have done this by stating the following logically complex expressions as axioms:

- $v(r \equiv (p \vee q)) = 1$.
- $v(p \equiv (r \wedge \neg q)) = 1$.
- $v(q \equiv (r \wedge \neg p)) = 1$.

This, however, violates treating the meanings of complexes as a function of constituents. The earlier truth conditions for p , q , and r ground the truth of the purported axioms and the latter are rather theorems of our propositional language extended with logical vocabulary. So a representationalist semantics also requires a notion of non-logical or *material* truth and a means of representing such truth conditions.

Inferentialists are in an analogous position regarding inference rather than truth. Suppose our notion of ‘good inference’ were assimilated to that of ‘logically valid inference’. E.g

$$\frac{\text{If it's tasty, then I'll eat it. It's tasty.}}{\text{I'll eat it.}}$$

This has the logical form

$$\frac{\text{If } A, \text{ then } B \quad A}{B}$$

That the conclusion follows from the premises need have nothing to do with the meanings of A and B . Just as with logical truth for representationalists, logical inference cannot be the basis of an inferentialist semantics for non-logical expressions. Rather than just those that are good in virtue of their logical form, we need to also attend to those that Brandom calls ‘material inferences’. These are inferences that are good in virtue of their conceptual contents or non-logical vocabulary. E.g

$$\frac{\text{Paula is a platypus}}{\text{Paula is a monotreme}}$$

This isn't logically valid as its sequent calculus logical form is

$$\frac{X \vdash A, Y}{X \vdash B, Y} \quad \frac{X, B \vdash Y}{X, A \vdash Y}$$

Rather it's good in virtue of the contents of ‘platypus’ and ‘monotreme’.⁷ It is these conceptual contents constituted by material inferential relations which can be made explicit by logical vocabulary. In this case by the

7. For the interested non-Antipodean, monotremes are mammals which lay eggs. There are two kinds: platypus and echidna.

quantified conditional $\forall xPx \supset Mx$.⁸ Logically valid inferences can be understood as those materially good inferences which remain good when holding logical vocabulary fixed and substituting and arbitrarily substituting the non-logical vocabulary. They are good in virtue of the contents of logical expressions (Brandom 1994: p.104)(Brandom 2000: p.55).

2.3.2 Atomic Systems

Here we formalise Brandom's notion of material inference between atomic sentences by extending some of Dag Prawitz's work on atomic systems and proof-theoretic validity.

Prawitz defines proof-theoretic validity using the notion of deductions over arbitrary atomic systems (Prawitz 1970, 1971, 1973), analogous to models in model-theoretic semantics (Wieckowski 2011: p.220).⁹ Prawitz defines an atomic system as:

a pair (L, R) where L is a set of descriptive constants including those that determine the language we are dealing with and R is a set of inference rules for inferences from atomic formulas to atomic formulas in the language L (Prawitz 1973: p.231).

We now build on Prawitz's notion of an atomic system within the context of the multiple conclusion sequent calculus. We define an Atomic System as a triple of a language $[L]$, a set of inference rules $[R]$, and an assignment function $[v]$: $\{L, R, v\}$. We stipulate that $[L]$ is made up only of atomic constants. Restriction will be lifted later in the chapter to include those with subsentential vocabulary. As in Prawitz's case, $[R]$ includes

8. Brandom also makes the point that many materially valid inferences are non-monotonic. For example, that from 'It is raining' to 'I should bring my umbrella' (Brandom 2000: p.87). This will not play a major role in the following discussion. The inferential relations considered here are closer to his incompatibility entailments focused on in (Brandom 2008).

9. In (Prawitz 1973), Prawitz refers to these as 'atomic bases'. I have adopted the term 'atomic system' from (Wieckowski 2011: p.220), who provides a critical explanation of Prawitz's work and a very different take on the meanings of atomics and their constituents than the one taken here.

inference rules linking atomic formula. Rather than restricting the rules in $[R]$ to behave appropriately, restrictions on v are introduced throughout the chapter.

2.3.3 Local Soundness and Completeness

As it stands, there are no restraints on the rules assigned by v , giving no guarantee that our atomic systems will be well-behaved (e.g. consistent). In proof-theoretic semantics a common restriction on the inference rules assigned to logical expressions is that they be *harmonious*. Harmony is often understood in terms of not being able to infer anything more from the introduction of an expression than from the grounds for its introduction. A further requirement, sometimes called *stability*, is that we can infer no less from the introduction of a logically complex sentence than from the grounds for its introduction.¹⁰ The take on these requirements adopted here is due to Pfenning & Davies, which they call *local soundness & completeness* [LSC] (Pfenning and Davies 2001), with soundness corresponding to harmony and completeness to stability. In a natural deduction system, the elimination rules for a connective are sound relative to the introduction rules when a derivation involving the application of the introduction and then the elimination rules can be reduced to one involving neither. E.g. conjunction

$$\frac{\frac{\frac{\vdots \pi_1 \quad \vdots \pi_2}{A \quad B} \wedge I}{A \wedge B} \wedge E_1}{A} \Longrightarrow A \quad \frac{\frac{\frac{\vdots \pi_1 \quad \vdots \pi_2}{A \quad B} \wedge I}{A \wedge B} \wedge E_2}{B} \Longrightarrow B$$

The elimination rules are complete relative to the introduction rules when we can expand a derivation of a complex sentence into one where we first

10. Dummett (1991) provides a more philosophical discussion of harmony and stability.

Examples

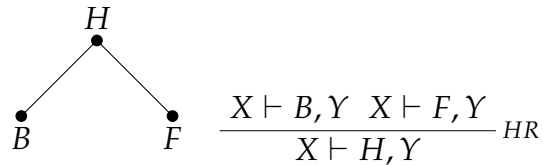
Before moving on to material inference rules in general, we will briefly describe three examples of the kinds of rules we are talking about. First, the example of “conjunctive” relations between the atomics H , B , and F , as represented below:

Figure 2.1: Human Example

H Socrates is human

B Socrates is a biped

F Socrates is featherless



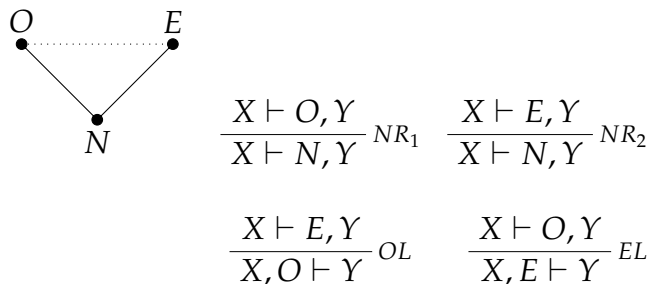
Above we have an R-rule for H and diagrammatic representation as a tree to its left. Trees will become useful in the next section to represent larger languages with many inferential relations. Second, below we have “disjunctive” and “negation”-like relations between the atomics O , E , and N .

Figure 2.2: Number Example

O 2 is odd

E 2 is even

N 2 is a number



In our first two examples, although strictly speaking atomics, in their English translations it is the predicates which appear to be doing the work. Below is an example where in the English it is the names doing so.

Figure 2.5: General Identity for Parents

(a) Bonsai

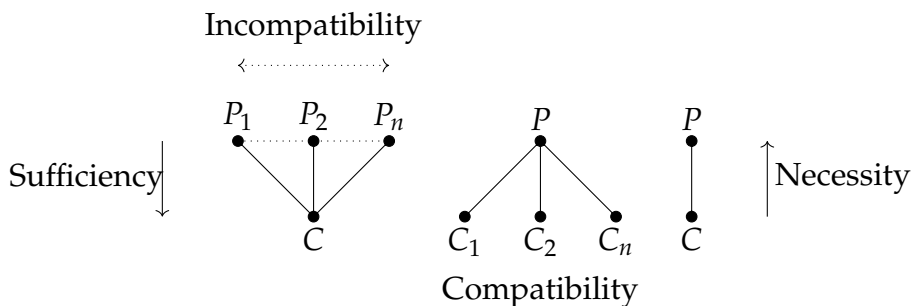


(b) Laputa



The collection of a root along with its leaves is a *concept cluster*, to which there are a corresponding *cluster of rules*. To represent a concept cluster we write $\{R, L_1, \dots, L_n\}$. The rules for a cluster are represented by vertical branches linking the root and leaves and, horizontal branches linking leaves. The earlier 'Human', 'Number', and 'Super' examples are all concept clusters. In more complex languages, one expression may be part of many clusters, and so for their rules.

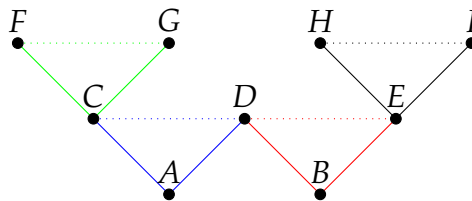
Figure 2.6: Tree Forms: Parents & Children



In our earlier examples we had rules representing three kinds of relations, those of sufficiency, necessity, and incompatibility. Within a con-

cept cluster we can identify different roles according to these relations. For each concept cluster, those at the top are parents [P] and those below children [C]. A root node might have many parents or children. For each child C [parent P], $\mathbb{P}[C]$ is the set of its parents [children]. Each pair of a parent [child] and the set of its children [parents] form a concept cluster. Parents and children stand in different kinds of relations to one another. Each parent is (by itself) a sufficient condition for each of its children. Conversely, each child is (by itself) a necessary condition for each of its parents. Necessity goes up, while sufficiency goes down the tree. Each set of children with the same parent are *siblings*. Siblings are compatible with one another. Dotted lines between parents of the same child represent incompatibility. Depending on our tree we may want parents to be compatible or incompatible. Each parent [child] of a child [parent] is one of its *ancestors* [*descendants*]. Ancestorhood [descendanthood] is transitive.

Figure 2.7: Example Tree



Above is a tree made up of several clusters. Each cluster whose root is a child is marked by different coloured branches. Note that because D is a parent of both A and B , it also heads the cluster $\{D, A, B\}$.

Rules

Below are general material inference rules corresponding to the general trees above.

Figure 2.8: General rule forms

$$\frac{X \vdash P_i, Y}{X \vdash C_i, Y} CR \quad \frac{X, C_1, \dots, C_n \vdash Y}{X, P_i \vdash Y} PL_1$$

$$\frac{X, P_1 \vdash Y \quad \dots \quad X, P_n \vdash Y}{X, C_1, \dots, C_n \vdash Y} CL$$

$$\frac{X \vdash P_i, Y}{X, P_j \vdash Y} PL_2$$

$$\frac{X \vdash C_1, Y \quad \dots \quad X \vdash C_n, Y \quad X, P_i \vdash Y \quad \dots \quad X, P_n \vdash Y}{X \vdash P_j, Y} PR$$

Each parent and child have rules introducing [eliminating] it on the left and on the right.

- [CR] tells us that for each parent P_i in a concept cluster, if it is on the right we may eliminate it and introduce one of the children C_i in the cluster. In terms of assertion and denial, if it is incoherent to deny a parent then it is incoherent to deny each of its children.
- [PL₁] tells us that for each child C_i in a concept cluster, if it is on the left we may eliminate it and introduce one of the parents P_i in the cluster. If it is incoherent to assert all of the children, then it is incoherent to assert each of the parents. Note that with weakening this follows from it being incoherent to assert one of the children.
- [CL] tells us that if we have for each parent P_1, \dots, P_n in a concept cluster, a derivation with the parent on the left and some (possibly empty) Y on the right, then we may eliminate the parents and introduce on the left each child C_1, \dots, C_n in the cluster. If asserting each of the parents is incoherent then so is asserting all of the children.
- [PL₂] tells us that for each parent P_i in a concept cluster, if it is on the right we may eliminate it and introduce some other parent P_j

on the left. If it is incoherent to deny a parent then it is incoherent to assert each of the other parents.

- [PR] is the most complicated. Suppose that for every child C_1, \dots, C_n in a cluster, we have derivations from some X ending with each child on the right. Also, for every parent P_1, \dots, P_n except for one, P_j , we have derivations with each parent on the left and some Y on the right. We may then eliminate the premise children and parents, introducing P_j on the right. Simply put, it's incoherent to deny a parent when it's incoherent to deny each of its children and assert each of the other parents.

The rules have been phrased in a way which is neutral regarding whether the root is a parent or child. In any actual cluster there will either only be one parent or only one child. This will be the root of the cluster.

To make these general rules more concrete we apply them to the examples from 3.4.1:

Figure 2.9: $\{N, O, E\}$ Rules

$$\begin{array}{c}
 \frac{X \vdash O, Y}{X \vdash N, Y}^{NR_1} \qquad \frac{X \vdash E, Y}{X \vdash N, Y}^{NR_2} \\
 \\
 \frac{X, N \vdash Y}{X, O \vdash Y}^{OL_1} \qquad \frac{X, N \vdash Y}{X, E \vdash Y}^{EL_1} \\
 \\
 \frac{X, O \vdash Y \quad X, E \vdash Y}{X, N \vdash Y}^{NL} \\
 \\
 \frac{X \vdash O, Y}{X, E \vdash Y}^{EL_2} \qquad \frac{X \vdash E, Y}{X, O \vdash Y}^{OL_2} \\
 \\
 \frac{X \vdash N, Y \quad X, E \vdash Y}{X \vdash O, Y}^{OR} \qquad \frac{X \vdash N, Y \quad X, O \vdash Y}{X \vdash E, Y}^{ER}
 \end{array}$$

In the above $\{N, O, E\}$ rules, [CR] has become the two [NR] rules. [PL₁] has become [OL₁] and [EL₁]. [CL] has become [NL]. The general form of

the rule allows for multiple children to be introduced on the left. However for clusters like $\{N, O, E\}$ whose root is a child, the instance of this rule will only introduce one child on the left. $[PL_1]$ has become $[OL_2]$ and $[EL_2]$. Lastly, $[PR]$ has become $[OR]$ and $[ER]$. As there are only two parents and one child, the premises for these instances of the rule are much simpler than the general rule itself.

Below we have the instances of the general rules for the $\{H, B, F\}$ cluster:

Figure 2.10: $\{H, B, F\}$ Rules

$$\frac{X \vdash H, Y}{X \vdash B, Y}^{BR} \quad \frac{X \vdash H, Y}{X \vdash F, Y}^{FR}$$

$$\frac{X, B \vdash Y}{X, H \vdash Y}^{HL_1} \quad \frac{X, F \vdash Y}{X, H \vdash Y}^{HL_2}$$

$$\frac{X, H \vdash Y}{X, B, F \vdash Y}^{B,FL}$$

$$\frac{X \vdash B, Y \quad X \vdash F, Y}{X \vdash H, Y}^{HR}$$

These are similar to those for $\{N, O, E\}$ but with some differences due it being a single parent, multi-child cluster (rather than multi-parent, single child). The instance of $[CL]$, $[B, FL]$, is a single premise multiple-conclusion rule, rather than the other way round. $[HR]$, the instance of $[PR]$, also differs in requiring derivations on the right of many children but none on the left of other parents. Lastly, those for the earlier non-branching ‘super’ cluster $\{S, C\}$:

$$\frac{X \vdash S, Y}{X \vdash C, Y}^{CR} \quad \frac{X, S \vdash Y}{X, C \vdash Y}^{CL}$$

$$\frac{X \vdash C, Y}{X \vdash S, Y}^{SR} \quad \frac{X, C \vdash Y}{X, S \vdash Y}^{SL}$$

There is no rule corresponding to PL_2 because there is only one parent. As will be important when discussing subsententials, clusters with branching result in asymmetric inference rules whereas the rules for those without branching are symmetric.

General Local Soundness & Completeness

We now show that the above general rule forms are Locally Sound & Complete (LSC). LSC is shown for each cluster rather than each constant. We divide the general rule forms into two groups, the second of which are locally sound and complete relative to the first.

Figure 2.11: First Rules

$$\frac{X \vdash P_i, Y}{X \vdash C_i, Y} CR$$

$$\frac{X, C_1, \dots, C_n \vdash Y}{X, P_i \vdash Y} PL_1 \quad \frac{X \vdash P_i, Y}{X, P_j \vdash Y} PL_2$$

We can think of the first rules as those showing movement from parents down to children or across to other parents. Parents are sufficient conditions for children ('dog' to 'mammal') and incompatible with one-another ('dog' to 'cat').

Figure 2.12: Second Rules

$$\frac{X, P_1 \vdash Y \quad \dots \quad X, P_n \vdash Y}{X, C_1, \dots, C_n \vdash Y} CL$$

$$\frac{X \vdash C_1, Y \quad \dots \quad X \vdash C_n, Y \quad X, P_i \vdash Y \quad \dots \quad X, P_n \vdash Y}{X \vdash P_j, Y} PR$$

We can think of the second rules as those showing movement from children up to parents (from 'biped' and 'featherless' to 'human').

Local Soundness: Our second rules are sound relative to the first if we

can apply the second rules to the outputs of the first rules, resulting only in the inputs for the first rules. No information is gained through the application of the second rules which is not already “contained” in the application of the first. Derivations which apply the first and then the second rules of the one cluster can be reduced to ones that do not.

Figure 2.13: Soundness of [PR] relative to [CR] and [PL₂]

$$\begin{array}{c}
 \begin{array}{cccc}
 \vdots \pi & \vdots \pi & \vdots \pi & \vdots \pi \\
 \frac{X \vdash P_i, Y}{X \vdash C_1} C_1R & \frac{X \vdash P_i, Y}{X \vdash C_n} C_nR & \frac{X \vdash P_i, Y}{X, P_j \vdash Y} P_jL_2 & \frac{X \vdash P_i, Y}{X, P_{n-i} \vdash Y} P_nL_2 \\
 \hline
 X \vdash P_i, Y & & & \\
 \hline
 & & & \text{PR}
 \end{array} \\
 \implies \begin{array}{c} \vdots \pi \\ X \vdash P_i, Y \end{array}
 \end{array}$$

Figure 2.14: Soundness of [CL] relative to [PL₁]

$$\begin{array}{c}
 \begin{array}{cc}
 \vdots \pi & \vdots \pi \\
 \frac{X, C_1, \dots, C_n \vdash Y}{X, P_1 \vdash Y} P_1L_1 & \frac{X, C_1, \dots, C_n \vdash Y}{X, P_n \vdash Y} P_nL_1 \\
 \hline
 X, C_1, \dots, C_n \vdash Y & \\
 \hline
 & \text{CL}
 \end{array} \\
 \implies \begin{array}{c} \vdots \pi \\ X, C_1, \dots, C_n \vdash Y \end{array}
 \end{array}$$

Local Completeness: Our second rules are complete relative to the first if we can apply the first rules to the outputs of the second rules, resulting in the inputs for the second rules. No information “contained” in the application of the first rules is lost through the application of the second. Derivations of children on the right and parents on the left can be

expanded into ones which eliminate, using the second rules, and then introduce, using the first rules, the same expressions on the right and left respectively.

Figure 2.15: Completeness of [PR] relative to [CR] and [PL₂]

$$\begin{array}{c}
 \begin{array}{c}
 \vdots \pi_1 \quad \vdots \pi_n \quad \vdots \delta_i \quad \vdots \delta_{n-j} \\
 X \vdash C_1, Y \quad X \vdash C_n, Y \quad X, P_i \vdash Y \quad X, P_{n-j} \vdash Y \\
 \hline
 X \vdash P_j, Y \quad \text{PR} \\
 \hline
 X \vdash C_1 \quad \text{C}_1\text{R}
 \end{array} \\
 \\
 \begin{array}{c}
 \vdots \pi_1 \\
 \leftarrow X, \vdash C_1, Y
 \end{array} \\
 \\
 \begin{array}{c}
 \vdots \pi_1 \quad \vdots \pi_n \quad \vdots \delta_i \quad \vdots \delta_{n-j} \\
 X \vdash C_1, Y \quad X \vdash C_n, Y \quad X, P_i \vdash Y \quad X, P_{n-j} \vdash Y \\
 \hline
 X \vdash P_j, Y \quad \text{PR} \\
 \hline
 X, P_i \vdash \quad \text{P}_i\text{L}_2
 \end{array} \\
 \\
 \begin{array}{c}
 \vdots \delta_i \\
 \leftarrow X, P_i \vdash Y
 \end{array}
 \end{array}$$

Figure 2.16: Completeness of [CL] relative to [PL₁]

$$\begin{array}{c}
 \begin{array}{c}
 \vdots \quad \pi_1 \qquad \qquad \vdots \quad \pi_n \\
 \vdots \qquad \qquad \qquad \vdots \\
 \frac{X, P_1 \vdash Y \quad X, P_n \vdash Y}{X, C_1, \dots, C_n \vdash Y} \text{CL} \\
 \hline
 X, P_1 \vdash Y \qquad \qquad \qquad \text{PL}_1
 \end{array} \\
 \\
 \begin{array}{c}
 \vdots \quad \pi_1 \\
 \vdots \\
 \Leftarrow X, P_1 \vdash Y \\
 \\
 \vdots \quad \pi_n \\
 \vdots \\
 \Leftarrow X, P_n \vdash Y
 \end{array}
 \end{array}$$

Note that on these definitions it is irrelevant which rules are chosen as “first” and “second”. We could have shown the first rules to be LSC relative to the second. It is this feature of material inference rules which fits with LSC rather than treating one of the left or right rules as basic (e.g. (Hallnäs and Schroeder-Heister 1991; Schroeder-Heister 1992)).

Two objections might be raised to our take on LSC. The first questioning why LSC should hold for clusters rather than individual expressions and the second why LSC should hold at all. The first objection says that given LSC holds for individual logical expressions then it should hold for individual non-logical expressions. This misses an important difference between our material inferential relations and those involving traditional logical constants. The rules for logical constants are given in terms of arbitrary expressions of a particular type, and which do only one of introducing or eliminating an expression. Because of this the inference rules for constants aren’t dependent on those for any other particular expression. In contrast, material rules relate particular expressions to one another, introducing one and eliminating the other. They are intrinsically related, and so LSC cannot be characterised as a property of a single expression but rather a cluster. The second objection says that LSC is

simply an issue for logical expressions rather than material, non-logical ones. Brandom, in his discussion of Dummett on harmony, claims that in as much as there is a notion of harmony for material expressions, it differs from that of logical expressions. This undermines the case for applying LSC to material concepts, so the thought goes. The distinction, however, that Brandom makes between logical and material expressions is that the addition of the former but not the latter must yield conservative extensions of the language, in order for logic to play an explicative role (Brandom 2000: p.68). The addition of material concepts may be non-conservative and this ‘non-conservativeness just shows that it has substantive content’ (Brandom 2000: p.71). Nothing said so far requires the extension of a language with a new material expression to always be conservative. It may sometimes be the case, as trees can easily be conservatively extended. In the case of non-conservative extensions, we’re simply required to not only add inference rules for the new vocabulary, but also remove and modify existing rules in order to meet LSC. There might be a number of different ways to do so and still meet LSC. This fits with Brandom’s claim that ‘[g]rooming our concepts and material inferential commitments... is a messy, retail, business’ (Brandom 2000: p.75).

What has been shown so far is that each of our concept clusters are LSC. We haven’t yet shown whether a whole language built up from many clusters is globally so. The global correlate of local soundness is the admissibility of the structural rule of *Cut* in our system without it. Demonstrating that *Cut* is admissible requires showing that for any derivation using the *Cut* rule, there is one of the same end-sequent which does not use *Cut*.

$$\frac{X \vdash A, Y \quad X, A \vdash Y}{X \vdash Y} \text{Cut}$$

Read top-to-bottom, *Cut* says that if $X \vdash A, Y$ is out of bounds and so is $X, A \vdash Y$ then the problem is with $X \vdash Y$ – the latter is out of bounds regardless of whether A is asserted or denied. Bottom-to-top, *Cut* tells us that assertion and denial are exhaustive, in the sense that if the position which asserts X and denies Y is coherent, then adding A to either its

assertions or denials must be as well. *Cut*'s inadmissibility would have two undesirable features. Top-to-bottom, it would allow for expressions which "gain information" in the sense of allowing more information to be extracted than is put in. E.g X may be sufficient conditions for A , A sufficient conditions for Y , but X not sufficient conditions for Y . Bottom-to-top, it would allow for situations where a position P is coherent but for some sentence A , P cannot coherently be extended to assert or deny A . *Cut* is however admissible to our system, meaning that it is globally sound. In fact, *Cut* can be eliminated in the sense that for any derivation using *Cut* there is a procedure for transforming it into one that does not [See Appendix B].

The global equivalent of completeness is an identity proof for arbitrary sequents of the form $A \vdash A$. *Id* reads as saying for any atomic sentence, it is incoherent to both assert and deny it

$$\frac{}{p \vdash p} Id$$

Normally the identity axiom applies only to atomic sentences, and identity sequents for logically complex expressions are shown to follow from *Id* for atomics and the connectives rules. A failure of general identity proofs allows for expressions which lose information, in contrast to failures of *Cut* gaining information. More worryingly, in terms of assertion and denial, it allows for the coherent assertion and denial of the same sentence. The languages under discussion are atomic. What corresponds to general identity proofs in these language are ones showing that given the identity axiom for the parents of a cluster, we can derive it for children and vice versa, though with two qualifications. First, for clusters with many parents and one child, to show that *Id* holds for some parent P_i we assume *Id* for the child and the other parents. Second, for clusters with one parent and many children, on the assumption of *Id* for the parent we derive sequents of the form $C_1, \dots, C_n \vdash C_i$ for each child C_i . This illustrates a sense in which *Id* holds for clusters rather than just individual expressions. Assuming asserting and denying the parent is incoherent,

then it is incoherent to assert all of the children and deny each of them [See Appendix A].

Some bilateralists argue that we should rethink the relation between assertion and denial to allow either failures of cut (Ripley 2013, 2015), or identity (French 2016). These arguments are made in the context of responding to paradoxes and it is not immediately clear to what extent these concerns carry over to the issues discussed here. One difference is that for material rather than logical vocabulary, failures of transitivity (soundness, cut) for one expression can result in failures of reflexivity (completeness, identity) for another. For example, suppose we modify the rules for a cluster with one parent and n many children (e.g the {H,B,F} example cluster from in Figure 9 Section 3.4.2) so that the rule introducing the parent on the right requires only $n - 1$ children on the right in the premises. We however keep the normal rule introducing children on the right, treating PR^* as the ‘First’ rule and C_iR as the ‘Second’.¹²

$$\frac{X \vdash C_1, Y \quad X \vdash C_{n-1}, Y}{X \vdash P, Y} PR^* \quad \frac{X \vdash P, Y}{X \vdash C_i, Y} C_iR$$

Given these rules we have a failure of soundness because an application of PR^* and then C_iR cannot be reduced to one of the former’s inputs.

$$\frac{\frac{\frac{\vdots \pi_1 \quad \vdots \pi_2}{X \vdash C_1, Y \quad X \vdash C_{n-1}, Y} PR^*}{X \vdash P, Y} C_nR}{X \vdash C_n, Y} \not\Rightarrow \frac{\vdots \pi_3}{X \vdash C_n, Y}$$

We also have a failure of completeness because given an application of C_nR (an instance of C_iR) we cannot apply PR to its output. We cannot expand a derivation of $X \vdash P, Y$ into one which eliminates and then in-

12. Which rules are ‘First’ and which are ‘Second’ has been swapped for ease of exposition.

a compositional story about how their meanings are determined by those of their parts. This will be set out in the next section.

2.4 Subsententials

2.4.1 Introduction

Moving beyond logical vocabulary and sentential semantics to that of subsententials presents a challenge for inferentialism. For many it is not obvious how to extend the inferentialist philosophical thesis about meaning to subsentential expressions such as names and predicates. Unlike sentences, these expressions do not stand in directly inferential relations. So they must, in some way, contribute to the inferential role of sentences (Brandom 1994: p.363-4); analogous to a truth-conditional semantics, where the constituents' semantic contributions determine the whole's truth-conditions without themselves having truth-conditions. First we use the previous inference rules for atomics and apply them to names and predicates, showing that they can accommodate Brandom's inferentialist distinction between the two in terms of their inferential roles. Brandom's thesis is that names and predicates are distinguished by the former only standing in symmetrical inferential relations (Brandom 1994: Chapter 6) (Brandom 2000: Chapter 4).¹³ Next we show that our general rules and trees can accommodate these relations in a compositional semantics. Lastly, we respond to Fodor & Lepore's critique from the first chapter.

13. Brandom is officially telling a story about singular terms in general rather than just names. However we will here only treat names because they usually have no internal structure, whereas that of others such as definite descriptions brings with it other complications.

2.4.2 Subatomic Systems

Model Theory

Model-theoretic semantics has a standard story about predicates and names. The latter are assigned single objects and the former sets of objects, interpreted as their referring to individuals and properties respectively. Inferentialists need to draw this distinction in terms of inferential relations rather than kinds of reference, with Brandom arguing that names are distinguished from predicates by only standing in symmetrical inferential relations. Before showing how our inference rules can accommodate this, we show that it agrees with model-theoretic semantics on the underlying structure.

To set up the analogy with model theory, take a simple language \mathcal{L} with only the syntactic categories of ‘name’ $[t]$, ‘n-place predicates’ $[P_n]$, and ‘sentences’ $[S]$ of the form ‘ $P_n t_1, \dots, t_n$ ’. A model \mathfrak{M} is a triple of \mathcal{L} , a domain D , and a valuation function v which assigns objects from D to expressions in \mathcal{L} . v assigns to sentences one and only one of the truth values true or false, to names individual objects, and to n-place predicates sets of n-tuples of objects from the domain. The assignments to expressions are their semantic values. v is restricted such that the value of a sentence ‘ $P_n t_1, \dots, t_n$ ’ is true iff the n-tuple of the values of the names within the sentence, t_1, \dots, t_n , is a member of the value of the predicate ‘ P_n ’. Put less formally, names pick out individual objects, predicates sets of objects which satisfy them, and sentences are true iff the object(s) picked out by the names in the sentence satisfy the predicate in the sentence. This semantics is compositional in that the meanings (values) of sentences are a function of the meanings (values) of their constituents. Importantly, although truth plays a central role, subsentential expressions don’t have truth values, rather they contribute to the truth-values of sentences.

We define model-theoretic consequence such that a sentence p of \mathcal{L} is a consequence of some (possibly empty) set of sentences X of \mathcal{L} iff there is no model \mathfrak{M} where all of X are true and p is false. Truth is preserved from premises to conclusion. Using this, we can define ‘quasi-

consequence' relations for subsententials. A name [predicate] a [F] is a quasi-consequence of another, b [G], iff for each sentence S containing a [F], the substitutional variant $S/\frac{a}{b}$ [$S/\frac{F}{G}$] obtained by replacing at least one instance of a [F] by b [G] entails S . A subsentential entails another of the same category so long as truth is preserved under substitution. These quasi-consequence relations between names will always be symmetric because the values of names are single objections – the value of one is a member of some predicate iff the other is as well. The relations between predicates however can be asymmetric because their values are sets of objects. The value of one might be a proper subset of another, allowing truth-preservation one way but not the other. This structure of symmetry for names and asymmetry for predicates is shared by both model-theoretic representationalist semantics and Brandom's inferentialism. They can agree on the general structure while still disagreeing about the relative priority of representation and inference. Later in 2.4.4, we show that these model-theoretic relations can be derived from more basic inference rules as in 2.2.2 and 2.3.5.

2.4.3 Inference Rules and Trees

Here we show how the general inference rules from the previous section apply to subsententials and that asymmetry and symmetry corresponds to branching and non-branching trees.

We formulate inference rules for subsententials as in [1] and [2] below:

$$\frac{X \vdash \Phi a, Y}{X \vdash \Phi b, Y} 1 \quad \frac{X, G\alpha \vdash Y}{X, F\alpha \vdash Y} 2$$

In rules such as [1] for names, the names, here a and b , stand in an arbitrary predicate context, represented by Φ . In those for predicates, such as [2], the n-place predicates, G and F , stand with an n-tuple of arbitrary names α . Φ and α respectively play an analogous role to the arbitrary A s and B s in rules for connectives.

We will soon show how Brandom's thesis that names and predicates are distinguished by standing in symmetric only and asymmetric infer-

ential relations respectively can be captured by our subatomic systems. Before this, we show that our rules in general can accommodate symmetric and asymmetric relations, corresponding to non-branching and branching trees.

Figure 2.17: General rule forms

$$\frac{X \vdash P_i, Y}{X \vdash C_i, Y} \text{CR} \quad \frac{X, C_1, \dots, C_n \vdash Y}{X, P_i \vdash Y} \text{PL}_1$$

$$\frac{X, P_1 \vdash Y \quad \dots \quad X, P_n \vdash Y}{X, C_1, \dots, C_n \vdash Y} \text{CL} \quad \frac{X \vdash P_i, Y}{X, P_j \vdash Y} \text{PL}_2$$

$$\frac{X \vdash C_1, Y \quad \dots \quad X \vdash C_n, Y \quad X, P_i \vdash Y \quad \dots \quad X, P_n \vdash Y}{X \vdash P_j, Y} \text{PR}$$

Instances of these general rules will be symmetric or asymmetric depending on whether their concept cluster branches. If a cluster branches, the inferential relations between parents and children will be asymmetric. With upwards or downwards branching, CR and PL₁ can both be used to derive $P_i \vdash C_i$ – they are different perspectives on the same inferential relation. However $C_i \not\vdash P_i$, because either only $C_1, \dots, C_n \vdash P$ with downwards branching, or only $C \vdash P_1, \dots, P_n$ with upwards branching due to CL and PR. Branching clusters capture asymmetric inferential relations. With non-branching clusters, each of CR, PL₁, CL, and PR is a single-premise single-conclusion rule, allowing for $P_i \vdash C_i$ from the first two and $C_i \vdash P_i$ from the next. So our general rules can also capture the structure of symmetric inferential relations when applied to concept clusters without branching with only one parent and one child. Our rules go beyond Brandom's theory by also representing relations of incompatibility. This is in part a result of our bilateralism and Brandom's unilateralism. Bilateralists get incompatibility for cheap by taking both assertion and denial, and incompatibilities between them as basic. In contrast Bran-

dom needs to define incompatibilities between propositions in terms of the commitment to one disentitling one to the other (Brandom 1994: p. 160)(Brandom 2000: p.43).¹⁴

The story about symmetry and asymmetry so far has nothing to say about examples of names which do not stand in any substitution relations. Surely they still play an inferential role, just as names which are not co-referential with any others still play a role in model-theoretic semantics.¹⁵ To capture this, we take the identity axiom to apply not to atomic propositions but instead to names in arbitrary predicate contexts.

$$\frac{}{\Phi_\alpha \vdash \Phi_\alpha} Id_s$$

We substitute a name in the language, a , for α to get an instance of the rule for a , and then substitute a predicate F to get an instance of the rule for the atomic proposition Fa . The identity axiom captures the simple sense of asserting and denying the same thing being out of bounds. In propositional logic there is no simpler sense of ‘the same thing’ than an atomic proposition, and in predicate logic the particular names and predicates are normally irrelevant. However, because we are concerned with particular names, and particular predicates, we treat the propositional sense of asserting and denying ‘the same thing’ as derived from that of asserting and denying the same predicate of the same name. This matches the model-theoretic notion of the value of a name never being both in and not in the extension of the same predicate.

Extending the earlier notion of an atomic system, let us define a Sub-Atomic System as a triple of a language $[\mathcal{L}]$ made up of names, n -place predicates, and sentences of the form ‘ $P_n(t_1, \dots, t_n)$ ’, a set of substitution rules $[R]$, and an assignment function $[v]: \{\mathcal{L}, R, v\}$. We set the following restrictions on v :

14. See (Restall, Kukla, and Lance 2009: p.229, fn.5) for an argument for taking incompatibility as basic even in a unilateral theory.

15. I would like to thank Lloyd Humberstone for pointing out this as a problem with a previous version of the theory.

LSC The rules for each concept cluster are instances of the general rule forms;

Symmetry For names, each concept cluster has only one parent and one child;

Identity Each name in the language is assigned an instance of the identity axiom Id_s ; and

Compositionality For sentences, rules are assigned by substituting the predicate of the sentence into the rules for its names and names into the rules for its parents.

The first restriction simply carries over from the previous atomic systems, ensuring that our sub-atomic systems are locally sound and complete. **Symmetry** ensure that inferential relations for names are symmetric and allows those for predicates to be asymmetric. **Identity**, as discussed above, gives a subsentential notion of asserting and denying the same thing being out of bounds. **Compositionality** ensures that the rules assigned to sentences are a function of those of their constituents and the way they combine. For example, suppose we have the sentence Fa and the following rules for F and a .

$$\frac{X, \Phi b \vdash Y}{X, \Phi a \vdash Y}^{aL} \quad \frac{X \vdash \Phi b, Y}{X \vdash \Phi a, Y}^{aR}$$

$$\frac{X, G\alpha \vdash Y}{X, Fa \vdash Y}^{FL}$$

By substituting F for the metalinguistic variable Φ in the a rules and a for the metalinguistic variable α in the F rule we get the following rules for Fa .

$$\frac{X, Fb \vdash Y}{X, Fa \vdash Y}^{FaL_1} \quad \frac{X \vdash Fb, Y}{X \vdash Fa, Y}^{FaR}$$

$$\frac{X, Ga \vdash Y}{X, Fa \vdash Y}^{FaL_2}$$

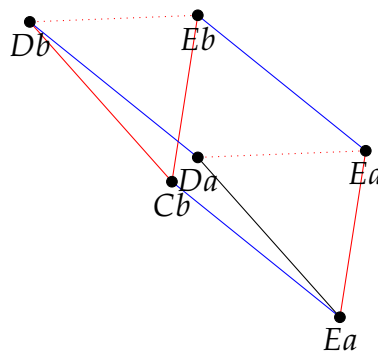
We can also represent trees for languages with subsentential structure, which are similarly compositional. Suppose we have the predicate concept cluster $\{C, D, E\}$ and the name concept cluster $\{a, b\}$ below.

Figure 2.18: Name $\{a, b\}$ and Predicate $\{C, D, E\}$ Cluster Trees



Each of these clusters represents by itself the inferential relations between a cluster of names and predicates respectively. We can combine these clusters to represent the inferential relations between atomics as determined by those for their constituent names and predicates. We do so by making two copies of the predicate tree (one for each name) and three copies of the name tree (one for each predicate). We then fuse each of the b nodes from the name trees to one (and only one) of each of the predicates on one copy of the predicate tree. We then fuse each of the a nodes to the corresponding predicate on the other copy of the predicate tree. The resulting tree below represents the inferential relations between six atomics as determined by their constituent names and predicates.

Figure 2.19: Predicate & Name Tree



In this way, concept clusters and larger trees for atomics can be built out of those for names and predicates. These trees are compositional in the

sentence that they are a function of the trees for their constituents and the way they combine.

2.4.4 Limit Positions and Subsentialials

We have similar results for Limit Positions, allowing us to read off model-theoretic extensions. We have the following facts (See Appendix C.3). Applying FACT 6 to the case of symmetric trees, we have:

FACT 7

- (i) For symmetric concept clusters, if the parent [child] is to one of the left or the right, then the child [parent] is the same.

As in the case of atomic sentences, we can read off model theoretic valuations from our limit positions, however with a modification. The number of names in our languages so far has been finite. However we wish to consider models with infinite domains, or for that matter finite models with simply more objects than there are names in the language. Limit positions are intended to represent idealisations where *everything* has been decided on. In order to decide on everything though, we need to extend the language L to one L_+ which can do so. Given a language L we pair up the names which share clusters. For each name which is a member of more than one cluster, we construct an n -tuple of it and its partners. Suppose we have a set of size n made up of names without any partners, and the n -tuples of partners. Then for a model \mathfrak{M} with m many objects, we extend L to L_+ with $m - n$ many names x_1, x_2, x_3, \dots , each only assigned an instance of the identity axiom.¹⁶ This allows everything to be decided on and captures the way in which the predicate rules are intended to apply to any arbitrary name, were it introduced to the language. You might think of these new names as playing the role of demonstratives or definite descriptions which allows us to talk about objects which we don't

16. An alternative is to extend the language with a denumerable set of names x_1, x_2, x_3, \dots . However, then we have more names than we need.

have names for.

From FACT 7 and the earlier FACT 6 we can read off the following restrictions on a model theoretic valuation function v :

1. For any two names α and β , if whenever $\Phi\alpha$ is to the left [right] $\Phi\beta$ is also, then $v(\alpha) = v(\beta)$;
2. For any predicate F if Fa is on the left [right] then $v(a) \in v(F)$ [$v(a) \notin v(F)$];

From FACT 6 & 7 and our above restrictions restriction:

Subsententials Fact

- (i) For any two names α and β which share a concept cluster, $v(\alpha) = v(\beta)$;
- (ii) For any predicates F and G , if F is a parent of G , then $v(F) \subseteq v(G)$. If these are members of an upwards branching cluster then $v(F) \subset v(G)$.

As previously, our inference rules determine classes of models much like meaning postulates. As can be seen, these are the model-theoretic quasi-consequence relations identified earlier. Our adoption of Brandom's inferentialist characterisation of names and predicates gets at the same structure as the traditional model-theoretic story.

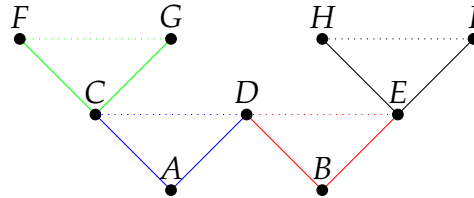
2.5 Conclusion: Inferentialism and Compositionality

Here we can situate the current semantics in relation to the criticism of Fodor & Lepore's raised in Chapter 1, Section 1.4, namely that an inferentialist semantics was bound to fail because it could not meet requirements of compositionality. There we adopted a definition of compositionality, C_0 , as the meaning of complex expressions being a function of the meanings of their parts and the way they combine. We saw that the main justification for thinking that our languages are compositional is to explain

their apparent productivity (projectability) and systematicity. We then saw Brandom's incompatibility semantics for S5 as an example of a semantics which is non-compositional but both productive and systematic. The meanings of complex expressions were determined by those of simpler expressions but rather than the latter only being their constituents they included (potentially) all those of the same logical complexity. We now locate the current semantics within this discussion, showing that on a narrow notion of meaning it is compositional and on a broader notion it is non-compositional but still recursive.

There is a clear sense in which our semantics is plausibly holistic. It is so in that the meanings attached to expressions are inference rules relating expressions to one another. This is in contrast with the earlier example simple extensional model theoretic semantics where the meanings (extensions) of expressions were objects from the domain completely independent from other expressions. Whether the semantics is compositional depends on what exactly we take the meanings of expressions to be. We might adopt a *narrow* understanding of the meaning of an expression as just the inference rules assigned to it. If this is so, then the semantics is compositional and has what Brandom called the semantic subformula property. The inference rules (meaning) assigned to some sentence Fa will only depend on those assigned to F and to a and not any other expressions. This might better be called a kind of molecularism rather than holism, as expressions are related to each other in small clusters rather than to every or most of the expressions in the language (Jackman 2017). Alternatively, we could adopt a broader notion of meaning, making it more holistic but also non-compositional. Take our earlier example tree

Figure 2.20: Example Tree



An expression such as *F* shares a concept cluster with only *G* and *C*, but due to *C* sharing a cluster with *D* and *A*, and *F* being a parent of *C*, *F* is an ancestor of *A* and incompatible with *D*. A “fuller” sense of grasping *F*’s meaning then requires more than just the inference rules for its concept cluster. This comes out in the way limit positions are determined. Although not directly linked by any inference rules, any position on which *F* is on the left will also be one in which *A* is on the left. Similarly, if *F* is on the left, then *D* is on the right (and vice versa). In as much as limit positions are taken as some aspect of “meaning” or as required to grasp an expression, then they are holistic in a broader sense than just the inference rules assigned to expressions, although still not to the extent that they relate every expression to one another. Regardless of whether the broad or narrow notion of meaning is adopted, Fodor & Lepore’s in principle objections to an inferentialist semantics can be avoided. For in either case they are recursive, in Brandom’s sense, and in the narrow case are compositional, having the semantic sub-formula property.

A qualification should be made that Fodor & Lepore take their argument to also be bound up with concerns about analyticity, which has not been discussed here. Roughly, they believe that inferentialists must appeal to a notion of analyticity in order to identify which inferential relations are meaning constitutive, but that inferentialists have either failed to tell a plausible story about analyticity or denied it in the first place (Fodor and Lepore 2002: Chapter 1 & 7). Besides a few observations, discussions of analyticity in any detail are beyond the scope of this thesis. First, the notion of inference used here is one of incompatibilities between assertion and denial rather than weaker notions of such as war-

rant. A entails B only when asserting A and denying B is incoherent. What's required from Fodor & Lepore are examples of these sorts of incoherences which are non-compositional. Second, the semantics of this chapter may provide a notion of an analytic proof: a proof is analytic if it only employs rules from one concept cluster and has no expressions which it introduces and then eliminates. These will have the subformula property. Third, the normative pragmatism employed here does not require us to interpret someone in terms of the inferences that they endorse or perform. It is not a dispositional theory. Rather it is a form of social externalism (anti-individualism) and someone may be bound by inferential norms in virtue of participating in a particular practice. So concerns with analyticity as a criterion of concept possession do not apply.

CHAPTER THREE

Imperative Inference without Truth

3.1 Introduction

In Chapter 1 we introduced three arguments made respectively by Liptow, Dummett, and Fodor & Lepore. The thesis then began addressing these in reverse order. The previous chapter addressed Fodor & Lepore's argument that inferentialism about semantic content could not meet requirements of compositionality. It showed how inferentialists could proof-theoretically formalise the meanings of atomic sentences and their constituent names and predicates. On a narrow notion of meaning as inference rules, this semantics was compositional and on a broader notion of meaning, e.g inclusion in limit positions, it was non-compositional but still recursive (productive and systematic). This chapter will begin to provide a response to Liptow and to Dummett. Liptow argued that pragmatist theories of meaning, to which our inferentialism is linked, are bound to fail due to their inability to account for the shared propositional content expressed by different sentence types. One avenue for responding to Liptow was the idea that there may be no shared propositional content, which we called content pluralism. Dummett's argument was against content pluralism in trying to show that there must be one sentence level semantic type. That this is propositional was assumed. So adopting content pluralism in response to Liptow first requires a counter to Dummett's argument. In this chapter, we begin telling a pragmatist

story about languages with both imperatives and declaratives, which respects compositionality (or recursivity), and while rejecting strict uniformity of meaning shows how the meanings of words across different sentence types are related if not wholly shared. Here the focus will be on giving a sentential level account of imperatives and their logico-semantic relations. The first section (3.2.1) will provide some background to imperatives and motivate the idea that although imperatives are involved in logical relations such as inference, incompatibility, and equivalence, they are not truth evaluable. Section 3.2.2 will provide a brief outline of some historical and existing approaches to imperatives, partly motivating the course that we will take. In Section 3.3, we will extend Restall's bilateralist interpretation of the sequent calculus to imperatives. Next, in 3.4, we show how bilateralism can accommodate languages with both sentential declaratives and imperatives. We see that in such a language logical connectives can be assigned the same inference rules, regardless of whether they are applied to imperatives or declaratives. This goes part of the way to responding to Dummett's objection. In Section 3.4 we will respond to a general objection to the idea of imperative inference. This is Ross' Paradox, the worry that imperative inference allows the expansion or creation of permissions. The related issue of Free Choice Permission (FCP) will also be discussed.

We use lower case Greek letters, ϕ and ψ etc, for atomic imperatives and upper case Greek, Γ and Σ etc, for multisets of imperatives. For declaratives, lower case standard Latin, p and q etc are used for atomics, and upper case, X and Y etc, for multisets. For sentences of an arbitrary type we use lower case Latin maths sans serif, p and q etc, and upper case for multisets, X and Y etc.

3.2 Motivations and Current Theories

3.2.1 Motivating imperative (non-propositional) content and inference

Standard approaches to both semantics and logic are very closely tied to truth. ‘Meaning’ or ‘content’, the object of semantics, is normally thought of in terms of truth-bearing propositions. Regardless of which is primary, truth and inference are tied together closely enough that propositions are also seen as being “at the heart of logic” (Restall 2005a), and often as what we exclusively reason with. Imperatives present a challenge regarding both truth and inference. They are *prima facie* not truth-evaluable and yet appear to stand in inferential and other logical relations. For example,

1. a) Wipe the bench!
b) *That’s true.
c) Yeah!
2. a) Do your homework!
b) *That’s false.
c) Nah!

Applications of truth and falsity predicates to 1.a and 2.a appear incorrect, suggesting that they aren’t in the game of being true or false. Perhaps though, this is only a result of the force conventionally attached to imperatives, and so their content is still propositional. Traditionally, features of sentences which embed are taken to be part of their content rather than force, as it is contributed to the meaning of complex sentences. Though rare, there are some embedded imperatives in English. For example:

3. a) Ede to Magda: This book is brilliant, everyone should buy it!
b) Magda to colloquium audience: Ede said buy that book.
(Kaufmann 2014)

Notice that Magda is not directly quoting Ede. Rather 'buy that book' is being attributed to Ede and contributing its content to the larger sentence. This hardly rules out the possibility of a truth-conditional account but it ought to motivate an alternative, assuming it doesn't come at too high a cost.

Imperatives being non-truth evaluable presents a challenge to the idea of inferential relations being fundamentally truth preserving. For imperatives appear to stand in their own non-truth-preserving inferential relations. Take this example from Peter Vranas (Vranas 2011: p.369). Say someone is sitting an exam. They read instructions (a), (b) and (c), and then notice that the third follows from the first two.

- (a) Answer exactly three out of the six questions;
- (b) Do not answer both questions 3 and 5;
- (c) Answer at least one even-numbered question.

It as an instruction (a what-to-do) is information-wise redundant, just like the conclusion of a declarative inference, despite potentially being informative.

Besides inference, imperatives also stand in other logical relations such as incompatibility and equivalence. 4. and 5. are both examples of incompatibilities, respectively formal and material:

- 4. a) Both buy jam and don't buy marmalade ($\phi \wedge \neg\psi$)
b) Either don't buy jam or buy marmalade ($\neg\phi \vee \psi$)
- 5. a) Run!
b) Be still!

Equivalences also come in formal and material kinds, as in 6. and 7.:

- 6. a) Neither buy quinoa nor soy falafel mix! ($\neg(\phi \vee \psi)$)
b) Don't buy quinoa falafel mix and also not the soy! ($\neg\phi \wedge \neg\psi$)
- 7. a) Jump!

b) Leap!

These examples don't demonstrate the undeniability of imperatives being non-propositional yet inferential. Rather they motivate the non-propositional inferential semantics for imperatives set out in this chapter and the next.

3.2.2 Some current approaches

In this section we briefly outline some current approaches to imperative meaning and inference before in the next section proposing my own.

Aside from whether they see imperatives as expressing propositions, theories of imperative inference tend to fall into two categories, focusing on either fulfilment or bindingness (Fox 2012; Ross 1941). The first is based on the observation that imperatives are the kinds of things that can be fulfilled or satisfied which is then used to explain their inferential relations. In Vranas' earlier exam example, fulfilling instructions (a) and (b) appeared to result in fulfilling (c), thus making it redundant. Fulfilment conditions could in this way supporting a notion of imperative consequence. It also appears plausible for incompatibility. In examples 6. and 7., it appears that for each pair of incompatible imperatives, both members cannot be fulfilled at once. However, drawing on Lepore & Leslie's argument from Chapter 1 (Lepore and Leslie 2001), a worry about thinking of imperatives in terms of fulfilment, or at least fulfilment conditions, is that it easily reduces to truth-conditions, and therefore propositions. The fulfilment conditions of some imperative appears to be just the obtaining of a certain state of affairs, the truth of some proposition. For those wanting a non-propositional theory of imperatives, fulfilment conditions are suspect.

An alternative that appears to avoid some of the above issues is the binding approach. The idea here is that the endorsement of ψ on the basis of ϕ is an explicit acknowledgement of the validity or bindingness of the former on the basis of that of the latter. In the exam example, the reader acknowledges the bindingness of (c) as following from that of (a)

and (b). It is normatively redundant, even if informative. Incompatibilities appear to be where someone cannot be genuinely bound by both or perhaps where someone cannot coherently bind somebody else by them. One might try and use Lepore & Leslie's argument in this case as well, claiming that these notions of 'binding' merely express deontic modals. However, this is less of a problem than in the fulfilment case because: (1) it is more plausible as deontic modals would preserve the explicit connection with notions of obligation, permission, and prohibition that are central to imperatives, and (2) there's room to explain the connection between imperatives and deontic modals by seeing the latter as building on, rather than being the content of, the former. In a Brandomian spirit, we might say that deontic modals make explicit imperative positions in the declarative part of the language.

In the current literature, two theories close to the one presented here are those of Paul Portner (Portner 2004) and Rosja Mastop (Mastop 2005, 2011) both of which have a similar idea in regards to the non-propositional content of imperatives. Portner and Mastop share a picture of the pragmatics of conversation where the conventional force of declaratives is to add propositions to the Common Ground (the shared beliefs) of the conversation and that imperatives play an analogous role but in updating the 'To Do Lists' of individual participants. The meaning or content of an imperative has to be such that it can add new actions to the To Do List. In Portner's case, he sees imperatives as denoting properties which agents are to make true of themselves – despite imperatives being non-propositional, truth still plays a central role. Mastop takes the idea further, and closer to the position we will adopt, by treating imperatives in an update semantics where the content of an imperative is a practical commitment function which assigns an action plan (set of actions) to each world. Essentially an imperative tells us what to do, given a situation.

3.3 Imperative Bilateralism, Gaps and Gluts

3.3.1 Imperative Bilateralism

Having set out some of the features of imperatives along with existing theories, in this section we sketch how an account might work from a normative pragmatist perspective. We will extend the bilateralist interpretation of declaratives from the previous chapter to imperatives, showing that bilateralism can be motivated for imperatives for similar reasons to declaratives and likely comes with similar benefits of being able to model “non-classical” reasoning.

The kind of bilateralism, drawn from Restall, and sketched in Chapter 2, can easily be generalised so as to accommodate a theory of imperatives along the line of Portner and Mastop, particularly the latter. In Chapter 2 we had the two speech acts of assertion and denial, performed using declaratives, and where coherent collections of these formed positions. Positions “clashed” or were “out of bounds” when the same thing was both asserted and denied, and inference rules, initially for logical connectives and then later for atomics and subsententials, placed constraints on what could coherently be asserted and denied.

$$\frac{X \vdash A, Y \quad X \vdash B, Y}{\Gamma \vdash A \wedge B, Y} \wedge R$$

The conjunction right-hand rule for example, says that if it is incoherent to deny A and also incoherent to deny B then it is incoherent to deny $A \wedge B$. Read bottom to top, if it is coherent to deny $A \wedge B$ then it is coherent to deny (at least one of) A or B . In order to generalise this to imperatives we begin by thinking of assertion and denial as kinds of ruling-in and ruling-out respectively. They rule-in and -out states of affairs or ways things might be. The Porter-Mastop view of imperatives is that they shift agents’ practical commitments, what actions are on their ‘To Do Lists’. So for an imperative bilateralism, we need speech acts that rule-in and -out actions for agents, shifting their practical commitments. The speech acts of commanding and prohibiting do just this. Commands rule-in actions

for someone by requiring their performance – making them “in bounds” – whereas prohibiting rules out actions for someone by forbidding their performance – making them “out of bounds”. Commands and prohibitions of the same action clash just as assertions and denials of the same proposition do.

We will call $\Gamma : \Sigma$ an *imperative position* of (someone’s) commands Γ and prohibitions Σ . For now, we can think of these positions as representing a simple “Overseer-Underling” type situation where Overseer gives Underling commands and prohibitions but not the reverse. We will later extend these positions to accommodate multiple givers and receivers of imperatives, which may yield different notions of coherence and incoherence. We write

$$\Gamma \vdash \Sigma$$

for those imperative positions which “clash” or are “out of bounds” and again treat the simple case of commanding and prohibiting the same thing

$$\frac{}{\phi \vdash \phi} \text{Id}$$

as the basic form of imperative incoherence. This gives us a natural reading of standard classical multiple conclusion sequent calculus rules. E.g conjunction:

$$\frac{\Gamma, \phi \vdash \Sigma}{\Gamma, \phi \wedge \psi \vdash \Sigma} \wedge L_1 \quad \frac{\Gamma, \psi \vdash \Sigma}{\Gamma, \phi \wedge \psi \vdash \Sigma} \wedge L_2 \quad \frac{\Gamma \vdash \phi, \Sigma \quad \Gamma \vdash \psi, \Sigma}{\Gamma \vdash \phi \wedge \psi, \Sigma} \wedge R$$

$\wedge L_1$ [$\wedge L_2$] tells us that if it is incoherent to command ϕ [ψ] then it is incoherent to command $\phi \wedge \psi$, whereas $\wedge R$ tells us that if it is incoherent to prohibit ϕ and also ψ then it is incoherent to prohibit $\phi \wedge \psi$. Structural rules such as weakening and contraction also have natural readings.

$$\frac{\Gamma \vdash \Sigma}{\Gamma \vdash \phi, \Sigma} \text{KR} \quad \frac{\Gamma \vdash \Sigma}{\Gamma, \phi \vdash \Sigma} \text{KL} \quad \frac{\Gamma \vdash \phi, \phi, \Sigma}{\Gamma \vdash \phi, \Sigma} \text{WR} \quad \frac{\Gamma, \phi, \phi \vdash \Sigma}{\Gamma, A \vdash \Sigma} \text{WL}$$

Weakening says that if it is incoherent to command [prohibit] ϕ then that position continues to be incoherent if a command or prohibition of another action ψ is added to it. Contraction records that commanding [prohibiting] once is equivalent to doing so multiple times. If the position

of commanding [prohibiting] ϕ , ϕ is incoherent then so is one the one commanding [prohibiting] just ϕ . This makes sense of readings where someone commanding ‘Write an essay’ and then saying so again later is reinforcing the first command with the second rather than telling them to write two essays.

One of the motivations of Restall’s bilateralist reading of the multiple conclusion sequent calculus introduced in Chapter 2 was its ability to provide a shared vocabulary for different logics, with a focus on negation. Classical logicians treat the assertion of a negation as having the same force as a denial of its negand (and vice versa) whereas dialetheists and supervaluationists uncouple the two, allowing for truth gluts and gaps respectively. There appear to be similar possibilities in the case of imperative negation. These will not be discussed in any detail, though several examples will be given. It should be kept in mind that the negation of an imperative ϕ is not ‘It is not the case that ϕ ’ but rather ‘Don’t ϕ ’.

$$\frac{\Gamma \vdash \phi, \Sigma}{\Gamma, \neg\phi \vdash \Sigma} \neg\text{L} \quad \frac{\Gamma, \phi \vdash \Sigma}{\Gamma \vdash \neg\phi, \Sigma} \neg\text{R}$$

If $\neg\text{L}$ is removed then we have an imperative equivalent of truth gluts, allowing for both ϕ and $\neg\phi$ to be ruled-in. One way of interpreting this would be in terms of inconsistent commands, where one is commanded to perform an action and also commanded not to perform it. Alternatively we might interpret the kind of ruling-in involved in this situation to be something weaker than commanding, such as permitting, as permitting ϕ and $\neg\phi$ appears to be consistent. Though this permissive reading may require also modifying the conjunction rules to avoid permitting $\phi \wedge \psi$ following from permitting each conjunct separately.¹⁷ Thinking of ruling-in an imperative as involving permission even in the presence of classical $\neg\text{L}$ helps us better understand the force of commands. The force of being a command has two important features. The first is that it

17. I would like to thank Lloyd Humberstone for pointing out this change in the behaviour of conjunction in the context of permissions.

permits the action commanded, it makes it “in bounds”. The second is that it requires the action commanded. In other words it makes the non-performance of the action out of bounds. Adopting classical negation rules give uses of imperatives the force of commands by making ruling-in an imperative equivalent to ruling-out its negation, just as in the declarative case it makes the assertion of a declarative equivalent to denying its negation. Altering or removing $\neg R$, the equivalent of truth-gaps, also allows for an interesting change in the relation between ruling-in and ruling-out an imperative. $\neg R$ makes ruling-out an imperative, prohibiting it, equivalent to ruling-in, commanding, its negation. If we think of commands as permitting the action commanded then it also permits its negation. If $\neg R$ is removed, then it allows for the coherent prohibition of an imperative and its negation without it following that either is commanded and thereby permitted. This appears to be a “bind” where whatever the agent does they do something that is prohibited, and thereby not permitted. Lastly, there may be scope for altering structural rules to give a different interpretation of the logic. Here, due to the presence of contraction, we are treating multiple occurrences of the same imperative as equivalent to one. Dropping contraction, however, may allow for an interpretation of multiple occurrences of an imperative as commanding or prohibiting more than one performance of the action. While interesting in their own right, such non-classical imperative logics are left to the investigation of further work.

3.3.2 Imperative Systems and Limit Positions

Here we apply the definition of atomic systems and results regarding limit positions from the previous chapter to the case of imperatives.

We can adopt the previous definition of an atomic system as a triple of a language \mathcal{L} , a set of rules R , and a valuation function v . Rather than \mathcal{L} being made up of declaratives we stipulate that \mathcal{L} is made up of atomic imperative sentences, the binary connectives \wedge , \vee , and the unary connective \neg , and those complex imperatives formed from the first two. As

previously we restrict v so that all rules assigned to atomics are instances of the general rules. We also adopt the standard structural and connective rules from the classical multiple conclusion sequent calculus.

$$\begin{array}{c}
\frac{}{\phi \vdash \phi} \text{Id} \qquad \frac{\Gamma \vdash \phi, \Sigma \quad \Gamma, \phi \vdash \Sigma}{\Gamma \vdash \Sigma} \text{Cut} \\
\\
\frac{\Gamma \vdash \Sigma}{\Gamma \vdash \phi, \Sigma} \text{KR} \qquad \frac{\Gamma \vdash \Sigma}{\Gamma, \phi \vdash \Sigma} \text{KL} \\
\\
\frac{\Gamma \vdash \phi, \phi, \Sigma}{\Gamma \vdash \phi, \Sigma} \text{WR} \qquad \frac{\Gamma, \phi, \phi \vdash \Sigma}{\Gamma, \phi \vdash \Sigma} \text{WL} \\
\\
\frac{\Gamma \vdash \phi, \Sigma \quad \Gamma \vdash \psi, \Sigma}{\Gamma \vdash \phi \wedge \psi, \Sigma} \wedge R \quad \frac{\Gamma, \phi \vdash \Sigma}{\Gamma, \phi \wedge \psi \vdash \Sigma} \wedge L_1 \quad \frac{\Gamma, \psi \vdash \Sigma}{\Gamma, \phi \wedge \psi \vdash \Sigma} \wedge L_2 \\
\\
\frac{\Gamma \vdash \phi, \Sigma}{\Gamma \vdash \phi \vee \psi, \Sigma} \vee R_1 \quad \frac{\Gamma \vdash \psi, \Sigma}{\Gamma \vdash \phi \vee \psi, \Sigma} \vee R_2 \quad \frac{\Gamma, \phi \vdash \Sigma \quad \Gamma, \psi \vdash \Sigma}{\Gamma, \phi \vee \psi \vdash \Sigma} \vee L \\
\\
\frac{\Gamma \vdash \phi, \Sigma}{\Gamma, \neg \phi \vdash \Sigma} \neg R \quad \frac{\Gamma, \phi \vdash \Sigma}{\Gamma \vdash \neg \phi, \Sigma} \neg R
\end{array}$$

The imperative positions introduced above can be understood as agents' 'plans' or 'schedules'. They determine what actions are explicitly permissible, prohibited, and commanded for an agent. Many more actions may of course be implicitly premissable, prohibited, or commanded – in the same way that various propositions might be implicitly asserted or denied in the declarative case. We can now define what it is for actions to be permitted, prohibited, and commanded:

Permitted an imperative position $\Gamma : \Sigma$ permits an action ϕ iff $\Gamma \vdash \phi, \Sigma$.

Prohibited an imperative position $\Gamma : \Sigma$ prohibits an action ϕ iff $\Gamma, \phi \vdash \Sigma$.

Commanded an imperative position $\Gamma : \Sigma$ commands an action ϕ iff $\Gamma \vdash \phi, \Sigma$ and $\Gamma, \neg \phi \vdash \Sigma$.

These notions of permitted and prohibited correspond to the previous chapter's of being 'to the left' and 'to the right'. Given the above classical

rules for negation, whenever an action is permitted or its negation prohibited, then it will also be commanded, due to the negation rules making ruling-in something have the equivalent force of ruling-out its negation. Note that this makes being permitted and commanded in the above sense equivalent, as whenever $\Gamma \vdash \phi, \Sigma$ then via $\neg\text{L}$ $\Gamma, \phi \vdash \Sigma$. This should be interpreted as saying that the speech act of ruling-in, which in this case is a command, has the force of permitting the action commanded and prohibiting its negation (non-performance), rather than permissions and commands amounting to the same thing. This system does however lack a distinct speech act of merely permitting (without also commanding) an action. We can also define weaker notions of permission and prohibition, corresponding to non-prohibition and non-permission respectively. These are similar to what Ripley calls ‘tolerant’ rather than ‘strict’ assertion and denial in the declarative case (Ripley 2013: Section 4.2).

Permitted* an imperative position $\Gamma : \Sigma$ permits* an action ϕ iff $\Gamma, \phi \not\vdash \Sigma$.

Prohibited* an imperative position $\Gamma : \Sigma$ prohibits* an action ϕ iff $\Gamma \not\vdash \phi, \Sigma$.

We can for the most part treat these two types of permission and prohibition as distinct but related notions, although we will soon see a situation where they correspond.

We can think of an imperative position as a plan or schedule, which determines which actions are permitted, prohibited, and commanded. This is with the proviso that our plans are more like shopping lists. They say what to do but not in any particular order. The inference rules for both connectives and atomic sentences constrain the way positions (plans) can be coherently extended, just as in the case with declaratives. We can now carry over the limit position results from Restall’s work and the previous chapter, and apply it to the case of imperatives. A limit position for imperatives can be thought of as a maximally extended schedule or plan. Imagine someone whose diary is as full as it can be, given their language. While no one could write down every action (including logically complex ones) ruled-in and -out, we do in a sense carry out these

schedules within a given time period. In the case of limit positions the above two notions of being permitted and prohibited come together. For an imperative limit position $\mathfrak{G} : \mathfrak{S}$, any action is one of either to the left, permitted, or to the right, prohibited. Thus in order for $\mathfrak{G}, \phi \not\vdash \mathfrak{S}$ to be the case, ϕ must already be on the left, permitted, because if it weren't, then it would be to the right and $\mathfrak{G}, \phi \vdash \mathfrak{S}$. Swap 'left' and 'right' and the same follows for prohibition.

We can now interpret the limit position results in the imperative case

FACT 5: For any limit position P (i) $A \wedge B$ is to the left of P iff A and B are both to the left of P . (i') $A \wedge B$ is to the right of P iff either A or B is to the right of P . (ii) $A \vee B$ is to the right of P iff A and B are both to the right of P . (ii') $A \vee B$ is to the left of P iff either A or B is to the left of P . (iii) $\neg A$ is to the left of P iff A is to the right of P . (iv) $\neg A$ is to the right of P iff A is to the left of P . (v) A is to the left of P iff A is not to the right of P (Restall 2009: p.,249).

(i) and (i') tell us respectively that a conjunction is permitted iff its conjuncts are permitted and prohibited iff one of its is. (ii) and (ii') tell us respectively tell us that disjunction is the dual of conjunct. (iii) and (iv) tell us that a negation is prohibited iff its negand is permitted and vice versa. This turns what would otherwise be mere permission into a command, and also rules out "binds".

FACT 6: For any limit position P

(i) A parent P_i is to the left of LP iff all its children $C_1...C_n$ are to the left of LP and all other parents $P_j...P_{n-i}$ are to the right of LP .

(i') A parent P_i is to the right of LP iff either some child C_i is to the right of LP or some other parent P_j is to the left of LP .

(ii) A child C is to the left of LP iff a parent P is to the left of LP .

(ii') A child C is to the right of LP iff all its parents $P_1...P_n$ are to the right of LP .

Fact 6 can be read in the same way. From our imperative limit positions for a language of atomics and connectives we can read off Boolean eval-

uations determining (classes) of atomic models for imperatives. As expected, the evaluations of logically complex imperatives will be determined by those of their constituents and the way they are combined, and thus compositional, whereas those for atomics will be holistic and codependent on the evaluations of other atomics. In the next chapter we will carry over the limit position results for subsententials to the imperative case.

Some might be concerned that unlike for declaratives limit positions are inappropriate models for imperatives, because our plans or schedules are never fully determined. First, it should be noted that our collections of assertions and denials are in actuality never fully determined. Limit positions are an idealisation for those as well. Second, just as one might think that the "world" is fully determined, so might be the schedules which we execute – for any space of time I do in fact perform or not-perform any given action. Third, there is room to extend this kind of story to include incomplete plans. One could take the partial Boolean evaluations determined by imperative (non-limit) positions as incomplete models.

3.4 Imperatives and Declaratives

In this section we sketch an inferentialist semantics for a mixed language made up of both declarative and imperative atomics, along with logical connectives. In doing so we go part way to responding to the objection attributed to Dummett in Chapter 1, namely that content pluralism cannot account for both compositionality and sameness of meaning across different sentences types. Here we show that the meanings of logically complex sentences can be compositional and invariant across sentence types. That this is also so for predicates and names will be shown in the next chapter.

3.4.1 Mixed Inference Rules

Here we introduce the notion of mixed positions and inference rules. When introducing imperative bilateralism we abstracted from the declarative nature of assertion and denial to thinking of them as forms of ruling-in and ruling-out, and that commanding and prohibiting were their respective imperative forms. We can now introduce the notion of a mixed position $X : Y$ made up of ruling-ins, X , and ruling-outs, Y . Ruling-ins are assertions or commands depending on sentence-type, and denials or prohibitions for ruling-outs.

We can represent structural rules and those for logical connectives, except the conditional, in a sentence-type neutral way.

$$\begin{array}{c}
 \frac{}{p \vdash p} \textit{Id} \qquad \frac{X \vdash A, Y \quad X, A \vdash Y}{X \vdash Y} \textit{Cut} \\
 \\
 \frac{X \vdash Y}{X \vdash A, Y} \textit{KR} \qquad \frac{X \vdash Y}{X, A \vdash Y} \textit{KL} \\
 \\
 \frac{X \vdash A, A, Y}{X \vdash A, Y} \textit{WR} \qquad \frac{X, A, A \vdash Y}{X, A \vdash Y} \textit{WL} \\
 \\
 \frac{X \vdash A, Y \quad X \vdash B, Y}{X \vdash A \wedge B, Y} \wedge R \qquad \frac{X, A \vdash Y}{X, A \wedge B \vdash Y} \wedge L_1 \qquad \frac{X, B \vdash Y}{X, A \wedge B \vdash Y} \wedge L_2 \\
 \\
 \frac{X \vdash A, Y}{X \vdash A \vee B, Y} \vee R_1 \qquad \frac{X \vdash B, Y}{X \vdash A \vee B, Y} \vee R_2 \qquad \frac{X, A \vdash Y \quad X, B \vdash Y}{X, A \vee B \vdash Y} \vee L \\
 \\
 \frac{X \vdash A, Y}{X, \neg A \vdash Y} \neg R \qquad \frac{X, A \vdash Y}{X \vdash \neg A, Y} \neg R
 \end{array}$$

We interpret these in terms of ruling-in and ruling-out and treat the different speech acts as instances of this. In our natural languages, or at least English, imperatives cannot be the antecedents of conditionals. Two simple options are to either exclude the conditional and make do with the

other connectives, or to adopt the following rule:

$$\frac{X, A \vdash B, Y}{X \vdash A \supset B, Y} \supset^R \quad \frac{X \vdash A, Y \quad X, B \vdash Y}{X, A \supset B \vdash Y} \supset^R$$

This is the standard material conditional but with the restriction that the antecedent must be a declarative. Principled argument for and explanation of the restriction is beyond the scope of this thesis, though two points will be noted. First, given that material conditional $A \supset B$ is equivalent to both $\neg A \vee B$ and $\neg(A \wedge \neg B)$, and that both of these can be expressed with imperatives, the lack of imperatives in the antecedents of conditionals undermines the claim that \supset expresses ‘If...then...’. Second, a plausible avenue for explaining the restriction may relate to imperatives being non-propositional. If we think of conditionals as telling us that something (the consequent) holds given a particular situation (the antecedent), then the lack of imperative antecedents is unsurprising. For they relate to actions rather than situations (states of affairs) and so do not express the right kind of thing for situations or actions to be conditional on. Investigation of this idea is left for further work.

The story so far makes declaratives and imperatives appear very similar when operating just at a sentential level. They will be differentiated in terms of their internal structure in the next chapter, but there are still important ways in which they can be differentiated at the sentence and speech act level. In their book ‘Yo!’ and ‘Lo!’ Rebecca Kukla & Mark Lance point out that declaratives and imperatives differ in terms of how they change the conversational score by declaratives having agent-neutral and imperatives agent-relative effects. (Kukla and Lance 2009: Chapter 1, Section 1.2) To illustrate this, if Oliver tells Mac that ‘*Plantasia* is a great album’ then he is being inconsistent if he denies the same thing to Sarah, or anybody else. He also disagrees with Sarah if she, or anybody else, denies it. Declaratives are agent-neutral in the sense that there is a clash between assertions and denials of the same thing, regardless of who the speaker or addressees are.¹⁸ Imperatives are agent-relative in the sense that if Oliver

18. This is assuming the language is free of indexicals.

commands Mac to ‘Listen to *Plantasia!*’ he is not being inconsistent if he prohibits Sarah from doing the same. He is only being inconsistent if he both commands and prohibits the same action for the same person. Similarly, he only “disagrees” or clashes with somebody else if the two of them respectively command and prohibit the same action for the same person. We can capture this difference in the way declaratives and imperative clash by introducing contexts to the representation of the language. We write a context

$$\langle a, b \rangle$$

where a is the speaker and b is the addressee. To represent a sentence in the context of a speaker and a hearer we write

$$S_{\langle a, b \rangle}$$

This represents S said by a to b . If on the left, it is a ruling-in and if on the right a ruling-out. The basis kind of clash is now represented by

$$\frac{}{S_{\langle a, b \rangle} \vdash S_{\langle a, b \rangle}} Id_c$$

rather than the previous ‘context-free’ [Id] rule.

We call S said in a different context, i.e a different speaker and/or addressee, a contextual variant of $S_{\langle a, b \rangle}$. We can now represent agent-neutrality and agent-relativity using ‘perspective shifting rules’ which shift incompatibilities between contextual variants. The first of these rules, govern incompatibilities between speakers (asserters, prohibitors etc).

$$\frac{X, S_{\langle a, b \rangle} \vdash Y}{X, S_{\langle c, b \rangle} \vdash Y} 1stL \quad \frac{X \vdash S_{\langle a, b \rangle}, Y}{X \vdash S_{\langle c, b \rangle}, Y} 1stR$$

What these rules say is that if it is incoherent for a to rule-in [-out] S to b , then it is incoherent for some other arbitrary agent c to rule-in [-out] S to b . We take these rules as applying to both declaratives and imperatives. In the declarative case this captures the way in which assertions and denials clash regardless of who the speaker is. As for imperatives, it captures the way in which there is a clash if the same thing is both commanded and prohibited of the same person, even if the speakers (sources)

differ. If Oliver tells Mac to listen to *Plantasia* and Sarah prohibits it, then this creates a “clash” or inconsistency in the whole conversation. Though we may have norms for resolving such issues.

The second perspective shifting rules govern inconsistencies between addressees.

$$\frac{X, S_{\langle a,b \rangle} \vdash Y}{X, S_{\langle a,c \rangle} \vdash Y} \text{2ndL} \quad \frac{X \vdash S_{\langle a,b \rangle}, Y}{X \vdash S_{\langle c,b \rangle}, Y} \text{2ndR}$$

What these rules say is that if it is incoherent for a to rule-in [-out] S to b , then it is incoherent for a to rule-in [-out] S to some other arbitrary agent c . We take these to only apply to declaratives rather than imperatives. This captures the way that uses of declaratives, assertions and denials, clash regardless of who is addressed. By having these rules not apply to imperatives, this captures the way in which clashes of commands and prohibitions require the same addressee.

3.4.2 Mixed Limit Positions

In the previous section we showed how we can have a language made up of atomic declaratives and imperatives, and logical connectives, where: (1) connectives had the same meanings, in terms of inference rules, regardless of sentence types, and (2) the atomics were structurally different in terms of declaratives being agent-neutral and imperatives being agent-relative. Here we show what limit positions look like for this kind of language.

Our limit position results largely carry over from before but with some important differences. The first is that the language we are dealing with is a contextual one, where inference rules were defined for sentences in a speaker-addressee context. Without the perspective shifting rules, what we have are valuations of sentences in a context, and with no systematic connections between contexts. Our perspective shifting rules correct this however. We have the following FACT 7 about contextual declaratives and imperatives [See Appendix C.4]:

FACT 7: For any contextual mixed limit position CMP:

- (i) A contextual declarative $D_{\langle a,b \rangle}$ is to the left [right] iff all of its contextual variants are.
- (ii) A contextual imperative $I_{\langle a,b \rangle}$ is to the left [right] iff all of its speaker variants are.

A consequence of (i) above is that for any contextual mixed limit position, Boolean evaluations of declaratives will be the same across all contexts. We can use this to determine a value for the sentences simpliciter, i.e. context free, and have this function as one of our models just as in Chapter 2. The declarative part of the position is shared among all participants, much like in more standard models of common ground. What (ii) tells us is that for imperatives in any contextual mixed limit positions, Boolean valuations will agree across all speaker contextual variants. This then determines a value for the sentence paired with a conversational participant. These imperative parts of the position are much like ‘To Do Lists’ in Porter and Mastop’s theories.

The second difference from our previous limit positions is that mixed positions allow for the interaction between contextual declaratives and imperatives. Mixed sentences are ones such as

- 8. a) Tim’s always late and don’t worry [$p \wedge \neg\phi$]
- b) Stop or I’ll shoot [$\phi \vee \neg p$]

FACT 5 about connectives in limit positions in general and the FACT 7 above about contextual limit positions carries over to these as well, though they are worth some discussion of their own. They will be on the left or right (ruled-in or -out) of different pairs of declarative and imperative parts of mixed limit positions. (8a) will be on the left iff ‘Tim’s always late’ is on the left for every context, i.e. it’s part of the Common Ground, and ‘Don’t worry’ is on the left for every speaker variant of the addressee of the conjunction, i.e. it’s on their To Do List. (8a) will be on the right, just if one of its conjuncts is on the right. If the declarative is then it will be so for all, whereas if the imperative is then only for the original

addressee. Philosophers often interpret sentences such as (8b) as expressing the same as ‘If you don’t stop, then I’ll shoot’. (Mastop 2005: Chapter 5, Section 5.7) That may be so, however it also has a plausible “surface level” interpretation. (8b) will be on the left iff one of the disjunct is on the left. For ‘Stop’ to be on the left for the original addressee, is for it to be on their To Do List. It represents their acceptance of or bindingness of the command to stop. In the case where the disjunct is to the left and *only* ‘Stop’ is to the left, we have the situation where someone is bound to stop and the other person will not shoot. However if ‘Stop’ is on the right, then the only way for the disjunction to be on the left is for ‘I’ll shoot’ to be on the left. Given our language doesn’t have indexicals, we can replace ‘I’ll’ with ‘a will’. If the addressee does not accept, or is not bound by, the command to stop, then from the perspective of the conversation, the speaker will shoot them. This sounds fairly natural. Similarly, (8b) will be on the right, ruled-out, if neither the addressee accepts the command to stop (or isn’t bound by it) nor from the perspective of the conversation is the speaker going to shoot the addressee. The remaining case is less natural. This is the one where the disjunct is to the left but both disjuncts are also. It looks like a case where someone is bound to stop but where the other will still shoot them. The one who utters the imperative isn’t going to follow through on their word. It is counter-intuitive that the imperative holds, is to the left, in this situation. Note that this isn’t a consequence of it being read as a disjunction rather than the conditional ‘If you don’t stop, then I’ll shoot’. For if this is the material conditional then it will still be true in the situation where someone stops and the other shoots. The oddness of this last case might motivate reading it as a conditional, but definitely not the material conditional. This however is not within the scope of this thesis.

3.4.3 Compositionality and Sameness of Meaning

In Chapter 1 Dummett’s objection to content pluralism was introduced. This was that content pluralism could not meet requirements both of

compositionality and sameness of meaning across sentence types. The semantics in this chapter goes some way to answering this challenge. For our mixed language of declaratives and imperatives, the inference rules assigned to logical connectives were neutral regardless of sentence type, showing that pluralists can meet Dummett's second requirement for logical vocabulary. The meaning of logically complex sentences was also compositional, just as in the case for the purely declarative language. Thus Dummett's criteria are met for logical vocabulary. The inference rules assigned to atomic sentences were not compositional, as we have only operated at a sentential rather than subsentential level in this chapter. In the next chapter we will give a compositional semantics for imperatives at the subsentential level as well as for a mixed language of both imperatives and declaratives. This will respond to the rest of Dummett's objection and also Liptow's argument from Chapter 1, that pragmatists cannot account for the shared meanings of non-declaratives.

3.5 Ross' Paradox and Free Choice Permission

The strategy in this chapter has been to apply the same inference rules to logical vocabulary in regard to both declarative and imperatives sentences. One might think however that the logic of imperatives, if there is one, needs to be substantially different. Such a concern might be motivated by Ross' Paradox and the problem of Free Choice Permission (FC). Ross' Paradox relates to disjunction introduction for imperatives (Ross 1941). Suppose somebody commands another to 'Post the letter!'. The addressee then infers 'Post the letter or burn the letter!' via disjunction introduction. The problem of FC concerns the way in which we normally interpret disjunctive imperatives as permitting both their disjuncts, though not at once (Fox 2015; Fusco 2015). This leads to imperative absurdity when combined with disjunction introduction. For if our addressee above interprets 'Post the letter or burn the letter!' as permitting both disjuncts, they may opt for letter burning as a way of fulfilling their practical commitments. Note that the issue isn't with 'burn the letter' being

incompatible with 'post the letter'. The former could be replaced with any other action.¹⁹

Ross Inference	FC Inferences
$\phi \Rightarrow \phi \vee \psi$	$\phi \vee \psi \Rightarrow \phi$
	$\phi \vee \psi \Rightarrow \psi$
	$\phi \vee \psi \not\Rightarrow \phi \wedge \psi$

Above we have the Ross and FC inferences. The Ross inference is simple disjunction introduction. The FC inferences should be read as saying that a disjunctive imperative permits either of its imperatives but not both. Hence the idea that the addressee has permission to freely choose which one they carry out. It should be clear that one ought not to endorse both the Ross and FC inferences, with imperative logics and semantics tending to opt for one or the other.²⁰ Our inferences rules accept the Ross inference, because if it is incoherent to prohibit ϕ it is incoherent to prohibit $\phi \vee \psi$. However the semantics rejects the first two FC inferences. If is incoherent to prohibit $\phi \vee \psi$ then it is incoherent to prohibit both ϕ and ψ but not either by themselves. Our system does not result in imperative absurdity.

The rest of this chapter will briefly motivate this option rather than the alternative of rejecting Ross and accepting FC. The argument is drawn from Castaneda (1981). The first argument shows that when $\phi \vee \psi$ is introduced from ϕ , the only particular action commanded is still ϕ . In his solution to Ross' paradox, Castañeda points out that we mustn't forget about our premises once we infer our conclusions:

No sentence is an island unto itself. In particular, the members of an inference form a tightly knit community of thought

19. Ross' Paradox and particularly Free Choice Permission are often discussed in the context of deontic rather than imperative logic. Given that the same puzzles appear in both, one might expect a the solution to one to carry over to the other.

20. See (Mastop 2005: Chapter 4), Barker (2010), and Fusco (2015) for theories which reject disjunction introduction and endorse the FC inferences. See Kamp (1978) and Fox (2007) for theories which treat free choice as a pragmatic matter of implicature rather than semantic entailment.

contents. When one infers a conclusion one is considering one member of a related set – and one must remember the premises, or remember that the premises are still valid or true, or whatever property is supposed to be preserved in inference (Castaneda 1981: p.64).

Once we recognise Castañeda's point, we see that no other particular actions become commanded when a disjunction is introduced, beyond what was commanded by the premises. Suppose for some imperative position, ϕ is ruled-in. With the classical negation rules, this is a command, meaning that ϕ is permitted and $\neg\phi$ is prohibited. So far all this position requires is that the agent refrains from doing what is prohibited, i.e they are commanded to ϕ , for $\neg\phi$ is prohibited. If ϕ is permitted then it is incoherent to prohibit $\phi \vee \psi$. So the latter can be introduced. However, once it is introduced the only particular action which is commanded is still ϕ . Showing that nothing more is commanded after a disjunction has been introduced doesn't yet show that nothing more is permitted however. The FC inferences say that both disjuncts are permitted (though not together). That this doesn't follow from our inference rules is fairly easy to see. In the above example, the only particular action permitted is still ϕ rather than also ψ . So commanding someone to post the letter won't permit them to burn it.

We have shown that according to our rules no more commands nor more permissions are introduced by disjunctions. To finish we will motivate first our rejection of the FC inference and our endorsement of disjunction introduction. Castañeda's point earlier was that we must look at premises and conclusions together, and his emphasis on how imperatives are related to one another can be used again to reject the FC inferences:

There are several reasons why a disjunctive order, or a disjunctive norm, may not open a genuine choice between alternatives. Not being an insular thing each order and norm must be related to the other orders or norms. Among such reasons we have: (a) one disjunct may itself be self-contradictory; (b) one disjunct may be physically impossible of realization; (c)

one disjunct may be forbidden, wrong, or interdicted by another order or norm. (Castaneda 1981: p.64)

The relevant relation I will focus on is that if the FC inferences are endorsed then a disjunction and the negation of either of its disjuncts are incompatible.

$$\phi \vee \psi, \neg\phi \Rightarrow \perp$$

I will give two examples, motivating the idea that a disjunctive imperative and the negation of one of its disjuncts are compatible.

1. The Tricky Master: Suppose we have a household of a rich master and a number of servants. The master's attention to logic and careful reasoning has been integral to her attaining her fortune and these are virtues she wishes to instil in her servants. One day she tells her servants to 'Serve ice-cream or cake for dessert'. Later in the day she tells them 'Don't serve cake for dessert'. The servants infer that they are now bound to serve ice-cream for dessert. The view we are opposing however is committed to saying that the master is being inconsistent in commanding ' $\phi \vee \psi$ ' along with ' $\neg\psi$ ' and that the only way for her to be consistent is to withdraw her earlier command. But if she is interpreted as doing so then the servants are not bound to serve ice-cream for dinner, which they appear to be.
2. The Ignorant Master: Say some of these servants, fed up with their master's "logical" tricks, seek new employment. The new master is happily ignorant of both logical laws and those of the land. He frequently gives them disjunctive commands such 'Spend Monday reading or robbing the bank', assuming that both options are on the table. Little does he know that bank robbing is illegal and that all of his servants are already bound by the imperative 'Don't rob the bank!'. From the servants' perspective their only option is to spend Monday reading.

These are examples of coherently commanding a disjunctive imperative and also the negation of one of the disjuncts, showing that we, with Cas-

tañeda, ought to reject the idea that disjunctive imperatives always offer a 'genuine choice between alternatives'. We now motivate disjunction introduction. In the declarative case, it generally goes against Gricean maxims to explicitly introduce a disjunction into the conversation. Despite this, it is still a valid inference. That an explicit introduction of a disjunctive imperative also goes against Gricean maxims ought not to undermine the validity of the inference. For declaratives, we might explicitly make these inference when the disjunction is the antecedent of a conditional. We have a analogous example for imperatives, but with the conditional translated into a disjunction. Take the following line of reasoning

1. Sing! [ϕ] (Premise)
2. Either, neither sing nor dance, or *do* skip! [$\neg(\phi \vee \psi) \vee \rho$] (Premise)
3. Sing or dance! [$\phi \vee \psi$] (From 1.)
4. (So) Skip! [ρ] (From 2. & 3.)

which we represent formally below

$$\frac{\frac{\frac{\phi \vdash \phi}{\phi \vdash \phi \vee \psi} \vee R}{\phi, \neg(\phi \vee \psi) \vdash} \neg L}{\frac{\phi, \neg(\phi \vee \psi) \vdash \rho}{\phi, \neg(\phi \vee \psi) \vee \rho \vdash \rho} KR} \rho \vdash \rho \vee L$$

Here, disjunction introduction plays an important role in a disjunctive syllogism, analogous to the declarative case. Were it rejected such forms of reasoning would become invalid.

What we have shown in this section is that: (1) our inference rules do not result in imperative absurdity, as disjunction introduction but not free choice inferences are valid, and (2) that this alternative can be motivated by situations where imperative disjunctions do not offer a genuine choice between the disjuncts and those where imperative disjunction introduction plays a role in our reasoning.

CHAPTER FOUR

Plural Composition

4.1 Summary and Introduction

In Chapter 1 three arguments were introduced and the aim set of responding to them throughout the thesis. The first argument was one by Jasper Liptow concluding that pragmatist theories of meaning are set to fail, because they cannot account for the shared propositional content of different sentence types. Liptow assumed that all sentence types must share a core propositional content. We then examined an argument of Michael Dummett's concluding that this must be so. Dummett assumed both that meaning is compositional and that word meaning is invariant across sentence types. Lastly an argument of Jerry Fodor & Ernie Lepore's was presented, and which concluded that pragmatist theories of meaning could not meet requirements of compositionality. The thesis then began addressing them in reverse order. In Chapter 2 we showed that, contra Fodor & Lepore, a compositional pragmatist (inferentialist) proof-theoretic semantics can be given for atomic declarative sentences and their components – predicates and names. Next, in Chapter 3, we set out a normative pragmatist theory of sentential level imperative content, which was governed by norms of commanding and prohibiting, on analogy with assertion and denial. There we went part way to responding to Dummett's objection, by showing that the meanings of logical connectives could be invariant across sentence types, while also keeping the

meaning of logically complex expressions compositional. In this concluding chapter, we will combine last chapter's story about imperatives with Chapter 2's about subsententials, to give an account of how the sentential content of imperatives is composed out of that of their parts, yet without requiring a propositional core that imperatives share with declaratives. We then extend this to a language with both imperatives and declaratives, showing how they can interact without sharing such a core. This responds to Dummett's argument, showing that we need not adhere to the kind of invariance of word meaning that he claims is necessary. In doing so, we then show Liptow's argument to be unsound because pragmatists need not require there to be a shared propositional core to all sentence types.

4.2 Imperatives

Here we set out a compositional semantics for imperatives but which does not feature a 'propositional core'. We start off with 'bare' or 'unmarked' imperatives, which do not feature a subject, and then introduced 'marked' imperatives with a subject. Most of the central points of this are taken from Rosja Mastop's update semantics for imperatives (Mastop 2005: Chapter 5).

4.2.1 Bare Imperatives

Bare or unmarked imperatives are those such 9. a) and b) which do not feature a subject represented at sentence level.

9. a) Hide!
- b) Find Wally!

English imperatives are often of this form, in that they do not require an explicit subject. Rather than merely being a feature of English, this is 'extremely common, if not universal' (Konig and Siemund 2007: 304). In this chapter, we will take this feature at face value and use it to do some of

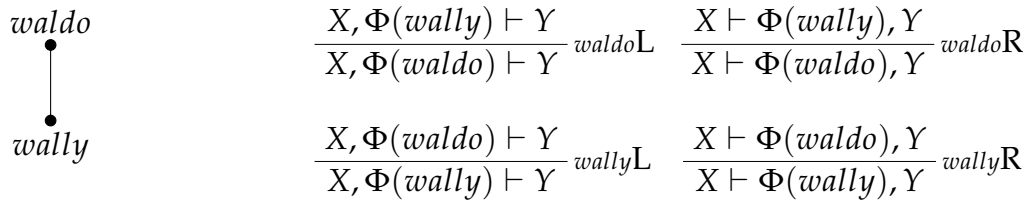
the work in explaining why imperatives are not truth-evaluable, an idea which we motivated in the previous chapter. We set out a syntax and semantics where subjectless imperatives are treated as the basic form, and where this plays a role in them not expressing propositions at a sentence level. We begin with a simple language, similar to that of Chapter 2, made up of n -place imperative predicates \mathcal{P}_n , and names t . Sentences are, as expected, of the form $\mathcal{P}_n(t_1\dots t_n)$. These imperatives may be zero-place and represent the predicate (verb) parts of 9.a) and b). If \mathcal{H}_0 and \mathcal{F}_1 stand for the predicates ‘Hide’ and ‘Find’, and w for the name ‘Wally’ then 9. a) and b) will be represented by

10. a) \mathcal{H}_0
 b) $\mathcal{F}_1(w)$

We use math calligraphy font for imperative predicates (why we do not use Greek will become apparent when we add in declaratives). Predicate argument subscripts and brackets will be left out when it results in no ambiguity.

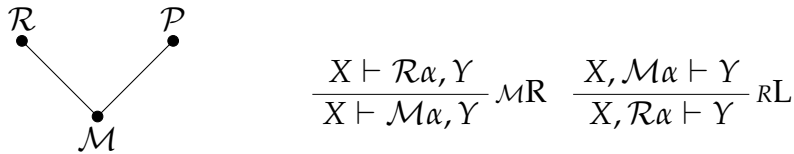
Given this syntax, the semantics for this language can also be taken over from Chapter 2. We assign names instances of the subsentential identity axiom $[Id_s]$ and symmetric inference rules corresponding to non-branching concept clusters, and assign predicates asymmetric rules corresponding to branching concept clusters. For example, given the names ‘Wally’ and ‘Waldo’, linking them via symmetric rules will ensure that commanding [prohibiting] imperatives of the form $\Phi(wally)$ and $\Phi(waldo)$ are interchangeable.

Figure 4.1: Wally-Waldo Cluster & Rules



In the case of predicates, asymmetric rules between ones such as ‘Run’ [\mathcal{R}] and ‘Move’ [\mathcal{M}], ensure that whenever it is incoherent to prohibit the former it is also incoherent to prohibit the latter, but not the reverse.

Figure 4.2: Partial Run-Move Cluster & Rules



Successful uses of bare imperatives shift or update the addressee’s practical commitments – what is permitted, prohibited, and commanded. As agents themselves are not part of the practical commitment, they do not need to be represented at the sentence level as imperative subjects. For example, if I am committed to feed the cat, then what gets added to my To-Do List isn’t ‘Kai feeds the cat’ but ‘Feed the cat’.²¹ Our practical commitments may be simple and built out of only a predicate, like ‘run’, ‘jump’, and ‘hide’. Alternatively, they might be complex in the way ‘feed the cat’ is, where it is composed out of the predicate ‘feed α ’ and the singular term ‘the cat’. Due to this structure they are however not apt for being asserted or denied. For they do not relate a predicate to a name in the sense of predicating a property of an object. Predicates (or commitments to act) are not themselves the kind of thing that can be true or false, making the imperatives which express them non-truth apt.

4.2.2 Marked Imperatives

Marked imperatives are those such as 11.a) and b) which explicitly mark the addressee or subject of the imperative.

11. a) Wally hide!

21. The point that simple imperatives do not require a subject is argued in detail by Mastop (Mastop 2005: Chapter 2, Chapter 5).

b) Odlaw find Wally!

Our view so far, adopted from Mastop, is that the basic, “bare”, form of imperatives require no subjects. Again drawing from Mastop’s update semantics, we show how in the case of marked imperatives with subjects, the imperative subject plays a different role from its declarative counterpart. In the case of declaratives, predicates take their subjects as arguments. In contrast, imperatives subjects, Mastop argues (Mastop 2005: Chapter 5, Section 5.6), act as operators scoping over predicates. The central idea is that ‘Wally’ in 11a) makes explicit who the addressee of the imperative is – the agent whose practical commitments are being updated. In English, at least, our imperatives appear to be second-personal. That is, the person being spoken to and the addressee of the imperative, in the sense of the one whose practical commitments are being affected, are one and the same. A second-person subject or addressee is sometimes taken as constitutive of imperatives, distinguishing them from other constructions such as ‘hortatives’ and ‘jussives’ which appear to have first- or third-person subjects (Konig and Siemund 2007: p.303, 313). In our set-up however, there is no in-principal reason for all imperatives to be second-personal in this way. Several languages have sentence types which can be used for commands when marked for the second-person but with differing force when marked for the first- or third-person (Xrakovskij 2001). First-personal imperatives are typically used to either express intentions or seek permission (Aikhenvald 2010: p.74). We might think of the first as publicly taking on a practical commitment and the second as an instance where somebody does not have the authority to update their own practical commitments in some domain. Third-person imperatives come closest to ‘Let’ constructions in English such as

12. Let Odlaw try and find Wally!

Third-person imperatives can be interpreted as updating the practical commitments of someone who is not actually present. This may appear odd, as without being present they are not to know that their commitments have changed. A shift in someone else’s commitments however,

can have an effect on one's own. If I acknowledge the legitimacy of 12., namely that Odlaw is now permitted to find Wally, then that will effect how I may relate to Odlaw. Perhaps I am no longer permitted to sanction him, should he try and find Wally.²²

In order to represent marked imperatives, we extend the language of the previous section so that if ϕ is a bare imperative and a name, then $a(\phi)$ is a marked imperative. We then use the contexts from the previous chapter to represent their semantics, with the underlying idea being that imperative subjects make explicit the addressee or target, in a broad sense, of the imperative. We again define a context $\langle a, b \rangle$ of a speaker a and a addressee b . We understand the addressee as the one whose practical commitments are being updated by the imperative. The contextual imperative $\phi_{\langle a, b \rangle}$ represents the imperative ϕ made by a to b . We then assign marked imperatives the following inference rules:

$$\frac{\Gamma, \phi_{\langle a, b \rangle} \vdash \Sigma}{\Gamma, b(\phi)_{\langle a, b \rangle} \vdash \Sigma} \text{markL} \quad \frac{\Gamma \vdash \phi_{\langle a, b \rangle}, \Sigma}{\Gamma \vdash b(\phi)_{\langle a, b \rangle}, \Sigma} \text{markR}$$

These make marked imperatives behave as expected. Coherencies and incoherencies of commanding and prohibiting are preserved between ϕ as addressed to b and $b(\phi)$. This shows how while bare imperatives may not require subjects, when imperatives subjects do occur, they play a different role to their declarative counter-parts. Imperative subjects make explicit the targets or addressees of imperatives and scope over predicates. In contrast, declarative subjects represent the object of which a property is predicated and is an argument of the predicate.

4.3 Imperatives and Declaratives

In this section we have reached the point of being able to fully respond to Dummett's objection against content pluralism. In doing so we also

22. Although no formal semantics for 'Let' constructions will be given here, Mastop, whose work serves as a model for mine, does so in (Mastop 2005: Chapter 5, Section 5.6)

provide a response to Liptow's criticism of pragmatic theories of meaning. First, we show how a language of names, predicates, atomic declaratives and imperatives can be content plural, compositional, and assign the same meanings to the subsentential vocabulary. Second, we show what limit positions look like for a language with mixed subsententials.

4.3.1 Mixed Inference Rules

We now combine the declarative subsentential language from Chapter 2 with the imperative subsentential language sketched in the previous section. We show that it is content plural, compositional, and assigns the same meanings to subsentential vocabulary. As in the previous section, this approach is adopted from Mastop (Mastop 2005: Chapter 5).

We begin by defining a syntax for a simple language \mathcal{L} . \mathcal{L} is made up of names, n -places predicates, and atomic sentences. For each predicate there are two symbols, corresponding to its declarative and imperative form. For each imperative predicate $\mathcal{P}_{n \geq 0}$ there is a corresponding declarative predicate P_{n+1} with one more argument place. In order to better represent them as being forms of the same predicate, rather than Greek for imperatives we use the maths calligraphy font to distinguish them from declaratives. Bare imperative sentences are of the form $\mathcal{P}_{n \geq 0}(t_1, \dots, t_n)$ and declarative sentences of the form $P_{n+1}(t_1, \dots, t_n)$. As in the previous section, if ϕ is a bare imperative and a is a name, then $a(\phi)$ is a marked imperative. To each sentence S we add a context $\langle a, b \rangle$ of a speaker a and addressee b , with $S_{\langle a, b \rangle}$ representing S said by a addressed to b .

We now define a mixed subatomic system, which as previously is a triple of our language \mathcal{L} , a set of inference rules R , and an assignment function v . We restrict R and v in a similar way to before. Note that \mathcal{L} is a contextual language as described above. We limit R to inference rules between expressions of the same syntactic type – names to names, predicates to predicates, sentences to sentences, etc. v is then restricted such that expressions form concept clusters, and the rules assigned to expres-

sions are instances of the general rules forms from Chapter 2. Names are assigned instance assigned instances of the subsentential identity axiom and symmetric (non-branching) inferences rules, whereas predicate are assigned asymmetric (branching) inference rules. The rules assigned to sentences, are again a function of those assigned to their constituents, in the manner of Chapter 2, Section 2.4.3.

We make one novel restriction on v . This is that we assign rules to predicates in a type-neutral way. This means that an imperative predicate $\mathcal{P}_{n \geq 0}$ and its declarative form P_{n+1} both receive the same inference rules. This is similar, although not strictly the same, as our sentence-type neutral rules for logical connectives in the previous chapter. To illustrate, take the predicates ‘Run’ and ‘Move’, represented in their respective imperative and declarative forms by the pairs \mathcal{R}_0, R_1 and \mathcal{M}_0, M_1 . The following inference rules are assigned type-neutrally to the predicates:

$$\frac{X \vdash R, Y}{X \vdash M, Y} \text{MR} \quad \frac{X, M \vdash Y}{X, R \vdash Y} \text{RL}$$

What MR tells us is that if it is incoherent to rule-out ‘Run’ then it is incoherent to rule-out ‘Move’. In the declarative case, this will be a relation between denying that something runs and that it moves, whereas in the imperative case it is between prohibiting someone from running and moving. It is the same inference rules governing the predicate regardless of what form it takes. This is the sense in which predicates ‘mean the same thing’ regardless of what sentence type they are part of.

Lastly, we have inference rules governing ruling-ins and ruling-outs in general and then declaratives and imperatives in general. The first are the structural rules of the classical multiple conclusion sequent calculus – contraction, weakening, and cut. As all our inferences assigned to expressions in the language are instances of the general form of material inference rules and these are cut free, then so is our subatomic system. Second, we adopt the perspective shifting rules from the previous chapter. As we did there, we apply both to declarative but only the first to imperatives. Declaratives clash regardless of speaker and addressee, whereas imperative clashes are located around a single addressee. This

further maintains the difference between declaratives and imperatives despite their constituents sharing meanings.

A subatomic system of this form is an example of a language with subsentential structure, and which is content plural, compositional, and respects sameness of meaning across different sentence types. It is content plural, because sentences of different types are governed by fundamentally different norms of use. Declaratives are governed by norms of assertion/denial, and imperatives by those of commanding/prohibiting, with the former but not the latter being agent-neutral in the way they change the conversational score. Corresponding to their respective agent-neutrality and agent-relativity, their contents have differing internal structures. Agents or subjects in the declarative case form a necessary part of the sentence level representation, whereas imperative subjects are not required. When imperative subjects are present, they make explicit the addressee of the imperative, rather than a part of the action it puts on the addressee's To-Do List. The subatomic system is compositional, in the same way as the language from Chapter 2 was, in that the inference rules assigned to sentences are a function of those assigned to their constituents and the way they combine. Lastly, it respects sameness of meaning in the sense described above, where names and predicates are assigned the same inference rules regardless of the sentence types of which they are constituents, despite our predicate symbols being split into their imperative and declarative forms.

4.3.2 Mixed Limit Positions

In the previous chapter, we saw how sentential imperative and mixed contextual limit positions worked. In these, the imperative parts of the language ended up being relativised to addressees, whereas the declarative parts applied to the whole position. The question here is what their subsentential equivalents look like.

We keep the previous restrictions on the extensions of names and predicates, though now relative to contexts, and where the predicates

may be of either imperative or declarative form:

1. For any two names α and β , if whenever $\Phi\alpha_{\langle a,b \rangle}$ is to the left [right] $\Phi\beta_{\langle a,b \rangle}$ is also, then $v(\alpha) = v(\beta)$;
2. For any predicate F if $Fa_{\langle a,b \rangle}$ is on the left [right] then $v(a) \in v(F_{\langle a,b \rangle})$ [$v(a) \notin v(F_{\langle a,b \rangle})$];

As in the previous chapter, the perspective shifting rules allow for us to speak of imperatives relative to a specific addressee and declaratives for the whole conversation. In the case of 1., because the same names appear in both imperative and declarative sentences, then they receive the same extensions. 2. however splits into two cases for F 's respective declarative and imperative forms, F and \mathcal{F} . Their extensions will not be the same. First, because they will differ in argument places. \mathcal{F} will have $n \geq 0$ argument places whereas F will have $n + 1$. Second, being on the left or the right, ruling-in or -out, for imperatives and declaratives are separate, unless coordinated by connectives. Correspondingly, what it means for an object to be in the extension of some predicate are in each case quite different things. In the declarative case, it indicates that the objects satisfy some property or relation. Whereas for imperatives, it indicates that the object is to be acted on in a particular way by a particular agent. If \mathcal{F} is 'Find', then objects in its extension are to be found by a particular person – these will differ between agents. Contrast with F , which will have pairs of finders and found objects. This difference in extensions is not, however, a problem for our theory. The meanings of predicates on our theory are the inference rules which they are assigned, rather than their extensions, and imperative and declarative versions of a predicate are assigned the same inference rules.

We can of course imagine situations where our imperative and declarative predicate extensions come closer to lining up. These are ones where every object which is to be acted on by an agent is acted on by that agent. Less awkwardly, ones where if Odlaw is commanded to find Wally, he does so. Call these limit positions 'compliant':

Complicance A limit position $X : Y$ is compliant iff $\forall \mathcal{P}(t_{\geq 0}, \dots, t_n)_{\langle a, b \rangle}$ whenever $\mathcal{P}(t_{\geq 0}, \dots, t_n)_{\langle a, b \rangle} \in X$ [$\in Y$], then $P(b, t_{\geq 0}, \dots, t_n)_{\langle a, b \rangle} \in X$ [$\in Y$].

In compliant limit positions, for every n -tuple of objects in the extension of an imperative predicate relative to some agent, the $n+1$ -tuple of those objects, but beginning with that agent, are in the extension of the corresponding declarative predicate [See Appendix C.5]:²³

Compliant Extensions For all compliant limit positions $X : Y$, if $\forall x, v(t_{\geq 0}, \dots, t_n) \in v(\mathcal{P}_{\langle x, b \rangle})$, then $\forall x \forall y, v(b, t_{\geq 0}, \dots, t_n) \in v(P_{\langle x, y \rangle})$.

This allows us to talk in our metalanguage about situations where agents fulfil imperatives. It is left to further work to introduce this sort of vocabulary into the object language. This would be an important step for the kind of theory advocated here, because rival theories of imperatives often understand their meaning in terms of fulfilment conditions (Boisvert and Ludwig 2006) or deontic modals (Kaufmann 2011).

4.4 Conclusion: Plural Composition

We are now in the position of having responded to all three arguments set out in Chapter 1. These were

1. Liptow's argument against semantic pragmatism;
2. Dummett's argument against content pluralism; and
3. Fodor & Lepore's argument against inferentialism.

We responded to these in reverse order:

23. Limit positions are used here, but this could be done with non-maximal positions, so long as: (i) for each negation on the left, its negand is on the right and vice versa; (ii) For each conjunct on the left, both conjuncts are also, and for each on the right, at least one conjunct is also; and (iii) Dual for disjunction.

3. Fodor & Lepore's argument was that inferentialist theories of content, of which ours is a species, cannot meet requirements of compositionality, due to them being inherently holistic. In Chapter 2 we showed how an inferentialist semantics for languages made up of atomic sentences, names, and predicates could on a narrow notion of meaning be compositional and on a broader one still be recursive (productive and systematic). Expressions were divided into clusters and assigned inference rules based on these. These inference rules were all of a general form, which ensured that, locally, clusters neither gained (soundness) nor lost (completeness) information. The global equivalents (cut and general identity proofs) also held for the whole language. We then drew on Brandom's inferentialist distinction between names and predicates. On the basis of this we assigned symmetric inference rules to names and (possibly) asymmetric ones to predicates, resulting in the same structure as standard extensional model theoretic semantics. The narrow, and compositional, notion of meaning was treating the inference rules assigned to an expression as its meaning, while the broader notion included relations which extended beyond a single concept cluster, such as inclusion in limit positions. Either way, the semantics met Fodor & Lepore's challenge.

2. Dummett argued that given (a) compositionality of meaning, and (b) uniformity of word meaning across sentence types, sentence level meaning must all be of the same type. If the type of sentence level meaning composed differed, then this would have to result from a difference in word meaning, violating (b), or from something other than its constituents, violating (a). A related issue was logical constants having the same meaning, despite applying to different sentence types. We responded to this second concern in the previous chapter, by showing that logical constants can be given the same inference rules, despite applying to two sentence types, once declaratives and imperatives are each given their own kind of 'ruling-in' and 'ruling-out'. Declaratives are used for assertions and denials, ruling-in and -out ways the world could be. In contrast, imperatives are used for commanding and prohibiting, ruling-in and -out actions for particular agents. This then set the stage for us

showing in this chapter, how the same can be done for subsententials, by drawing on the results from Chapter 2. Declaratives and imperatives were first differentiated in terms of their subsentential structure, with simple forms of the former but not the latter requiring an explicit subject. “Bare” imperatives simply expressed actions or practical commitments, which are added to someone’s To Do List, and those with subjects make explicit the addressee. For languages with subsentential structure and both declaratives and imperatives, we divided predicates into their declarative and imperative forms, but assigned the same inference rules to both. This met Dummett’s requirement of uniformity of meaning, because meaning is here understood as inference rules rather than extensions. The latter, but not the former, will differ in our semantics. As the semantics is built on that from Chapter 2, it is compositional. Thus, it meets both of Dummett’s requirements, and yet is content plural.

1. The argument of Liptow’s which we began with was, essentially, that semantic pragmatism was bound to fail because it couldn’t be content monist. Liptow assumed that different sentence types must still share a propositional core. Based on this assumption, he then argued that pragmatists could not recover the shared core from the uses of these sentences. For they systematically differ in the way they affect the conversational score (their pragmatic force). Having responded to the second and third arguments, we have now made sense of a content pluralist pragmatist semantics, which doesn’t assume that all sentence types share a propositional core. In doing so, we’ve seen that pluralism and pragmatism about semantic content come together as a natural fit. Possessing different kinds of content explains the way different sentence types systematically affect the conversational score, and meaning being tied to norms of use doesn’t require that there be only one kind of content from the outset.

Representationalists are where we left them at the end of Section 1.5.1 of the first chapter. There we identified an impasse, with representationalists appearing to be committed to the following trilemma:

1. Sentence meaning determines truth-conditions (is propositional);
2. The difference between declaratives and non-declaratives appears to be included in the content they embed; and
3. Novel semantics predicates such as 'answered' and 'obeyed' appear to:
 - a) be tied to use rather than representation; or
 - b) collapse into truth conditions.

In order to accommodate 2., representationalists seem to need to adopt novel semantic predicates. However if 3.a) is accepted, then they must reject 1, yet this is the cornerstone of representationalism. Aside from this, if 3.b) is correct, then there is no difference in kind between declarative and non-declarative meaning. For it follows from 1. that sameness of truth-conditions leads to sameness of meaning. Yet 2., the difference in declarative and non-declarative meaning, was the reason for adopting these novel semantic predicates in the first place. These issues are not faced by those in the pragmatist camp. We've seen how pragmatists can naturally explain differences in sentence meaning types, without also being committed to the claim that deep down, it must all be propositional. This allows us to recongnise, with Belnap, that declaratives are not enough:

My thesis is simple: systematic theorists should not only stop neglecting interrogatives and imperatives, but should begin to give them equal weight with declaratives. A study of the grammar, semantics, and pragmatics of all three types of sentence is needed for every single serious program in philosophy that involves giving important attention to language (Belnap 1990).

Appendices

APPENDIX A

Identity

Here we show that general identity proofs for rules of our general forms hold (see Chapter 2, Section 3.4.4).

Figure A.1: General Identity for Parents

(i) One Parent, Many Children (ii) Many Parents, One Child

$$\frac{\frac{C_1 \vdash C_1 \quad C_n \vdash C_n}{C_1, \dots, C_n \vdash P} \text{PR}}{P \vdash P} \text{PL} \qquad \frac{\frac{\frac{C \vdash C}{P_j \vdash C} \text{PL} \quad \frac{P_i \vdash P_i}{P_i, P_j \vdash} \text{PL}_2 \quad \frac{P_n \vdash P_n}{P_n, P_j \vdash} \text{PL}_2}}{P_j, P_j, P_j \vdash P_j} \text{PL}}{P_j \vdash P_j} \text{WL}\times 2$$

Figure A.2: General Identity for Children

(i) One Parent, Many Children (ii) Many Parents, One Child

$$\frac{\frac{P \vdash P}{C_1, \dots, C_n \vdash P} \text{CL}}{C_1, \dots, C_n \vdash C_i} \text{CR} \qquad \frac{\frac{P_1 \vdash P_1}{P_1 \vdash C} \text{CR} \quad \frac{P_n \vdash P_n}{P_n \vdash C} \text{CR}}{C \vdash C} \text{CL}$$

APPENDIX B

Cut Elimination

We now show that our rules meet general conditions sufficient for cut elimination (see Chapter 2, Section 3.4.4). These are variants of those found in Belnap (1982) and Restall (2005b).

B.1 Definitions

First some definitions:

Parameter Parameters are those formulas which are held constant in the premises and conclusion of a rule. I.e all formula except those introduced or eliminated by the rule.

Parametric Class Two formulas are a part of the same parametric class if they are represented by the same letter in a presentation of the rule (e.g the instances of A in an inference of contraction,) or if they occur in the same place in a structure (e.g in an antecedent X).²⁴

Principal A formula is principal if it is not a parameter.

Parent Some formula A is the parent of another B iff A and B are principal formulas in an inference in the premise and conclusion sequent

24. This definition is taken almost word for word from (Restall 2005b: p.167)

respectively. E.g in [CL]

$$\frac{X, P_1 \vdash Y \quad \dots \quad X, P_n \vdash Y}{X, C_1, \dots, C_n \vdash Y} \text{CL}$$

P_1 through to P_n are parents of C_1, \dots, C_n .

Child Some formula A is the child of another B iff B is a parent of A .

Ancestor If B is a parent of C then B is an ancestor of C . If A is an ancestor of B and B is an ancestor of C then A is an ancestor of C .

Descendent Some formula A is the descendent of another B iff B is an ancestor of A .

B.2 Conditions for Cut Elimination

The following are sufficient conditions for cut elimination:

1. **Cut/Identity:** cut on an identity sequent can be directly eliminated.
 - This can be seen from the two cases of cutting on the left or right of an identity sequent:

$$\frac{\begin{array}{c} \vdots \\ \vdots \pi_1 \\ X \vdash S, Y \end{array} \quad \begin{array}{c} \vdots \\ \vdots \pi_2 \\ S \vdash S \end{array}}{X \vdash S, Y} \text{Cut} \implies \begin{array}{c} \vdots \\ \vdots \pi_1 \\ X \vdash S, Y \end{array}$$

$$\frac{\begin{array}{c} \vdots \\ \vdots \pi_1 \\ S \vdash S \end{array} \quad \begin{array}{c} \vdots \\ \vdots \pi_2 \\ X, S \vdash Y \end{array}}{X, S \vdash Y} \text{Cut} \implies \begin{array}{c} \vdots \\ \vdots \pi_2 \\ X, S \vdash Y \end{array}$$

2. **Regularity:** If a cut formula is parametric in an inference immediately before the cut, the cut may be permuted above the inference.
 - This holds for each of our rules. In each case the derivation reduces to one in which we push the instance of [Cut] above the other rule. See the following:

For Weakening [K]:

$$\frac{\frac{\frac{\vdots^{\pi_1} \quad \vdots^{\pi_2}}{X \vdash S, Y \quad Z, S \vdash W} \text{LK}}{X, Z, K \vdash Y, W} \text{Cut}}{X, Z, K \vdash Y, W} \text{KR} \Rightarrow \frac{\frac{\vdots^{\pi_1} \quad \vdots^{\pi_2}}{X \vdash S, Y \quad Z, S \vdash W} \text{KL}}{X, Z \vdash Y, W} \text{KR}}{X, Z, K \vdash Y, W} \text{KR}$$

For [CL]

$$\frac{\frac{\frac{\vdots^{\pi_2} \quad \vdots^{\pi_n}}{X, P_1 \vdash S, Y \quad X, P_n \vdash S, Y} \text{CL}}{X, C_1, \dots, C_n \vdash S, Y} \text{Cut}}{X, C_1, \dots, C_n \vdash Y} \text{Cut} \Rightarrow \frac{\frac{\frac{\vdots^{\pi_2} \quad \vdots^{\pi_1}}{X, P_1 \vdash S, Y \quad X, S \vdash Y} \text{Cut}}{X, P_1 \vdash Y} \text{Cut}}{X, C_1, \dots, C_n \vdash Y} \text{CL} \frac{\frac{\frac{\vdots^{\pi_n} \quad \vdots^{\pi_1}}{X, P_n \vdash S, Y \quad X, S \vdash Y} \text{Cut}}{X, P_n \vdash Y} \text{Cut}}{X, C_1, \dots, C_n \vdash Y} \text{CL}$$

For [CR]

$$\frac{\frac{\frac{\vdots^{\pi_1} \quad \vdots^{\pi_2}}{X, S \vdash P_i, Y} \text{CR}}{X \vdash C_i Y} \text{Cut}}{X \vdash C_i Y} \text{Cut} \Rightarrow \frac{\frac{\frac{\vdots^{\pi_1} \quad \vdots^{\pi_2}}{X \vdash S, Y \quad X, S \vdash P_i, Y} \text{Cut}}{X \vdash P_i, Y} \text{Cut}}{X \vdash C_i, Y} \text{CR}$$

For [PL₁]

$$\frac{\frac{\frac{\vdots^{\pi_1}}{X, C_1, \dots, C_n \vdash S, Y} \text{PL}_1}{X, P_i \vdash S, Y} \text{PL}_1}{X \vdash Y} \text{Cut} \Rightarrow \frac{\frac{\frac{\vdots^{\pi_1} \quad \vdots^{\pi_2}}{X, C_1, \dots, C_n \vdash S, Y \quad X, S \vdash Y} \text{Cut}}{X, C_1, \dots, C_n \vdash Y} \text{Cut}}{X, P_i \vdash Y} \text{PL}_1$$

For [PL₂]

$$\frac{\frac{\frac{\vdots^{\pi_1}}{X \vdash P_i, S, Y} \text{PL}_2}{X, P_j \vdash S, Y} \text{PL}_2}{X, P_j \vdash Y} \text{Cut} \Rightarrow \frac{\frac{\frac{\vdots^{\pi_1} \quad \vdots^{\pi_2}}{X \vdash P_i, S, Y \quad X, S \vdash Y} \text{Cut}}{X \vdash P_i Y} \text{Cut}}{X, P_j \vdash Y} \text{PL}_2$$

For [C]

$$\frac{\frac{\frac{\vdots \pi_{Ri}}{X \vdash P_i, Y}}{X \vdash C_i} \text{CR} \quad \frac{\frac{\frac{\vdots \pi_{L1}}{X, P_1 \vdash Y} \quad \frac{\vdots \pi_{Ln}}{X, P_n \vdash Y}}{X, C_1, \dots, C_n \vdash Y} \text{CL}}{X, C_1, \dots, C_{n-i} \vdash Y} \text{Cut}}{X, C_1, \dots, C_{n-i} \vdash Y} \text{Cut} \implies [\text{Repeated}] \frac{\frac{\frac{\vdots \pi_{Ri}}{X \vdash P_i, Y} \quad \frac{\vdots \pi_{Li}}{X, P_1 \vdash Y}}{X \vdash Y} \text{Cut}}{X, C_1, \dots, C_{n-i} \vdash Y} \text{KL}}$$

For [P] there are two cases. The first using [PL₁] and the second using [PL₂].

Using [PL₁].

$$\frac{\frac{\frac{\frac{\vdots \pi_{R1}}{X \vdash C_1, Y} \quad \frac{\vdots \pi_{Rn}}{X \vdash C_n, Y} \quad \frac{\vdots \pi_{L1}}{X, P_i \vdash Y} \quad \frac{\vdots \pi_{Ln}}{X, P_n \vdash Y}}{X \vdash P_j, Y} \text{PR} \quad \frac{\frac{\vdots \pi_{L1n}}{X, C_1, \dots, C_n \vdash Y}}{X, P_i \vdash Y} \text{PL}_1}}{X \vdash Y} \text{Cut}}$$

\implies

$$[\text{Repeated}] \frac{\frac{\frac{\vdots \pi_{Ri}}{X \vdash C_i, Y} \quad \frac{\vdots \pi_{L1n}}{X, C_1, \dots, C_n \vdash Y}}{X \vdash Y} \text{Cut}}$$

Using $[PL_2]$.

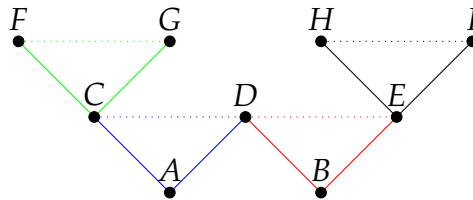
$$\frac{\frac{\frac{\frac{\vdots \pi_{R1}}{X \vdash C_1, Y} \quad \frac{\vdots \pi_{Rn}}{X \vdash C_n, Y}}{X \vdash P_j, Y} \quad \frac{\frac{\frac{\vdots \pi_{L1}}{X, P_i \vdash Y} \quad \frac{\vdots \pi_{Ln}}{X, P_n \vdash Y}}{X \vdash P_i, Y} \quad \frac{\vdots \pi_{Lj}}{X, P_j \vdash Y}}{X \vdash Y} \text{PR} \quad \frac{X \vdash P_i, Y}{X, P_j \vdash Y} \text{PL}_2}{X \vdash Y} \text{Cut}}{\Rightarrow}$$

$$\frac{\frac{\frac{\vdots \pi_{Ri}}{X \vdash P_i, Y} \quad \frac{\vdots \pi_{Li}}{X, P_i \vdash Y}}{X \vdash Y} \text{Cut}}{\Rightarrow}$$

This holds because for each of our general rule forms if some formula B , on one of the left or the right, is a premise (parent) for introducing another formula A on the left [right], then A on the right [left] will be a premise (parent) for introducing B on the other of the left or the right.

The second case to consider is when the left and right instances of the cut formula are introduced via rules from different concept clusters, yet at least one of their parents are introduced via a rule from the same concept cluster as used to introduce the cut formula. Because this is an instance of introducing and eliminating a formula within the same concept cluster we apply LSC and cut on an instance of the cut formula in the same position but of a lower grade. Take our earlier example structure:

Figure B.1: Example Structure



Suppose we have the following instance of cut where each instance of the cut formula A are introduced via rules from different concept clusters.

If either of the derivations π_1 and π_2 end in a rule which belong to the same concept clusters as [AR] or [CL] respectively, then we can cut on the premises of that rule instead.

$$\begin{array}{c}
\begin{array}{c}
\vdots \pi_1 \quad \vdots \pi'_1 \\
\frac{X \vdash A, Y \quad X, D \vdash Y}{X \vdash C, Y} \text{CR} \\
\frac{X \vdash C, Y}{X \vdash A, Y} \text{AR} \\
\hline
X, B \vdash Y
\end{array}
\quad
\begin{array}{c}
\vdots \pi'_2 \\
\frac{X, A \vdash Y}{X, D \vdash Y} \text{DL}_1 \\
\frac{X, D \vdash Y}{X, A, B \vdash Y} \text{A,BL} \\
\hline
X, B \vdash Y
\end{array}
\quad
\text{Cut} \quad \Longrightarrow \quad
\begin{array}{c}
\vdots \pi_2 \\
\vdots \pi'_1 \quad \frac{X, A \vdash Y}{X, D \vdash Y} \text{DL}_1 \\
\frac{X \vdash A, Y \quad \frac{X, D \vdash Y}{X, A, B \vdash Y} \text{A,BL}}{X, B \vdash Y} \text{Cut}
\end{array} \\
\Longrightarrow \quad
\begin{array}{c}
\vdots \pi_1 \quad \vdots \pi'_1 \\
\frac{X \vdash A, Y \quad X, D \vdash Y}{X \vdash C, Y} \text{CR} \\
\frac{X \vdash C, Y}{X \vdash A, Y} \text{AR} \\
\hline
X \vdash Y
\end{array}
\quad
\begin{array}{c}
\vdots \pi'_2 \\
\frac{X, A \vdash Y}{X, B \vdash Y} \text{Cut} \\
\hline
X, B \vdash Y
\end{array}
\quad \text{KL}
\end{array}$$

In our last case, the parents of each instance of the cut formula are not introduced via rules within the same concept cluster as those used to introduce the cut formula. For example a case with A from the above structure again as the cut formula

$$\begin{array}{c}
\vdots \pi_1 \\
\frac{X \vdash F, Y}{X \vdash C, Y} \text{CR} \\
\frac{X \vdash C, Y}{X \vdash A, Y} \text{AR} \\
\hline
X, B \vdash Y
\end{array}
\quad
\begin{array}{c}
\vdots \pi_2 \\
\frac{X \vdash E, Y}{X, D \vdash Y} \text{DL}_2 \\
\frac{X, D \vdash Y}{X, A, B \vdash Y} \text{A,BL} \\
\hline
X, B \vdash Y
\end{array}
\quad \text{Cut}$$

We can eliminate cut in these instances by using two features of our general rules. The first is that if we can get from A on one of the left or the right, to B on one of the left of the right in n steps, then we can get from B on the other of the left or the right to A on the other of the left or the right in n steps. This is the result of the feature of our rules identified in our first case and our concept clusters being chained together, as represented by our trees. Because of this we can extend either of the derivations end-

ing in our cut formula by n steps to an endsequent containing one of the formulas n steps up the other derivations, but on the other side (right rather than left, left rather than right). Using the above example we could extend the derivation ending in $X \vdash A, Y$ so as to cut on E

$$\begin{array}{c}
 \vdots \\
 \vdots \pi_1 \\
 \frac{X \vdash F, Y}{X \vdash C, Y} \text{CR} \\
 \frac{\vdots \pi_2 \quad \frac{X \vdash A, Y}{X \vdash D} \text{AR} \quad B \vdash B}{X \vdash E, Y \quad \frac{X \vdash D}{X, E \vdash Y} \text{EL}_2} \text{DR} \\
 \frac{X \vdash E, Y \quad \frac{X \vdash D}{X, E \vdash Y} \text{EL}_2}{X \vdash Y} \text{Cut}
 \end{array}$$

Alternatively we could extend the derivation ending in $X, A, B \vdash Y$ so as to cut on F

$$\begin{array}{c}
 \vdots \\
 \vdots \pi_2 \\
 \frac{X \vdash E, Y}{X, D \vdash Y} \text{DL}_2 \\
 \frac{\vdots \pi_1 \quad \frac{X, A, B \vdash Y}{X, C, B \vdash Y} \text{A,BL}}{X \vdash F, Y \quad \frac{X, C, B \vdash Y}{X, F, B \vdash Y} \text{CL}_1} \text{FL}_1 \\
 \frac{X \vdash F, Y \quad \frac{X, C, B \vdash Y}{X, F, B \vdash Y} \text{FL}_1}{X, B \vdash Y} \text{Cut}
 \end{array}$$

In both cases the cut has the same grade as before, because in each case we have extended one derivation by n steps and shortened the other by n steps. The second feature we use is that all derivations must begin with an instance or instances of *Id*. So this process of extending one derivation and shortening another must at some point reach an instance of *Id*. We then appeal to the first condition on cut elimination, and eliminate the cut on *Id* directly.

B.3 Cut Elimination Theorem

Cut Elimination Theorem: Given a derivation in which the rule [Cut] is applied, we may effectively transform this derivation into one in which cut is not used.

Normally we here perform an induction based on the complexity of the cut formula S , where complexity or *grade* is equal to logical complexity of the formula (the number of logical symbols in it). This corresponds (in a cut free proof) to the number of logical inference rules used in deriving it. We instead formulate a measure of material complexity or grade. The idea is that the *material complexity* of a formula is the number of material rules used in deriving it.

- The grade γ of an instance of $Id = 0$
- The grade γ of an instance of a material rule = the sum of the grade of its parents.
- The grade γ of a cut formula = the sum of its left and right instances in the premise of the rule.

Our hypothesis is:

- *Cut on S :* If the premises of a Cut-rule in which an S is the Cut-formula are derivable, so is the conclusion.

We show that if Cut on S' holds for each ancestor of S then Cut on S holds for S also. Suppose we have an instance of cut:

$$\frac{\begin{array}{c} \vdots \\ \vdots \pi_1 \end{array} \quad \begin{array}{c} \vdots \\ \vdots \pi_2 \end{array}}{X \vdash S, Y \quad Z, S \vdash W} \text{Cut} \\ \hline X, Z \vdash W, Y$$

First we consider the cases where S is active. If either of π_1 or π_2 are instances of Id (i.e are beginnings of derivations) we apply condition 1. Cut/Identity to directly eliminate cut. Next, we consider the case where

the cut formula S is introduced via a rule. If it is weakened in we can also directly eliminate cut:

$$\frac{\frac{\frac{\vdots \pi_1}{X \vdash S, Y} \quad \frac{\frac{\vdots \pi_2}{Z \vdash W} \text{ #1.1}}{Z, S \vdash W} \text{ Cut}}{X, Z \vdash Y, W}}{\frac{\frac{\vdots \pi_2}{Z \vdash W} \text{ KL}}{X, Z \vdash W} \text{ KR}}{X, Z \vdash Y, W} \text{ KR} \Longrightarrow$$

If S is introduced via a material rule then we apply condition 6. Elimination of matching principal constituents. Each time we trade in a principal cut on S for a cut (or cuts) on its parents (ancestors) we reduce the material complexity (grade) of the cut formula. As we continue to push principal cuts upwards we will either hit on instance of *Id* in which case we can eliminate cut directly or a parametric cut.

Lastly, we consider the case where S is parametric. Take the class \mathbb{S} of occurrences of S in π_1 by tracing up π_1 and selecting each parametric instance of S which is in the same position as (congruent with) S in the conclusion of π_1 . We then use condition 2. Regularity and condition 4. Non-proliferation of parameters to push the cut upwards past each of the members of \mathbb{S} , cutting on (at least one of the premises/parents) of a principle instance of S . Non-proliferation of parameters ensures that all position-alike occurrences of S will be in \mathbb{S} and Regularity ensures that we can push the cut upwards in each case. What results is a proof where there are no more parametric cuts on members of \mathbb{S} , although there may be more principal cuts than before. We then do the same for the occurrences of the cut formula in π_2 . Again, what results may contain more instances of cut than before but all of which will be principal. We then apply the above method for eliminating principal cuts.

APPENDIX C

Limit Positions

Here we show the proofs for the limit position facts. The facts are numbered to follow from Restall's Fact 5 (see Chapter 2, Section 2.2). For the context of Fact 6 see Chapter 2, Section 3.5, for Fact 7 and the Subsententials Fact, see Section 4.4 for Fact 8 see Chapter 3, Section 4.3, and for Fact 9, see Chapter 4, Section 3.2.

C.1 Definitions

We reproduce Restall's limit position definitions:

POSITION Given a collection of sentences, with a consequent relation \vdash satisfying the rules of the classical sequent calculus, a pair $[X : Y]$ of sets of sentences is a *position* when $X \not\vdash Y$ (Restall 2009: p.,246).

LEFT AND RIGHT, IN A POSITION The **LEFT COMPONENT** of the position $[X : Y]$ is X . The **RIGHT COMPONENT** is Y . These are the formulas explicitly on the left and in the right, respectively. We say that A is to **TO THE LEFT** of $[X : Y]$ if and only if $X \vdash A, Y$. A is to **THE RIGHT OF** $[X : Y]$ if and only if $X, A \vdash Y$ (Restall 2009: p.,247).

EXTENSION OF POSITIONS $[X' : Y']$ extends $[X : Y]$ if every formula in X is in X' , and every formula in Y is in Y' (Restall 2009: p.,248).

LIMIT POSITIONS Given a language \mathcal{L} , a LIMIT POSITION is a pair $[\mathfrak{X} : \mathfrak{Y}]$ of sets of sentences such that (a) whenever $X \subset \mathfrak{X}$ and $Y \subset \mathfrak{Y}$ are finite sets of formulas, $[X : Y]$ is a position, and (b) $\mathfrak{X} \cup \mathfrak{Y} = \mathcal{L}$ (Restall 2009: p.,249).

C.2 Proof of Fact 6

Given these and our general rules, Fact 6. follows:

FACT 6: For any limit position LP

- (i) A parent P_i is to the left of LP iff all its children $C_1 \dots C_n$ are to the left of LP and all other parents $P_j \dots P_{n-i}$ are to the right of LP .
- (i') A parent P_i is to the right of LP iff either some child C_i is to the right of LP or some other parent P_j is to the left of LP .
- (ii) A child C is to the left of LP iff a parent P is to the left of LP .
- (ii') A child C is to the right of LP iff all its parents $P_1 \dots P_n$ are to the right of LP .

Proof:

For (i), $X \vdash P_i$ iff $X \vdash C_1, Y \dots X \vdash C_n, Y$ and $X, P_i \vdash Y \dots X, P_{n-j} \vdash Y$.

Left to right follows from [CR] and [PL₂].

Right to left follows from [PR]. This is local soundness and completeness for P on the right.

For (i'), $X, P_i \vdash Y$ iff either $X, C_i \vdash Y$ or $X, \vdash P_j, Y$.

Left to right. Suppose P_i is on the right. If no child C_i is on the right, then all children C_1, \dots, C_n are on the left. I.e $X \vdash C_1, Y \dots X \vdash C_n, Y$. If no other parent P_j is to the left, then all other parents $P_j, \dots, P_n - i$ are to the right. I.e $X, P_j \vdash Y \dots X, P_n - i \vdash Y$. But if this is the case, then via [PR] $X \vdash P_i, Y$. But then P_i would be on both the left and the right. So either one child C_i is on the right or one other parent P_j is on the left.

Right to left. This follows via local soundness and completeness from the other direction. For the first case, suppose some child C_i is on the right. If P_i is not on the right, then $X \vdash P_i$. Next via [CR] we have $X \vdash C_i$. But

then C_i is on both the left and the right, which can't be. So P_i isn't on the left, which means it's on the right. For the second case, suppose another parent P_j is on the left. Then $X \vdash P_j$. If P_i is not on the right, then it is on the left. I.e $X \vdash P_i$. But from $X \vdash P_j$ via $[PL_2]$ we have $X, P_i \vdash Y$. But then P_i is on both the left and the right, which it can't be. So P_i must be on the right.

For (ii), $X \vdash C_i$ iff $X \vdash P_i$.

Left to right. Suppose C_i is on the left. If no parent P_i is on the left, then each parent P_1, \dots, P_n must be on the right. I.e $X, P_1 \vdash Y \dots X, P_n \vdash Y$. But then via $[CL]$ $X, C_1, \dots, C_n \vdash Y$. This means that C_i is on the right, which it can't be while also being on the left. So some parent P_i must on the left.

Right to left. Suppose that some parent P_i is on the left. If C_i isn't on the left, then it's on the right. I.e $X, C_i \vdash Y$. From weakening we derive $X, C_1, \dots, C_n \vdash Y$ and then apply $[PL_1]$ resulting in $X, P_i \vdash Y$. But then P_i is on the right, which it can't be while also being on the left. So C_i must be on the right.

For (ii'), $X, C_i \vdash Y$ iff $X, P_1 \vdash Y \dots X, P_n \vdash Y$.

Left to right. Suppose C_i is on the right. If every parent P_1, \dots, P_n isn't on the right, then at least one is on the left. So, for some parent $X \vdash P_i, Y$. But if so, then via $[CR]$ $X \vdash C_i, Y$. This would mean that C_i were on the left, which it can't be while also being on the right. So each parent P_1, \dots, P_n must be on the right.

Right to left. Suppose every parent P_1, \dots, P_n is to the right. I.e $X, P_1 \vdash Y \dots X, P_n \vdash Y$. Then via $[CL]$ $X, C_1, \dots, C_n \vdash Y$. So not every child can be to the left. Suppose some child C_j is to the left, then $X \vdash C_j, Y$. But from (ii) above we saw that if a child is to the left then some parent is to the left. But all parents are to the right. So C_j can't be to the left. Therefore, it's to the right. C_j was arbitrary and so all children, including C_i must be to the right.

C.3 Proof of Fact 7 and Subsentials Fact

FACT 7

- (i) For symmetric concept clusters, if the parent [child] is to one of the left or the right, then the child [parent] is the same.

Proof: FACT 7 follows from FACT 6. In a symmetric concept cluster there is only one parent and one child. (i), (ii), (iii), and (iv) of FACT 6 become:

- (i) The parent P is in the left iff the child C is on the left;
 (i') The parent P is the right iff the child C is on the right;
 (ii) The child C is on the left iff the parent P is on the left;
 (ii') The child C is on the right iff the parent P is on the right.

Here (i) and (ii) merely swap the order of the biconditional, as with (i') and (ii'). These taken together are just what FACT 7 (i) says.

Subsentials Fact

- (i) For any two names α and β which share a concept cluster, $v(\alpha) = v(\beta)$;
 (ii) For any predicates F and G , if F is a parent of G , then $v(F) \subseteq v(G)$. If these are members of an upwards branching cluster then $v(F) \subset v(G)$.

Proof: The Subsentials Fact follows from facts 6 and 7, along with our restrictions on a model theoretical valuation function v :

1. For any two names α and β , if whenever $\Phi\alpha$ is to the left [right] $\Phi\beta$ is also, then $v(\alpha) = v(\beta)$;
2. For any predicate F if Fa is on the left [right] then $v(a) \in v(F)$ [$v(a) \notin v(F)$];

For (i), it follows from FACT 7 that if α and β share a concept cluster then α is on the right [left] iff β is also. From restriction (1), then $v(\alpha) = v(\beta)$.

For (ii), if $v(F) \not\subseteq v(G)$ then $\exists x, x \in F \wedge x \notin G$. It follows from FACT 6, that if F is a parent of G , then whenever Ga is on the right, then so is Fa . Remember that for any finite language L , we define limit positions relative to its (possibly) infinite extension L_+ where every object has a name. The second restriction then becomes a biconditional, meaning that membership of the extension of a predicate always corresponds to some sentence being on the left. Therefore if $v(a) \notin v(G)$ then $v(a) \notin v(F)$ and $\neg \exists x, x \in F \wedge x \notin G$. So $v(F) \subseteq v(G)$. In the case where F and G are part of an upwards branching cluster, then G may be on the left without F being so also. So $v(F) \subset v(G)$.

C.4 Proof of Fact 8

FACT 8: For any contextual mixed position CMP:

- (i) A contextual declarative $D_{\langle a,b \rangle}$ is to the left [right] iff all of its contextual variants are.
- (ii) A contextual imperative $I_{\langle a,b \rangle}$ is to the left [right] iff all of its speaker variants are.

Proof of (i). Left to right. Suppose $D_{\langle a,b \rangle}$ is on the left of some contextual mixed limit position CLP. Then $X \vdash D_{\langle a,b \rangle}, Y$. We then apply the [1stR] deriving $X \vdash D_{\langle c,b \rangle}, Y$ for some arbitrary c . This speaker contextual variant is therefore also to the left and because c was arbitrary so is any speaker contextual variant. We then apply [2ndR] to our first contextual variant on the left, deriving $X \vdash D_{\langle a,c \rangle}, Y$. Therefore this addressee contextual variant is also to the left and because c was arbitrary so is any addressee variant. We could also do the same to any speaker variant. Thus any contextual variant which is speaker and an addressee variant is also to the left. Any variant is either a speaker or addressee variant. So any variant is also to the left.

Right to left. Suppose some contextual variant of $D_{\langle a,b \rangle}, D_{\langle c,d \rangle}$ is to the left. Therefore $X \vdash D_{\langle c,d \rangle}, Y$. We first apply [1stR] deriving $X \vdash D_{\langle a,d \rangle}, Y$.

Then we apply [2ndR] deriving $X \vdash D_{\langle a,b \rangle}, Y$. Therefore, $D_{\langle a,b \rangle}$ is also to the left.

The proof for being on the right is the same however using the L rules.

Proof of (ii). The same as proof of (i) however only using the 1st rules.

C.5 Proof of Fact 9

Fact 9: Compliant Extensions

For all compliant limit positions $X : Y$, if $v(t_{\geq 0}, \dots, t_n) \in v(\mathcal{P}_{\langle a,b \rangle})$, then $\forall x \forall y, v(b, t_{\geq 0}, \dots, t_n) \in v(P_{\langle x,y \rangle})$.

Proof: Fact 9 follows from Fact 8, the restrictions on model-theoretic v , and the definition of compliance.

Complicance A position $X : Y$ is compliant iff $\forall \mathcal{P}(t_{\geq 0}, \dots, t_n)_{\langle a,b \rangle}$ whenever $\mathcal{P}(t_{\geq 0}, \dots, t_n)_{\langle a,b \rangle} \in X [\in Y]$, then $P(b, t_{\geq 0}, \dots, t_n)_{\langle a,b \rangle} \in X [\in Y]$.

Suppose for a compliant limit position $X : Y$, $v(t_{\geq 0}, \dots, t_n) \in v(\mathcal{P}_{\langle a,b \rangle})$. Then from our second restriction on v , the imperative $\mathcal{P}(t_{\geq 0}, \dots, t_n)_{\langle a,b \rangle}$ is to the left. For if it were not on the left, i.e on the right, then $v(t_{\geq 0}, \dots, t_n) \notin v(\mathcal{P}_{\langle a,b \rangle})$. From $X : Y$ being compliant, the declarative $P(b, t_{\geq 0}, \dots, t_n)_{\langle a,b \rangle}$ is also to the left. Again from the second restriction on v , $v(b, t_{\geq 0}, \dots, t_n) \in v(P_{\langle a,b \rangle})$. From Fact 8 (i), any contextual variant of $P(b, t_{\geq 0}, \dots, t_n)_{\langle a,b \rangle}$ is also to the left. So from the second restriction on $v, \forall x \forall y, v(b, t_{\geq 0}, \dots, t_n) \in v(P_{\langle x,y \rangle})$.

APPENDIX D

Sequent Rules and Semantic Restrictions

This appendix is a reference for all the sequent rules and restrictions on (sub)atomic systems.

D.1 Sequent Rules

Figure D.1: Structural Rules

$$\begin{array}{cc} \frac{}{\phi \vdash \phi} \text{Id} & \frac{\Gamma \vdash \phi, \Sigma \quad \Gamma, \phi \vdash \Sigma}{\Gamma \vdash \Sigma} \text{Cut} \\ \frac{\Gamma \vdash \Sigma}{\Gamma \vdash \phi, \Sigma} \text{KR} & \frac{\Gamma \vdash \Sigma}{\Gamma, \phi \vdash \Sigma} \text{KL} \\ \frac{\Gamma \vdash \phi, \phi, \Sigma}{\Gamma \vdash \phi, \Sigma} \text{WR} & \frac{\Gamma, \phi, \phi \vdash \Sigma}{\Gamma, \phi \vdash \Sigma} \text{WL} \end{array}$$

Figure D.2: Connective Rules

$$\begin{array}{c}
\frac{\Gamma \vdash \phi, \Sigma \quad \Gamma \vdash \psi, \Sigma}{\Gamma \vdash \phi \wedge \psi, \Sigma} \wedge R \quad \frac{\Gamma, \phi \vdash \Sigma}{\Gamma, \phi \wedge \psi \vdash \Sigma} \wedge L_1 \quad \frac{\Gamma, \psi \vdash \Sigma}{\Gamma, \phi \wedge \psi \vdash \Sigma} \wedge L_2 \\
\\
\frac{\Gamma \vdash \phi, \Sigma}{\Gamma \vdash \phi \vee \psi, \Sigma} \vee R_1 \quad \frac{\Gamma \vdash \psi, \Sigma}{\Gamma \vdash \phi \vee \psi, \Sigma} \vee R_2 \quad \frac{\Gamma, \phi \vdash \Sigma \quad \Gamma, \psi \vdash \Sigma}{\Gamma, \phi \vee \psi \vdash \Sigma} \vee L \\
\\
\frac{\Gamma \vdash \phi, \Sigma}{\Gamma, \neg \phi \vdash \Sigma} \neg R \quad \frac{\Gamma, \phi \vdash \Sigma}{\Gamma \vdash \neg \phi, \Sigma} \neg R
\end{array}$$

Figure D.3: General Material Rules

(i) First Rules

$$\frac{X \vdash P_i, Y}{X \vdash C_i, Y} CR$$

$$\frac{X, C_1, \dots, C_n \vdash Y}{X, P_i \vdash Y} PL_1 \quad \frac{X \vdash P_i, Y}{X, P_j \vdash Y} PL_2$$

(ii) Second Rules

$$\frac{X, P_1 \vdash Y \quad \dots \quad X, P_n \vdash Y}{X, C_1, \dots, C_n \vdash Y} CL$$

$$\frac{X \vdash C_1, Y \quad \dots \quad X \vdash C_n, Y \quad X, P_i \vdash Y \quad \dots \quad X, P_n \vdash Y}{X \vdash P_j, Y} PR$$

Figure D.4: Identity Rules

(i) Subsentential Identity

$$\frac{}{\Phi \alpha \vdash \Phi \alpha} Id_s$$

(ii) Contextual Identity

$$\frac{}{S_{\langle a, b \rangle} \vdash S_{\langle a, b \rangle}} Id_c$$

Figure D.5: Perspective Shifting Rules

$$\frac{X, S_{\langle a,b \rangle} \vdash Y}{X, S_{\langle c,b \rangle} \vdash Y} \text{1stL} \quad \frac{X \vdash S_{\langle a,b \rangle}, Y}{X \vdash S_{\langle c,b \rangle}, Y} \text{1stR}$$

$$\frac{X, S_{\langle a,b \rangle} \vdash Y}{X, S_{\langle a,c \rangle} \vdash Y} \text{2ndL} \quad \frac{X \vdash S_{\langle a,b \rangle}, Y}{X \vdash S_{\langle c,b \rangle}, Y} \text{2ndR}$$

Figure D.6: Marked Imperatives

$$\frac{\Gamma, \phi_{\langle a,b \rangle} \vdash \Sigma}{\Gamma, b(\phi)_{\langle a,b \rangle} \vdash \Sigma} \text{markL} \quad \frac{\Gamma \vdash \phi_{\langle a,b \rangle}, \Sigma}{\Gamma \vdash b(\phi)_{\langle a,b \rangle}, \Sigma} \text{markR}$$

D.2 Restrictions on (Sub)Atomic Systems

D.2.1 System Definitions

Atomic System An atomic system is a triple of a language $[\mathcal{L}]$ made up of atomic propositions, a set of substitution rules $[R]$, and an assignment function $[v]: \{\mathcal{L}, R, v\}$.

Subatomic System An atomic system is a triple of a language $[\mathcal{L}]$ made up of names, n-place predicates, and sentences of the form $\langle P_n(t_1, \dots, t_n) \rangle$, a set of substitution rules $[R]$, and an assignment function $[v]: \{\mathcal{L}, R, v\}$.

Contextual System A contextual system is either an atomic or subatomic system, where the language $[\mathcal{L}]$ is extended with speaker-addressee contexts $\langle a, b \rangle$ such that each sentence S is assigned a context to form the contextual sentence $S_{\langle a,b \rangle}$.

D.2.2 Semantic Restrictions

LSC The rules for each concept cluster are instances of the general rule forms.

Symmetry For names, each concept cluster has only one parent and one child.

Identity Each name in the language is assigned an instance of the identity axiom Id_s (or Id_c for contextual systems).

Compositionality For sentences, rules are assigned by substituting the predicate of the sentence into the rules for its names and names into the rules for its parents.

Agent Neutrality and Relativity Declarative sentences are assigned both pairs of perspective shifting rules. Imperative sentences are only assigned the first.

Uniformity of Meaning Predicates are assigned the same inference rules regardless of type.

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