

Discourse and Logical Form[†]

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Abstract:

We develop an original account of reference resolution for demonstrative pronouns that formally precisifies interdependences between the mechanisms structuring a discourse context and reference resolution. We argue that these mechanisms, contrary to the central claims of received views in broadly *Kaplanian* tradition, are linguistic in nature and grammaticized, and as such should be independently represented at the level of logical form. Once these systematic linguistic contributions are recognized, we will be able to characterize the meaning of a demonstrative pronoun, like ‘he’, such that, much like with pure indexicals, like ‘I’, its reference is straightforwardly determined as a function of linguistic context. We will argue that the resulting view is superior to its competitors in several respects. It recognizes and renders transparent certain linguistic mechanisms typically left implicit, or confused with pragmatic processes; and consequently, since our view treats the reference of a demonstrative pronoun purely as a function of context, it avoids ascribing ambiguity to seemingly unambiguous expressions, like the English demonstrative ‘he’.

0) Introduction: ‘He’ and ‘I’

A simple story about the English word ‘he’ would assign it a uniform, unambiguous linguistic meaning. After all, ‘he’ doesn’t seem to be ambiguous in the way, for example, that ‘bank’ is. But, on the other hand, its different uses can refer to different individuals. Uttered pointing at Bill, it refers to Bill; pointing at Sam, it refers to Sam. Obviously, its linguistic meaning plays some role in determining these referents, but which exactly? A straightforward answer would be that its linguistic meaning fully determines its referent in any given context; so construed the referent of ‘he’ is determined as a function of context. In effect, this suggestion treats ‘he’ much like ‘I’ (assuming the received view about ‘I’); its referent would be completely determined by linguistic rules governing its usage. Just as the referent of ‘I’ is always set by a particular feature of its context of use, namely, the speaker, so too, the referent of ‘he’ would always be set by a particular feature of its context of use. As neat as this suggestion is, the received view is that ‘he’ differs from ‘I’ inasmuch as its referent on an occasion of use is not determined exclusively by its linguistic meaning but

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rather must be supplemented by some sort of cue – typically, an accompanying demonstration and/or an appropriate speaker’s intention (Kaplan, 1989).¹ These supplementary mechanisms are understood to be extra-linguistic, or pragmatic cues, and so, not linguistically encoded.

In this paper, we will argue against the received view. For one, we will argue that ‘he’ and ‘I’ work in analogous ways; in particular, there are specific features of context that, for any given context of use, fix the referent of ‘he’ in that context. Moreover, even though we agree that reference resolution for a demonstrative pronoun, like ‘he’, requires that there be mechanisms supplementary to its linguistic meaning, we will argue that the received view is wrong both about the nature and about the role of these mechanisms. They are linguistic in nature: they take the form of linguistic rules that affect the values of relevant parameters of the context, which subsequent pronouns can pick up. Therefore, the referent of a demonstrative pronoun on an occasion of use is fully determined by rules of language.

We begin with some data.

1. A man walked in. He sat down. Therefore, some man sat down.
2. Phil tickled Stanley, and Liz poked him.²

Reference resolution for the pronouns in (1)–(2) is not an open-ended, unconstrained process. Though more than one interpretation is available in advance, we can point to reasons why certain are, and others are not, naturally recovered by English speakers in context. With (1), if ‘he’ is being used in the flow of a continuing narrative about a single person, it gets resolved to that person. However, if it’s being used in tandem with an accompanying pointing gesture, say, to a small child Bill, then its reference gets resolved to that child, namely, Bill. (Note that only on the first reading does the inference to the third sentence – that some man came in and sat down – go through.) With (2), if the second clause is describing the result of the event described by the first, its pronoun is resolved to Phil; but if (2) is comparing and contrasting Liz’s and Phil’s actions, then ‘him’ is resolved to Stanley. What is important to observe in these cases is that pronoun resolution is guided by interdependences that structure the flow of information. It is because the pronoun in (1) (on its anaphoric reading) occurs in the flow of a continuing narrative about a particular person, that its pronoun is resolved to that person; similarly, when the pronoun in (1) (on its deictic reading) occurs with an accompanying demonstration the pronoun is resolved to the object demonstrated.

In what follows, we will develop an original account that formally precisifies interdependences between the mechanisms structuring a discourse and reference

¹ Kaplan (1989) draws a distinction between ‘pure indexicals’ and ‘true demonstratives’. Expressions like ‘I’, whose reference in a context is fully determined by linguistic meaning, fall into the first class, while expressions whose linguistic meaning requires supplementation for the reference to be fixed given in a context, fall into the second class. Demonstratives like ‘he’, ‘she’ or ‘that’ according to him, and the subsequent literature all fall into the class of true demonstratives.

² Example (2) is from Kertz, Kehler & Elman (2008).

resolution for demonstrative pronouns. We will argue that these mechanisms are linguistic and grammaticized, and as such should be independently represented at the level of logical form (LF). Once these systematic contributions are recognized, we will be able to characterize the meaning of a demonstrative pronoun, like ‘he’, such that, much like with ‘I’, its reference is straightforwardly determined as a function of context. We will argue that the resulting view is superior to its competitors in several respects. It recognizes and renders transparent certain linguistic mechanisms typically left implicit, or confused with pragmatic processes; consequently, since it treats the reference of a demonstrative pronoun as a function of context, it avoids ascribing ambiguity to seemingly unambiguous expressions, like the English demonstrative ‘he’.

1) Attention

We call our approach the Attention-Coherence Approach. We begin with its attention component.

We suggest that pronouns, as a matter of meaning, always refer to the most prominent entity – the one ‘in the center of attention’. The idea is to model the relative prominence of candidate referents as a feature of context. The rule governing the use of the pronoun then automatically determines its referent, given the context – namely, it automatically picks out the most prominent candidate referent. Thus, intuitively, as a first pass, given its linguistic meaning, ‘he’ always denotes the most prominent candidate referent. We will take this idea quite seriously, and (with certain refinements) render it formally precise.

To start, we propose a model of the relative prominence of candidate referents by borrowing resources from centering theories (Sidner, 1983; Grosz, Joshi, & Weinstein, 1995; Bittner, forthcoming). These theories hypothesize that the referential candidates in discourse are ranked according to their relative prominence, so that those higher in the ranking are preferred over those lower as interpretations for pronouns. In this section, we sketch how a Dynamic Semantics approach to context can exploit these rankings in order to assign intuitively correct truth conditions to discourses, and to assign transparently uniform formal representations for pronouns.³

Following Dekker (1994) and Bittner (forthcoming), discourses, like (1)–(2), are interpreted by updates that track and affect the prominence ranking of candidate referents. Somewhat more precisely, we understand the context as representing the attentional state of an ongoing discourse; formally, a context is a sequence of individuals, ordered by their relative prominence, where the most prominent entity is intuitively understood to be at the center of attention. The meaning of utterances is represented by updates that change the attentional state of the discourse, where an update is interpreted as a relation between an input context and possible output contexts that can be obtained by incorporating the

³ We employ a dynamic semantic framework partly because it offers the most straightforward way of modeling data that interest us.

changes in information and attention that an utterance contributes.⁴ The basic idea is that an update tracks attention focus and attention shifts in an ongoing discourse.⁵ We will assume that for any position in the prominence ranking i , we have a variable x_i – the so called *discourse referent*, for short – that takes the i -th element of the prominence ranking as its value. We let the most prominent (‘top’) discourse referent, intuitively, correspond to the center of attention. We use the symbol, ‘@’, to denote this top discourse referent (the mnemonic is that ‘@’ is at the center of attention). A formula like ‘[man(@)]’, then, says ‘The discourse referent at the center of attention is a man’. Changes in attention occur systematically in tandem with updates, and are triggered by the introduction of discourse referents. Next, we posit an update ‘ $\langle \alpha \rangle$ ’ (named for, and corresponding to, the English indefinite article); it introduces a new top discourse referent, and pushes all the other referential candidates down one position in the ordering. The formula ‘ $\langle \alpha \rangle$; [man(@)]’, then, says ‘Introduce a new discourse referent at the center of attention; this discourse referent is a man.’ In other words, conventionally, indefinites shift attention focus, and update the center of attention, by introducing a new top-ranked referent.

Given this set-up, we can formally represent (1), on its anaphoric interpretation, as (3):

- $$\begin{array}{l} 3. \langle \alpha \rangle; [\text{man}(@)]; [\text{walk.in}(@)]; [\text{sit.down}(@)] \\ \quad \therefore \langle \alpha \rangle; [\text{man}(@)]; [\text{sit.down}(@)] \end{array}$$

The first line in (3), corresponding to the first two sentences in (1), instructs us to introduce a new, top-ranked discourse referent, constrained to be a man, to have walked in, and—then being picked up by an anaphoric pronoun—to have sat down. In dynamic semantics, this interpretation is true if, and only if, some man walked in and sat down. The second line in (3), corresponding to the third sentence in (1), instructs us to introduce a new top-ranked discourse referent, constrained to be a man and to have sat down. In dynamic semantics, this interpretation is true if, and only if, some man sat down. Observe that whenever the two premises describe a possible update, the conclusion does as well. In other words, the conclusion of the argument preserves the dynamic notion of truth in a

⁴ More precisely we can represent a context by an assignment function. An update is then understood as a relation between contexts. An update is true in a given context iff the input context is related to some output context by the update relation. The simplest update can contribute information contributed by some condition C . Those updates are written ‘[C]’ and are interpreted as partial identity relations between contexts. So if g is an input context, and h an output context, [C](g, h) if and only if $g=h$ and the condition C is true on the interpretation of variables given by g . In a standard fashion a sequence of updates H and K is represented by a single update $H ; K$ that performs the update H followed by K . In addition to the simplest updates, we also need updates that affect the prominence ranking of the candidate referents in the context. We introduce these presently. For a detailed exposition of our formal system, see the Formal Appendix.

⁵ For a systematic formal development of this idea as a framework for handling anaphoric relations see Bittner (forthcoming). Our approach is in the spirit of Bittner’s framework, but crucially different. We introduce updates that correspond to implicit shifts in attention. Furthermore, we have a very different take on the conventionality of different attention-shifting mechanisms, pointing to their essentially linguistic nature.

context. Thus, (3) represents (1) as a valid inference.⁶ (In fact, the inference is preserved, if all non-functional words are systematically replaced, and so, is valid as a matter of the logical form.) What, though, are we to do about the deictic reading of (1)?

Suppose (1) were uttered, while pointing at a small child, Bill, as in (4):

4. A man came in. He [pointing to a small child, Bill] sat down.

The problem is that if indefinites introduce a top-ranked discourse referent and if the pronoun picks out this discourse referent, then why doesn't 'he' pick out the man introduced in the first sentence? The correct response is that in (1 on the reading elaborated in 4) there is another shift in attention —one updating the context so that the discourse referent for Bill becomes the top-ranked discourse referent. It is prompted by the pointing gesture that accompanies the utterance of the pronoun. Since this change of attention affects interpretation, it should be reflected in LF.

To this end, we introduce a family of updates, written ' $\langle \pi c \rangle$ ', where ' π ' corresponds to the act of pointing and ' c ' to the individual being pointed at. This update stores the individual named by ' c ' as the value of the top-ranked discourse referent, and (as always) pushes all other referents down one position deeper in the ordering. It thereby represents the effect of pointing in tandem with the use of the pronoun. Letting ' b ' stand for Bill, the demonstrated child, (1/4) is, then, represented formally as (5):

5. $\langle \alpha \rangle$; [man(@)]; [walk.in(@)]; $\langle \pi b \rangle$; [sit.down(@)]
∴ $\langle \alpha \rangle$; [man(@)]; [sit.down(@)]

(5) represents the pronoun in (1/4) with '@'. The pronoun refers to Bill, because it occurs immediately after the update ' $\langle \pi b \rangle$ ', which corresponds to a pointing act, thus rendering Bill as the value of the most prominent discourse referent. On this reading, the inference in (1/4) is not valid: the discourse corresponding to its first two sentences is true if, and only if, some man came in and Bill sat down; the representation of its third sentence instructs us to introduce a new top-ranked discourse referent, constrained to be a man and to have sat down, and this is true if, and only if, some man sat down.

Traditionally, the shift in attention focus provoked by the pointing gesture accompanying an utterance (1/4) is treated as a result of a pragmatic process: the hearer comes to recognize the speaker's referential intention, by exploiting the epistemic cue provided by the speaker's pointing gesture, and this recognition thereby raises a new referent to salience. Crucially, the pointing gesture, although supplementing the incomplete linguistic meaning of a demonstrative, and thereby helping to fix the reference, is not understood as a part of the linguistic repertoire, but rather as an extra-linguistic cue which constraints the pragmatic interpretation of a speaker's utterance. We, however, are denying that understanding a gesture is a matter of constraining or guiding the *pragmatic* interpretation

⁶ See Dekker (2011; 2004) for more on validity in Dynamic Semantics.

of a speaker's words. Instead, on our account, the gestures that secure demonstrative reference for pronouns in cases like (1/4) are integral to the linguistic utterance itself; and so, are distinctively linguistic. Rules of language dictate, as a matter of linguistic meaning, that a demonstrative act of pointing introduces its referent at the top of the stack. In particular, this utterance of (1/4) includes the action of pointing at Bill and it contributes to logical form and meaning, in a way governed by knowledge of language.⁷

This is not to say context plays no role whatsoever in interpreting an utterance of (1/4). According to us, context interacts with gesture, given an utterance of (1/4), to determine *the form* of the demonstration. This contribution, much like quotation, is transparently determined by form: just as a quotation of a name must refer to that name,⁸ so too a demonstrative used while pointing at something must refer to whatever is being pointed at.⁹

This treatment of deixis is particularly appealing since our non-verbal means of indicating an entity are governed by linguistic rules sensitive to form, meaning, and the relationship with ongoing speech (Kendon, 2004). For example, English speakers seem to count deixis as well-formed only when the pointing action is synchronized in an appropriate way with the prosody of the accompanying utterance. As Kendon illustrates, English speakers often repair utterances when their performance fails to align speech and gesture in time. In addition, Kendon observes that although English speakers can use a range of hand shapes when they indicate an object, their particular choice affects the semantic contribution they intend to make by reference to the object. For example, a gesture with the index finger and thumb extended and the other fingers curled closed uses the direction of the index finger to single out an object as an individual distinct from its alternatives. By contrast, a gesture with a flat hand open toward the audience, its four fingers extended in a tight line, uses the direction of the fingers to exhibit an object as a representative of a broader class. Other possible indicating gestures are not part of the repertoire of English: English speakers use the thumb in the “thumbs up” hand shape, with the thumb extended from a tight fist, to demonstrate movement in the direction that the thumb points, but normally not to demonstrate an object located in that direction. Numerous languages, unlike English, allow speakers to indicate objects by deictic gestures of the lips (such as Cuna, a language spoken

⁷ For an example of a grammar integrating gesture and speech in this way, see Lascarides et al (2011).

⁸ See (Cappelen and Lepore, 2007).

⁹ This is why we represent the pointing gesture as an *act of pointing at Bill*. Crucially, the context *only* serves the function of determining *the form* of the pointing gesture. It is important to note that because we believe (1/4) contains a contextually determined action of pointing at Bill, and not an action of pointing with a context-sensitive interpretation, we deny there is a uniform character of pointing that the LF needs to capture. Rather, pointings are ambiguous, if you like. A gesture *can* target any concrete object if the situation presents that object in the right way. Context only serves the function of disambiguating between, say, an act of pointing at Bill, an act of pointing at Bill's shirt, an act of pointing at Bill's button, etc. This is quite a different role than the role context plays in determining the content of a context-sensitive expression.

in Panama) (Wilkins, 2003).¹⁰

Further, in typical cases, these acts are indispensable. In cases such as (1/4), where linguistically introduced candidate antecedents to the pronoun are available, explicit signaling of a shift of attention is necessary even to refer to a particularly salient individual in the situation of utterance; otherwise, grammar seems to commit the speaker to an anaphoric reading of the pronoun. For example, even if Bill is jumping up and down in the faces of all the interlocutors, unless there is an overt signal that establishes Bill as the referent of 'he', the audience will prefer the default anaphoric reading. Some means of explicit signaling of a shift of attention seems to be required even when a linguistic antecedent is unavailable, such as when a pronoun is used deictically in an utterance that initiates a new conversation.¹¹

To sum up: there are reasons to treat the effect of an attention shift as a part of the linguistic contribution of an indefinite NP, or as a *bona fide* linguistic contribution of an act of demonstration. Further, this picture captures the relevant desiderata, namely, only (1/3) but not (1/4/5), underwrites the inference from its first two sentences to its third. And this is accomplished all while assigning a single linguistic meaning to its pronoun, one that fully determines its reference in any given context – pronouns pick out the most prominent referent, the one at the center of attention. Accordingly, the contribution of a pronoun is, basically, that of its character ('top discourse referent').

2) Refinements

With these ideas in place, refinements are in order. Obviously, the idea that, for example, 'he', as a matter of its linguistic meaning, denotes the most prominent discourse referent, though on the right track, isn't quite right. 'He' in (6) cannot be interpreted as denoting the discourse referent introduced by 'a girl', because 'he' requires its referent to be a male.

6. A girl came in. He sat down.

But on the view we've sketched so far, nothing rules out the pronoun in (6) having both an anaphoric and a deictic interpretation, even if the only available one is deictic.

Similarly, 'she' in (7) cannot be interpreted as denoting the plural referent established by 'some girls', because 'she' requires a singular referent.

¹⁰ Sarah Murray (pc.) pointed out to us that similar phenomenon is observed in Cheyenne.

¹¹As we will argue below, grammar specifies a diverse set of resources for raising entities to prominence. Our formalism is expressive enough to make such resources available even for utterances that do not (merely) follow up an ongoing discourse. The precise prediction of our view is therefore not that deixis without demonstration is impossible discourse initially, but that it succeeds only for utterances that recognizably accomplish acts that independently require construing the referent as the center of attention in the current state of the ongoing discourse. For more detailed account of deixis without overt accompanying demonstrative gestures, see our "Deixis (Even Without Pointing)" (Stojnic, Stone, & Lepore, forthcoming).

7. Some girls came in. She sat down.

'We' and 'they' in (8) cannot be interpreted as co-referential; 'they' requires a referent that's disjoint from speaker and addressee, and 'we' includes the speaker.

8. We came in. They sat down.

A simple explanation for these data is, of course, that pronouns come with specific person, gender and number requirements that must be satisfied in the process of reference resolution. Furthermore, these requirements are a matter of the linguistic meaning of pronouns.¹² These modifications are unsurprising. It matters whether the speaker utters 'he' or 'she' or 'they'; and it matters precisely because they differ in meaning.¹³

Further, in (9), 'him' cannot refer to Paul, even though Paul would normally be an eligible referent for 'him' (satisfying the person, gender and number requirement).

9. Paul met him.

The usual explanation for this failure is that reference is constrained by syntactic principles—in this case, Condition B of Chomsky's (1981) Binding Theory, which requires non-reflexive pronouns to be free in their governing category.¹⁴ In general, a pronoun denotes the highest-ranked discourse referent whose value respects any specified

¹² Of course, we acknowledge that it can sometimes happen that the speaker uses the third person pronoun '(s)he' to refer to the speaker. Witness a Perry-type scenario (Perry, 1979.), where the speaker seeing, but not recognizing, himself in the mirror says, "He is the messy shopper". This case is arguably marked. (To take another example, consider a piece of discourse whereby the speaker is distancing himself from his earlier self, as in the following: "That day a boy was born. He was named John. That boy was me.") In these cases, it is the exploitation of the existing rule that makes for the surprising effect. These cases can be accommodated by having one and the same object represented by distinct discourse referents (see Cumming, forthcoming). Note also that we do not discuss here the appropriate treatment of the first person singular pronoun "I" and the second person pronoun "you". One way to approach this issue is to reserve a particular position on the list of salient referents for the speaker, and the addressee respectively, analogous to the treatment of subject and (in)direct object we offer below. (For a related treatment see Bittner (2012; forthcoming).) One might then argue that each utterance appropriately updates the stored value for the speaker and the addressee. "I" comes with the requirement that its referent be identical to the speaker, whereas roughly the meaning of "you" would require its referent be the addressee. This would also account for the differences in the representation between 'I' and 'he'.

¹³ This is true, regardless of the question whether a speaker can in some circumstance manage to 'speaker-refer', in the sense of Kripke (1977), to a woman with the pronoun 'he' (or a definite 'that man').

¹⁴ This basically amounts to saying that the antecedent of an anaphoric pronoun must not be local or c-command the pronoun – a non-reflexive pronoun must not be bound in its local domain. By contrast, a reflexive pronoun *must* have a local antecedent, according to the Condition A; so, *e.g.* in 'Pete told Sam to explain himself', 'himself' can refer only to Sam, not to Pete. See Chomsky, (1981).

grammatical features and any applicable syntactic principles. Thus, to interpret a pronoun, we consider the candidate referents in order of prominence until we find one that satisfies the operative linguistic constraints.¹⁵

(10) integrates the constraints of attention, semantics and syntax for the pronoun 'he'.

10. The pronoun 'he' denotes the highest-ranked discourse referent whose value is singular, masculine, and disjoint from the speaker and addressee of the utterance, and yields an interpretation where the pronoun is free in its governing category.¹⁶

To incorporate (10), we need to refine our formal language. Suppose 'p' is a predicate representing the constraints associated with a pronoun. Let '@p' be an individual expression that denotes the highest-ranked individual from the current assignment function that satisfies the property denoted by 'p'. We capture the rule for interpreting the pronouns in (1) on the anaphoric and deictic readings of its first two sentences respectively as (11)-(12), where '@he' encodes the relevant constraints on person, gender and number.

11. $\langle \alpha \rangle$; [man(@)]; [walk.in(@)]; [sit.down(@he)]
12. $\langle \alpha \rangle$; [man(@)]; [walk.in(@)]; $\langle \pi b \rangle$; [sit.down(@he)]

Even with these qualifications, however, we still fall short of a complete account. For example, (13)-(14) point to some deficiencies:

13. A man met Sam. He greeted him.
14. The city council denied the demonstrators a permit.¹⁷
 - i. They feared violence.
 - ii. They advocated violence.

In (13), 'he' would normally be resolved to the man introduced in the first sentence, and, 'him', to Sam.¹⁸ The syntactic constraint on binding explains why the pronouns in (13)

¹⁵ To be clear, the proposal to maximize attention subject to linguistic constraints involves *search*, rather than a simultaneous imposition of potentially competing constraints of attention and linguistic constraint. We are *not* saying the pronoun refers to the top-ranked discourse referent *unless* it violates a constraint; rather, it refers to the top-ranked discourse referent that satisfies the constraints. The idea of searching for the referent of an anaphor is a familiar ingredient of models of attention in the centering tradition (Grosz & Sidner 1986; Brennan, Friedman & Pollard 1987).

¹⁶ Roberts (2002) proposes similar rules associated with demonstrative pronouns, although with some important differences. Instead of our purely linguistically governed notion of attentional prominence ranking, she uses a more liberal notion of (contextual) salience. Moreover, she treats these semantic constraints on reference as presuppositions of a pronoun, whereas we understand them as a part of their character. Finally, she does not explicitly build the constraints on syntactic binding into the constraints on reference associated with the meaning of the pronoun directly.

¹⁷ The example in (14) is originally from Winograd (1972).

¹⁸ We are, of course, assuming that (13) is not uttered with accompanying demonstrative gestures.

cannot be co-referential. However, it won't explain why the first pronoun gets resolved to the man introduced in the first sentence, and not to Sam. The explanation cannot be that only 'a man' promotes a candidate referent to the top of the stack; a name can also affect attention focus.¹⁹ So, why is the former, and not the latter, the highest-ranked referent, picked out by 'he'? Similarly, given what's been said so far, (14) is puzzling. In (14i), the pronoun 'they' is resolved to the city council introduced in the previous example; in (14ii), it's to the demonstrators. Clearly, both can't be the top-ranked candidate discourse referents at the same time. What accounts for the difference?

We take up these challenges in turn. For (13), an explanation is readily available. In English, the ranking of discourse referents normally mirrors the grammatical role in which they are realized; in particular, in English discourse, the NP in subject position takes precedence over the one in object position (Kameyama, 1996; Kehler, 2002; Bittner, forthcoming).²⁰ In (13), then, we resolve the first pronoun 'he' to the discourse referent introduced by previous subject, 'a man', rather than that introduced by the previous object, 'Sam', because of this conventional ranking. This ranking applies consistently throughout the discourse; the discourse referent for 'a man' remains the most prominent one when we turn to interpreting 'him', too. However, 'him' must take a different discourse referent because of a syntactic constraint on binding; it must be free in its governing category, due to Principle B on binding, and so, it cannot refer to the referent introduced by 'a man'. Thus, 'him' will have to be resolved to a referent lower in the hierarchy, and the referent for 'Sam' is the top-ranked one that satisfies the relevant constraints.

The most streamlined way of capturing this formally is to link grammatical roles to specified positions on the list of prominent referents: the subject corresponds to position 0, the direct object to position 1, the indirect object to position 2, and so forth. We then use expressions of the form, ' $\langle \alpha n \rangle$ ' and ' $\langle \pi n c \rangle$ ', to encode updates that push referents to position n in the stack (limiting ourselves to $n = 0, 1$ or 2 and assume that the value of n follows compositionally from the grammatical status of the expression we are representing). The LFs of (1)'s anaphoric and deictic (as in (4)) interpretations become, respectively, (15)-(16):

15. $\langle \alpha 0 \rangle$; [man(x_0)]; [walk.in(x_0)]; [sit.down(@he)]
16. $\langle \alpha 0 \rangle$; [man(x_0)]; [walk.in(x_0)]; $\langle \pi 0 b \rangle$; [sit.down(@he)]

(15)-(16) are transparent about the distinction between compositional semantics and anaphora: since the semantics says the indefinite must be a man who walked in, the argument places of these predicates are filled in by the subject discourse referent ' x_0 ' and not the representation of a pronoun '@p'. Moreover, we can be even more uniform about the

¹⁹ Clearly, names, and other definites can raise discourse referents to prominence (as witnessed by sentences like 'Bill came in. He sat down').

²⁰ Note, this observation is about *English*; it is not universal. Languages with a more flexible syntax use word order to indicate prominence. And some grammaticize centering status with morphemes like topic markers that crosscut word order and grammatical role. (See Kameyama (1999;1986); Walker, Masayo, & Cote, 1994; Bittner, forthcoming.)

syntax-semantics interface by encoding the fact that the pronoun serves as the subject of its own sentence in turn, representing this by an explicit further update to the attentional state of the discourse, as in (17)-(18):

17. $\langle \alpha_0 \rangle ; [\text{man}(x_0)] ; [\text{walk.in}(x_0)] ; \langle \pi_0@he \rangle ; [\text{sit.down}(x_0)]$
18. $\langle \alpha_0 \rangle ; [\text{man}(x_0)] ; [\text{walk.in}(x_0)] ; \langle \pi_b \rangle ; \langle \pi_0@he \rangle ; [\text{sit.down}(x_0)]$

This change doesn't change the philosophical status of LF, but it may be linguistically significant.²¹

Further, we need to represent the effect of Principle B in resolving the pronoun. Principle B rules out a possible referent u for a pronoun on syntactic grounds. Let's introduce the expression '@p^u' to represent the most prominent referent that satisfies predicate p other than the referent u . We can resolve an object pronoun 'him' uniformly to the referent '@he^{x₀}' meaning the top-ranked male other than the subject. (The full translation of the direct object 'him' is the update ' $\langle \pi_1@he^{x_0} \rangle$ ' which stores this referent in direct object position ' x_1 '.) This refinement is, again, unsurprising; after all, it makes a difference whether someone utters 'he' or 'him', precisely because the two differ in meaning. We obtain LF (19) for (13), which implements the intuitive account:

19. $\langle \alpha_0 \rangle ; [\text{man}(x_0)] ; \langle \pi_1s \rangle ; [\text{met}(x_0, x_1)] ;$
 $\langle \pi_0@he \rangle ; \langle \pi_1@he^{x_0} \rangle ; [\text{greeted}(x_0, x_1)]$

Its first line introduces a referent at position 0 for a man, the subject, and introduces Sam, s , as the referent at position 1, for the direct object; it imposes the constraint that the subject met the object—the man met Sam. Its second line begins by pushing a copy of the most prominent male referent as the new center of attention, corresponding to the subject of the second sentence. The most prominent referent so far is the man. We next find the most prominent male referent other than the top referent—moving down the list, that's Sam—and push it to position 1, corresponding to the direct object of the second sentence. We end by imposing the constraint that the subject greeted the direct object: i.e., the man greeted Sam.

What about (14), the second challenging example?

14. The city council denied the demonstrators a permit.
 - i. They feared violence.
 - ii. They advocated violence.

²¹ In this case, the LF has the elegant property that it consists entirely of updates that can be read directly off the lexical items that comprise the utterance, along with their grammatical roles. The update that, in this formalism, corresponds to the pronoun – ' $\langle \pi_0@he \rangle$ ' – changes the prominence associated with the discourse referent associated with 'he'. Note that it does not really *introduce* a new discourse referent; it rather re-stores (i.e. pushes a copy of) an old one to the designated position on the list of prominent referents.

While (14i) could be explained in an exactly parallel fashion, by appealing to subject preference, (14ii) would seem to run directly counter to this explanation, for in (14ii), even though there is a prominent, accessible and compatible antecedent in subject position ('the city council'), the preferred resolution of the pronoun 'they' is to the antecedent in object position ('the demonstrators'). How can we explain this in the light of our previous discussion? Here is where the coherence part of the Attention-Coherence Approach comes into play. We turn in the next section to the resources of Coherence Theories (Kehler, 2002; Asher & Lascarides, 2003).

3) Coherence

Coherence Theories hypothesize an implicit organization of discourse that establishes inferential connections among successive utterances and, at least according to us, do so as a matter of meaning. The idea is that this implicit organization of the discourse stems from the communicative strategies that speakers utilize in an attempt to convey their ideas through the ongoing discourse. We suggest that one aspect of discourse organization is the dynamics of attention—thus, the attentional ranking of discourse referents depends on the specific meaningful connections that organize the discourse. For example, we suggest, the fact that (14ii) explains the decision about the demonstrators by spelling out what the demonstrator's problem was, and the fact that the demonstrators are promoted to the center of attention in this discourse, are both manifestations of the same underlying communicative strategy that organizes the discourse into a coherent whole. Thus, the right LF for (14ii) will showcase both the explanatory relationship that connects it to the ongoing discourse and the shift in attention that that relationship triggers.

Coherence Theories start from an obvious but often ignored observation about discourse: namely, that a discourse is more than a sequence of grammatical sentences. Successive contributions to discourse must be linked together by a recognizable flow of interpretive relationships; the speaker must signal how she develops her complex ideas, stories and arguments according to shared standards. We see this requirement of coherence in both of the discourses of (20) and (21) (Hobbs, 1979).

- 20. John took the train from Paris to Istanbul. He has family there.
- 21. John took the train from Paris to Istanbul. He likes spinach.

Discourse (20) doesn't just reveal two interesting facts about John: it suggests the reason he went to Istanbul was to visit his family there. A coherence relation of *Explanation* links the second sentence to the first (Cf. Asher & Lascarides, 2003; Kehler, 2002). Coherence theory recommends we represent this inferential connection explicitly in LF in order to capture the correct interpretation of (20). Conversely, the requirement that discourse must be coherent – that its implicit organization must be readily retrievable in virtue of the interlocutors general, linguistic and background knowledge – is strikingly evident in the interpretive effort that (21) elicits. Given the apparently unrelated facts about John in (21), we feel unsatisfied: we search for a connection. Is Istanbul known for its spinach? Is the train? Is eating spinach a symptom of some general timidity that also encompasses fear of

flying? Clearly, interlocutors must use the common ground to disambiguate coherence relations, just as they must use the common ground to resolve reference and other ambiguities. But just as clearly, failing to acknowledge any of these ingredients of interpretation as intended constitutes a failure to understand the discourse.

Kehler (2002) suggests that coherence relations cluster into (at least) three qualitatively different sorts, reflecting alternative strategies for organizing discourse. These are illustrated in (22)-(24).

22. Max spilt a bucket of water. He tripped on his shoelace.
23. Max spilt a bucket of water. He spilt it all over the rug.
24. Max spilt a bucket of water. John dropped a jar of cookies.

Discourse (22) is another illustration of the explanatory discourse we've already considered with regards to (20). For Kehler (2002), explanation is an instance of a broader class of cause-effect (or event-result) relations that speakers can use to organize discourse. Discourse (23), meanwhile, gives an extended description of unfolding events—thus, a narrative connection, which for Kehler epitomizes a broader class of contiguity relations. And, finally, (24) exemplifies what Kehler calls resemblance relations, organizing a discourse to draw comparisons and contrasts. In (24), there's a parallel between Max and John's respective accidents. Each of these three sorts of relation triggers corresponding interpretive effects, and thus, should be represented in LF.

Coherence theorists often observe that the two problems of identifying coherence relations and resolving semantic ambiguities are mutually constraining. In (14ii), for example, only resolving 'they' to the demonstrators allows for a plausible explanation of the council's decision. In (20), only resolving 'there' to Istanbul rather than to Paris allows for a plausible explanation of John's trip. In (22)–(24), meanwhile, we infer a temporal relation between the spill described initially and the tripping, spilling or dropping described next that matches the inferred coherence relation. Reference and coherence relations fit together in such cases.

A number of studies have experimentally confirmed the existence of the interpretive connections between pronouns and coherence (Kaiser 2011 cites Wolf, Gibson & Desmet 2004, Kertz et al. 2006, Kehler et al. 2008, Rohde & Kehler 2008, Kaiser 2009). In fact, these studies suggest an even tighter connection between coherence relations and the interpretation of pronouns than we have so far indicated. Reconsider example (2), from Kertz, Kehler & Elman (2008), for an illustration why.

2. Phil tickled Stanley, and Liz poked him.

Speakers tend to interpret (2) in one of two ways. One reading assumes Liz's action was prompted by Phil's. Liz is perhaps reacting with disapproval to what Phil has done. This cause-effect interpretation comes with the understanding that 'him' must refer to Phil. The second reading assumes Liz's action was similar to Phil's. This parallel interpretation

comes with the understanding that ‘him’ must refer to Stanley. The contrast between these interpretations suggests it’s a mistake to think of (2) as harboring two separate ambiguities that audiences need to resolve independently—one about discourse coherence and a second about pronoun interpretation. On the basis of such examples, we propose that pronoun resolution is settled by coherence relations that organize the discourse. More precisely, we assume, following Coherence Theory, that coherence relations are represented in LF, and we claim, further, that doing so requires representing shifts in attention, as well as inferential connections. Once those shifts are made explicit, we can then represent the intuitively correct interpretations of pronouns, while keeping their meaning uniform and unambiguous in the way we have already presented. In short, the difference between (14i) and (14ii) is about the type of coherence relation that figures in their respective LFs; and this affects, semantically, the resolution of the subsequent pronoun.

Here’s how we suggest it works. In both (14i) and (14ii), the coherence relation is one of Explanation. In both, the content of the first sentence (or the event it describes) is taken to explain the content of the second (or the event it describes). These explanation relations, though, are qualitatively different. In (14ii), the council’s decision about the demonstrators can be explained on the basis of the former’s beliefs about the latter: the relevant explanation is that it is because the demonstrators are potentially violent, or at least believed to be so by the city council, that the council has denied them a permit. We’ll use ‘eo(x,y)’ to formalize an explanatory connection justifying x’s decision about y in terms of y this way, that is, where some feature of, or x’s belief about, y is driving the explanation (‘eo’ stands for explanation via the object). Meanwhile, in (14i), the council’s decision about the demonstrators can be explained based on (other aspects of) the council’s attitudes: it is because the council feared violence, that they decided to deny the demonstrators a permit. We’ll use ‘es(x, y)’ to formalize an explanatory connection justifying x’s decision about y in terms of x this way, i.e. an explanatory connection based on some feature of, or x’s belief about, x. (‘es’ stands for explanation via the subject). According to Coherence Theory, one or the other of these relations surfaces in LF of (14i) and (14ii).

Our particular reference resolution proposal is that, as a matter of language, the explanatory relation affects the attentional structure of the discourse in both cases, promoting one or the other of the discourse referents to the top-ranked position. When an LF features eo(x, y), it also features an attention-shifting operation that raises y to prominence; when it features es(x, y), it features an attention-shifting operation that raises x to prominence. Thus, for (14i)-(14ii), we ascribe LFs (25)-(26) respectively:

25. $\langle \alpha_0 \rangle$; [council(x₀)] ; $\langle \alpha_1 \rangle$; [permit(x₁)] ; $\langle \alpha_2 \rangle$; [demonstrators(x₂)] ;
 [denied(x₀,x₁,x₂)] ; [es(x₀, x₂)] ; $\langle \pi_0 x_0 \rangle$;
 $\langle \pi_0 @ \text{they} \rangle$; $\langle \alpha_1 \rangle$; [violence(x₁)] ; [feared(x₀, x₁)]
26. $\langle \alpha_0 \rangle$; [council(x₀)] ; $\langle \alpha_1 \rangle$; [permit(x₁)] ; $\langle \alpha_2 \rangle$; [demonstrators(x₂)] ;
 [denied(x₀,x₁,x₂)] ; [eo(x₀, x₂)] ; $\langle \pi_0 x_2 \rangle$;
 $\langle \pi_0 @ \text{they} \rangle$; $\langle \alpha_1 \rangle$; [violence(x₁)] ; [advocated(x₀, x₁)]

(For our purposes here, we can ignore the difference between definiteness and indefiniteness, since the dynamics of the sequences of discourse referents and the uniqueness or familiarity condition associated with ‘the’ will not affect anything that concerns us in this paper. Definites have a similar effect as indefinites, except that the discourse referent they promote is typically a familiar or old one.) The difference in pronoun resolution follows from a specification of the coherence relations that structure the discourse and describe the attentional state, not from an arbitrary resolution of the pronoun to a specified index.²²

We need to say something about the nature of the attention shifts contributed by the coherence relation. You might be inclined to think they just reflect the speaker’s intentions and the hearer’s common-sense inference—that is, that they arise through pragmatic processes rather than through linguistic rules. So construed, an attention shift that guarantees the correct interpretation of the subsequent pronoun is a result not of a linguistic effect of an encoded coherence relation, as we are suggesting, but rather of pragmatic reasoning that occurs once a hearer has established a particular coherence relation is in play. For example, a hearer reasons that in (14i), since a particular relation of Explanation holds between the two sentences, the speaker must be intending to promote a certain referent, in this case, the city council, to the center of attention. Crucially, intention recognition affects the adequate re-centering of the list of prominent referents.

We can see why some might feel some sympathy for this alternative idea. It certainly makes sense for attention to shift in the ways (25) and (26) suggest. It would be perverse to reverse the preferences, so that when we came to consider what the council thought that made them deny the permit, the default referent for ‘they’ would be the demonstrators, and when we came to consider what the demonstrators were like that got them in trouble, the default referent for ‘they’ would be the council. These rules would make it much harder to communicate our ideas in concise discourse. However, ultimately, we recommend rejecting the popular, and perhaps even universal, idea that it is common sense that dictates that an implicit shift in attention has to take place in these contexts. The reason we do is that it seems that speakers and hearers take a rather restricted set of cues into account in resolving pronominal reference—privileging specifically linguistic cues over the broader constraints of background knowledge and rational inference that they might potentially consider. For a perfect example of what we have in mind, consider sentence (27), from Kehler (2002):

27. *Margaret Thatcher admires Ronald Reagan, and George W. Bush absolutely worships her.

²² Coherence relations are being represented in logical form, because, crucially, their effect is delivered by the grammar, constrained by linguistic rules, and interrelated with other aspects of meaning. This does not necessarily have to mean that the presence of a coherence relation is a part of truth conditions or asserted content. Conventional encoding of non truth-conditional content is not unusual. For simplicity and for our purposes here, however, our formalism has only a single dimension of semantic content.

As Kehler notes, something is not right with (27). By virtue of following ‘admires’ with ‘absolutely worships’—a stronger term in an obvious scalar relationship—the speaker gives clear evidence that (27) is organized around a contrast between Margaret Thatcher’s and George W. Bush’s comparable attitudes. And Coherence Theory suggests that this parallel should raise Reagan to prominence as the preferred referent for the pronoun in the object position. And, indeed, in reading (27), it seems as if the speaker has erred, inadvertently referring to Reagan as ‘her’. Of course, Thatcher has been evoked in the previous sentence, and she is already a well-known object of Bush’s admiration. So, you’d expect it would be rather easy to refer to Thatcher with ‘her’ were coherence just a by-product of the general pragmatic, common sense reasoning that interpreters use to recognize a plausible interpretation. This point is analogous to what we observed earlier about the conventionality of demonstration. Thatcher may attract our visual attention with what she’s doing in the current situation, but if the speaker is pointing elsewhere while saying ‘her’, then ‘her’ refers to someone else, regardless. Just so here, we suggest, the Parallel coherence relation encoded in (27) accomplishes a kind of inferred demonstration, indicating Reagan in a way that’s difficult for any common-sense inference to override.

Further support for our thesis that these characteristic cues for reference resolution are conventionalized come from the variation we find across language communities. Many languages have explicit operations for shifting attention, such as grammatical topic marking or a distinction between topic and non-topic pronouns. It happens that some of these languages are much more constrained than English in the sorts of shifts they permit to take place implicitly.²³

²³ We take the Greenlandic language Kalaallisut, as described by Bittner (2007), as a clear example. Bittner contrasts (i) in English with (ii) in Kalaallisut.

(i) When I came to this conference, I bought my ticket six months in advance.

(ii) Danmarkimut tikikkama,

Danmarki-mut tikit-ga-ma,

Denmark-sg.DAT come-FCT-1s

When I came to Denmark,...

qaammatit arvinillit siuqqullugu billitsisivunga.

qaammat-t arvinilli-t siuqqut-llu-gu billitsi-si-pu-nga.

month-pl six-pl v.ahead-ELA-3s ticket-get-IND.IV-1s

I got a ticket (for some other event) six month ahead (of that event).

Following Moens and Steedman (1988) and Webber (Webber (1988), Webber et al (2003)), we take sentences with subordinate clauses, such as ‘when’ clauses, to be mini discourses, with coherent interpretive connections between the clauses that, in many ways, mirror the interpretive connections found between successive sentences in a discourse. For (i), English speakers find a natural interpretation where buying the ticket early is a description that *elaborates* how the speaker came to the conference. For translation (ii), however, the analogous interpretation is unavailable to Kalaallisut speakers. The Kalaallisut sentence requires a *narrative* interpretation, where the main clause describes what happens after the speaker came to Denmark. Buying tickets for trips is the same the world over; if the resolution of context-dependent meanings in (i) and (ii) were just common sense, we would expect the same interpretation in both cases. However, that is

We need to be careful to note that all we are defending is that there is a particular linguistic effect of coherence relations, which, in the given case, establishes an attention shift. This is, of course, consistent with general reasoning playing a role in determining which coherence relation holds between any two sentences. Our point is that once a choice of a coherence relation has been made, its contribution to attention (re)-focusing becomes rule-determined, and is not left up to pragmatic reasoning. Once a certain coherence relation is established, its linguistic effect requires a re-ordering of prominence ranking of discourse referents. However, any role general reasoning plays is analogous to disambiguation (not pragmatic enrichment). For example, (2) is both ambiguous (at least) between the discourse containing the relation of result and the one featuring the relation of parallel. Some general reasoning might be involved in disambiguating between these two interpretations, much like some general reasoning might be involved in figuring out whether the speaker meant the financial institution, or the river bank, with 'bank', or which quantifier scope she intended in 'Every boy kissed a girl'. In order to interpret the sentence one needs to achieve this initial disambiguation. But once (2) is disambiguated in this way, the interpretation of the pronouns in (2) falls right out of the conventional contribution of a coherence relation – no further disambiguation of the pronouns takes place.

In sum, there is strong evidence in favor of treating the attention-shifting effects of coherence relations, as genuine linguistic contributions, governed by linguistic rules, rather than as a byproduct of pragmatic reasoning. Thus, not only is the reference of a demonstrative pronoun determined fully by its linguistic meaning, as a function of context, but moreover, the relevant features of context that fix this reference are themselves fixed and set-up by rules of language. So, the reference resolution of a demonstrative pronoun is fully linguistically determined – through and through. It is the set of linguistic regularities that structure the discourse, together with the rules governing the use of the pronoun that together determine the reference of a pronoun on an occasion of use.

4) The opposition

We close by highlighting significant advantages of our view over its competitors. They, recall, hold that any linguistic rule specifying the meaning of a demonstrative pronoun requires (a non-linguistic) supplementation for reference to be determined in a context; linguistic meaning in context does not fully determine the reference. Typically, this supplementation involves reasoning about speaker referential intentions, and recognizing accompanying demonstrations (which, on these views, are thought of as making a merely pragmatic, as opposed to a genuinely linguistic, contribution). These views typically don't represent the effects of these processes in LF. Instead, they typically represent pronouns as free variables, and handle co-reference via a method of co-indexing. The appropriate co-indexing, however is achieved through general reasoning about speaker intentions and extra-linguistic context.

not what we find. Only if languages interpret analogous expressions differently as signals of transitions in discourse can we accommodate the difference we actually find.

One way in which this idea has been implemented is through a formalism that indicates multiple mechanisms can be involved in interpreting pronouns, while preserving the assumption that the linguistic meaning of ‘he’ underspecifies its resolution; for the referent of any use of a demonstrative to be determined, something else must supplement its meaning. Work in computational semantics approaches this idea of underspecification explicitly. Reyle (1993) and Asher and Lascarides (2003) assume the grammar by itself does not determine but only constrains LF. The constraints permit multiple solutions, any one of which is a possible (completed) LF. Pragmatic reasoning is responsible for determining which LF among the many possible ones belongs with a specific utterance.

In this architecture, we can introduce the underspecified atomic formula ‘ $x=?$ ’ to represent the contribution of a pronoun. Pronouns require antecedents;²⁴ just so, the formula ‘ $x=?$ ’ must be resolved to a corresponding equation, such as ‘ $x = x_1$ ’, specifying the interpretation of the pronoun. The constraint ‘ $x=?$ ’ is consistent with any such equation; in other words, an underspecified LF involving the constraint ‘ $x=?$ ’ can and must be resolved by replacing the constraint with an appropriate equation of the form ‘ $x = v$ ’. To illustrate this idea, consider the following examples:

28. He [pointing to Bill] is happy. He [= Bill] is rich.
 29. He [pointing to Bill] is happy. He [pointing to Sam] is rich.
 30. He [pointing to Bill] is happy. He [pointing to Bill] is rich.²⁵

Following the idea of underspecification, specific interpretations of (28), (29) and (30), will all be derived from a common underspecified LF, determined by the grammar, as in (simplifying significantly) (31):

31. $Hx_1 \ \& \ Rx \ \& \ x=?$ ²⁶

To capture the different interpretations of (28)–(30), we resolve the constraint ‘ $x=?$ ’ either to ‘ $x=x_1$ ’ (which would yield a desired interpretation of (28) and (30), or ‘ $x=x_2$ ’ (which would give us the interpretation of (29)). The problem is, of course, that although this approach delineates the conventional, linguistic contribution of a pronoun from what a context needs to supply, it remains mute about the mechanisms through which context supplies a particular resolution of the pronoun. Furthermore, the final resolution seems to

²⁴ The antecedent need not be introduced by some previously occurring linguistic expression, as in the typical case of anaphora. All we mean is that the pronoun requires that there is some accessible discourse referent that can serve as a candidate referent of the pronoun in question.

²⁵ For anyone skeptical about examples with consecutive utterances of demonstratives whose *demonstrata* are the same objects, consider an utterance of “That [pointing at A] is identical to that [pointing at A],” used to indicate to two visible parts of one large, mostly occluded, object (Perry, 1977).

²⁶ We here simplify the formalism quite significantly, since we only care about the idea of co-indexing and underspecification which is easily illustrated with (33). The particular details, though certainly important, for our purposes do not matter.

suggest that disambiguating between possible LFs obtained from the underspecified (31) is the disambiguation of the representation of the pronoun itself; but, of course, as we have shown, it is not the pronoun that should be disambiguated, but rather the particular mechanisms that affect its interpretation. The pronoun itself has a uniform representation, which should be reflected at the level of LF. (Similar points, obviously, apply to all the earlier examples we have considered.)

Philosophers have pursued underspecification somewhat differently.²⁷ A common view is that 'he' gets its content partly through the uniform contribution of its meaning and partly through a pragmatic mechanism that indicates the referent of the pronoun in context. In this sense, again, the linguistic contribution of 'he' does not fully determine its semantic content, in a context.²⁸ In particular, for the semantic content of 'he' to be determined, its linguistic meaning has to be accompanied either with an appropriate demonstration, where demonstration is thought of as a pragmatic mechanism, rather than as a linguistic component, or supplemented with a speaker's referential intention.²⁹

These philosophical approaches shed little light on the meanings of pronouns, or on how semantics and pragmatics interact to resolve reference. The problem is, once again, that the mechanisms that supplement the meaning of pronouns are left out of LF; their contributions and effects, essentially thought of as pragmatic, are left inexplicit. Thus, the only recourse to describe the important linguistic similarities and differences among, say, the examples in (28)–(30) is to invoke pragmatic processes that the theories themselves neither formalize nor represent explicitly.

In response, as we have been arguing throughout, similarities among (28)–(30) should be *transparent* in LF. It should be transparent in LF that (28)–(30) are all utterances of the strings, 'He is happy.' and 'He is rich'; that each contains two occurrences of the same pronoun 'he'; and finally, that 'he' retains a stable linguistic meaning wherever it occurs in (28)–(30). Moreover, their differences should be transparent, as well. Distinctively in (28), its second occurrence of 'he' comes in the flow of a continuing discourse about Bill, as part of an utterance that elaborates or explains a prior description of Bill's happy state. In resolving the second 'he' to Bill, we take it to refer to the subject of the prior utterance and the topic of the speaker's broader contribution to the conversation. Distinctively in (29) and (30), the second occurrence of 'he' comes in the flow of two contrasting utterances describing the happiness and wealth of present company. In each, it occurs with an accompanying demonstration, and in each it is resolved to the person demonstrated. The

²⁷ Proponents of the view are many. Arguably, it can be attributed to Kaplan (1989b). See also, for example, King (forthcoming, a., forthcoming, b.), Neale (2004), Reimer (1992).

²⁸ Note that, of course, taking the linguistic meaning of a demonstrative pronoun like 'he' to incorporate a particular demonstration as its constituent would automatically result in the ambiguity at the level of linguistic meaning – for the pronoun 'he' would be associated with as many meanings as there are demonstrations. This is indeed an implausible result. For a version of this point and related discussion, see Braun (1996).

²⁹ (Braun, 1996) formalizes one generalization of Kaplan's notion of character that allows the reference of 'he' to vary with an accompanying demonstration.

referent, of course, differs in these cases: in (29) it's the same Bill who was evoked in the first sentence; in (30), it's someone new, Sam. This difference constrains the speaker's broader contribution: if one's interlocutor has suggested that everyone at the party is miserable and destitute, (29) is a good objection; if one's interlocutor has suggested that money actually makes people miserable, only (30) will do. Note, also, that (30), is importantly different both from (28) in that a different mechanism of resolution is exploited, and from (29), in that a different demonstratum is targeted by the accompanying demonstration.

None of this, however, gets reflected in LF, according to the views in question. Indeed, in all the formal proposals we have surveyed, the interpretation of the pronoun is represented by brute co-indexing, and there is no formalism for modeling the context-dependence of pronouns in LF. This creates a false and very misleading impression that the ambiguity at LF of 'He is happy. He is rich.' is due to the pronoun itself—rather than to the different resources of pronoun resolution supplementing linguistic meaning. Given our previous discussion, this not only fails to do justice to the uniformity of the meaning of the pronoun, but it completely omits the important, systematic, and as we have argued, *bona fide* linguistic contribution of different mechanisms of pronoun resolution.

5) Conclusion

We have argued for a joint attention-coherence account of the meaning and interpretation of pronouns. This account assigns a uniform linguistic meaning and representation to each pronoun, but is nevertheless powerful enough to account for wide range of data. The interpretation of pronouns responds to one overarching principle: pronouns pick out the top-ranked discourse referents in a stack of referents, maintained and updated across the discourse context. However, the referent of each pronoun is restricted by various additional constraints, including person, gender and number, which trigger a search for a matching referent on the stack, and independently motivated syntactic constraints. Think of the character of a pronoun as incorporating these constraints, as in (10). It constitutes the meaning of the pronoun and on our account it is transparently visible in LF. More importantly, it determines the reference of a use of 'he' automatically, as function of context.

To this end, the context must be appropriately set up. This is achieved by tracking the ranking of the discourse referents that models the attentional state of the context, established through attention-shifting operations, which are represented in LF. These operations record the diverse mechanisms that speakers have learned for structuring discourse and shaping the interpretation of pronouns, including evoking discourse entities in specific grammatical roles, demonstrating entities with non-verbal (yet linguistic) actions, and signaling the direction of discourse through various interpretive connections between clauses. Although these operations are heterogeneous, we have argued, they are governed by linguistic rules, rather than by pragmatic reasoning, and as such they belong in LF.

Of course, our account is provisional in several respects. We haven't talked about the modal profile of context-sensitive utterances. Dynamic semantics has the expressive resources to distinguish the dynamics of reference across discourse from the propositions that utterances express and the attitudes they can attribute to agents.³⁰ Developing a formalism that combines these ingredients remains a task for future work. However, based on Bittner's (forthcoming) successful foray into modal dynamic semantics with centering, we are optimistic that such formalisms can be straightforwardly adapted to take into account the context-dependent character of pronouns and the attention-shifting operations of discourse that we have proposed.

We also have been silent about a great many of the ambiguities associated with discourses containing pronouns—both within English and across languages.³¹ Cases like Kehler's (27)—among others—show that fleshing out our view will require us to postulate a variety of coherence-triggered attention shifts within complex sentences. Hobbs (1990), among others, has long argued that the effects of discourse coherence are visible not just when sentences are combined together, but in the many inferential connections that must be established to knit the interpretation of each clause together. So far, however, these relationships remain largely unexplored in formal semantics, and call for future work.

We ourselves are most excited about the philosophical ramifications of the kinds of tools developed here. Philosophers often use linguistic examples to argue for context dependence—in cases like knowledge attributions, the implicit domain of quantifiers, standards for vague scalar terms, and many others—and then use this context dependence to defend broader philosophical views. The kind of context dependence they have in mind, implicitly, is generally the traditional one where context-dependent elements are ambiguous and open-ended in ways we have discussed and get their interpretations from context freely, selecting from an open-ended array of candidates by unspecified, and typically pragmatic mechanisms (e.g., enrichment). Often, in fact, both the linguistic analyses and the philosophical arguments depend on this model of context dependence.

It turns out, though, that context is not as powerful as the traditional model seems to presume. In fact, as we have seen in interpreting (1), much of our discourse ultimately lacks any dependency on *non-linguistic* context. And many of our practices in using language presuppose that our discourse has constrained and self-contained interpretations: when we judge truth and falsity, when we report one another, and when we talk about language and meaning itself. This observation suggests a project of extending our account to other interpretive effects—like domain restriction, implicit arguments, and lexical semantics. If our approach succeeds in capturing the apparent interpretive variability of such cases with uniform meanings and constrained variation, then philosophers will have to appeal to context sensitivity in their arguments in quite different ways than what they have grown accustomed to.

³⁰ See Brasoveanu (2010) and Cumming (2008) for detailed discussion of these issues.

³¹ For example, we do not discuss cases of bound pronouns, or offer treatment of dependent clauses.

Appendix: Formal definitions

for a fragment of the attention-coherence approach

We have the following basic types in our language:

- individuals (type e)
- possible worlds (type s)
- truth values (type t)
- sequences of individuals and worlds (type c)

We reserve the symbol a for the actual world.

We use the following notation to describe operations on sequences:

- i_m
If m is an integer, i_m is the m th element of i .
- $i_{m,n}$
If m and n are integers, $i_{m,n}$ is a sequence containing the subsequence of elements of i in order from element number m up through the element that precedes n (if any).
- $i_{m\dots}$
If m is an integer, $i_{m\dots}$ is the sequence containing the complete subsequence of elements of i in order beginning from element number m .
- $i + j$
If i is a sequence and j is a sequence then $i + j$ is the sequence containing the elements of i in order followed by the elements of j in order.
Note then that $i = i_{0,k} + i_{k\dots}$
- u, i
If u is an individual and i is a sequence, then u, i is the sequence that begins with u and continues with the elements of i in order.
- $w(i)$
If i is a sequence then $w(i)$ is the first element of i that is of world type.

The language of formulas and its semantics is as follows:

- Individual expressions
 - if t is an individual constant, then t is an individual expression
(represents the name of an individual)
 - the variable x_m is an individual expression
(represents a discourse reference contributed by argument structure)
 - if p is a unary predicate then $@p$ is an individual expression
(represents a syntactically unconstrained anaphor)
 - if p is a unary predicate and o is an individual expression then $@p^o$ is an individual expression
(represents a syntactically constrained anaphor)

The interpretation of individual expressions at a sequence i and world u :

- $\llbracket t \rrbracket i, u = I(t)$ for interpretation function I .
(Access constants from model.)
- $\llbracket x_m \rrbracket i, u = i_m$.
(Look up values of variables. We need variables to manage argument structure, otherwise it will be very cumbersome to deal with the syntax–semantics interface for transitive and ditransitive verbs; we need to potentially distinguish the order in which arguments are introduced, how salient they are after the utterance, and what role they play in the described event. Having variables clears this all up. Basically, x_0 will correspond to the subject, x_1 to the direct object, x_2 to the indirect object, and so forth.)
- $\llbracket @p \rrbracket i, u = i_0$ if $i_0 \in I(p, w(i))$.
 $\llbracket @p \rrbracket i, u = \llbracket @p \rrbracket i_{1\dots}, u$ otherwise.
(Find most prominent referent that agrees with anaphor.)
- $\llbracket @p' \rrbracket i, u = i_0$ if $i_0 \in I(p, w(i))$ and $i_0 \neq \llbracket t \rrbracket i$.
 $\llbracket @p' \rrbracket i, u = \llbracket @p' \rrbracket i_{1\dots}, u$ otherwise.
(Find most prominent free referent that agrees with anaphor.)

The language and interpretation of conditions:

- If r is an n -place predicate symbol and t_1 through t_n are individual expressions, then $r(t_1, \dots, t_n)$ is a condition.
- $\llbracket r(t_1, \dots, t_n) \rrbracket i, u$ is true if and only if $(\llbracket t_1 \rrbracket i, u, \dots, \llbracket t_n \rrbracket i, u) \in I(r, u)$
(interpret atomic conditions by making sure the specified entities are in the specified relation at the world of evaluation)

The language of dynamic updates:

- $\langle \alpha k \rangle$ is an update.
(push new indefinite assignment for variable k)
- $\langle \pi k t \rangle$ is an update.
(push new assignment of t to variable k)
- $[\varphi]$ is an update if φ is a condition.
(restrict the values of variables)
- $H; K$ is an update if H and K are updates
(composition—conjunction)
- $\Box K$ is an update if K is an update
(metaphysical necessity)

At each possible world u , the interpretation of a dynamic update is a relation on sequences:

- $\llbracket \langle \alpha k \rangle \rrbracket (u, i, j)$ if and only if $j = i_{0,k} + o, i_{k\dots}$ for some individual o of type e .
- $\llbracket \langle \pi k t \rangle \rrbracket (u, i, j)$ if and only if $o = \llbracket t \rrbracket i, u$ and $j = i_{0,k} + o, i_{k\dots}$ for some individual o of type e .
- $\llbracket [\varphi] \rrbracket (u, i, j)$ if and only if $j = i$ and $\llbracket \varphi \rrbracket i, u$ is true.
- $\llbracket [H; K] \rrbracket (u, i, j)$ if and only if there is some sequence h such that $\llbracket [H] \rrbracket (u, i, h)$ and $\llbracket [K] \rrbracket (u, h, j)$.
- $\llbracket [\Box K] \rrbracket (u, i, j)$ if and only if $j = i$ and for all worlds v accessible from u , there is some k such that $\llbracket [K] \rrbracket (v, i, k)$.

We represent the initial context by a sequence $I = (a, x, y)$ where a is the actual world, x is the speaker of the utterance, y is the addressee. In a more general language I could be extended by whatever parameters are appropriate for the interpretation of relevant indexical elements.

Finally, you have some general definitions:

- H is true, when uttered at a world a , by x to y if and only if there is some sequence i such that $\llbracket H \rrbracket(a, I, i)$.

You can obviously explicitly relativize truth to a model M that gives the domain e and the interpretation I for constants and predicate symbols.

- H is valid if and only if it's true in all models.

- H entails K (version 1: K is a summary of H)

For any model M , a and individuals x and y in a , if H is true when uttered at a by x to y in M , then K is true when uttered at a by x to y in M .

- H entails K (version 2: K doesn't add information to H)

For any model M , any world a in M , and any assignment i such that $\llbracket H \rrbracket(a, I, i)$, there is an assignment j such that $\llbracket K \rrbracket(a, I, j)$.

Version 2 is the one that's usually given in treatments of dynamic semantics designed to accommodate anaphora, because it allows anaphoric links not only between the premises but from the premises to the conclusion.

Worked examples:

- A man met Sam. He greeted him.

formula	gloss	output
$\langle \alpha 0 \rangle; [\mathbf{man}(x_0)];$	“A man (is the subject)”	(m, \dots) where m is a man
$\langle \pi 1 s \rangle;$	“Sam (is the object)”	(m, s, \dots)
$[\mathbf{met}(x_0, x_1)];$	“(the subject) met (the object)”	(m, s, \dots) where m met s
$\langle \pi 0 @ \mathbf{he} \rangle;$	“He (is the subject)”	(m, m, s, \dots) since m is a he
$\langle \pi 1 @ \mathbf{he}^{x_0} \rangle;$	“him (is the object)”	(m, s, m, s, \dots) since m, s are he but $m = x_0$
$[\mathbf{greeted}(x_0, x_1)]$	“(the subject) greeted (the object)”	(m, s, m, s, \dots) where m greeted s

The formulas look pretty cryptic until you master the trick of reading “0” as “the subject” and “1” as “the direct object,” which is their meaning in the formalism.

- The city council denied the demonstrators a permit. They advocated violence.

formula	gloss	output
$\langle \alpha 0 \rangle; [\mathbf{cc}(x_0)];$	“The city council (Subj)”	(c, \dots)
$\langle \alpha 1 \rangle; [\mathbf{permit}(x_1)];$	“a permit (DO)”	(c, p, d, \dots)
$\langle \alpha 2 \rangle; [\mathbf{demo}(x_2)];$	“the demonstrators (IO)”	(c, p, d, \dots)
$[\mathbf{deny}(x_0, x_1, x_2)];$	“(Subj) denied (DO) to (IO)”	(c, p, d, \dots) where c denied p to d
$[\mathbf{eo}(x_0, x_2)]; \langle \pi 0 x_2 \rangle;$	“look to IO to explain”	(d, c, p, d, \dots) where c denied p to d
$\langle \pi 0 @ \mathbf{they} \rangle;$	“they (Subj)”	(d, d, c, p, d, \dots) since d is a they
$\langle \alpha 1 \rangle; [\mathbf{violence}(x_1)];$	“violence (DO)”	$(d, v, d, c, p, d, \dots)$
$[\mathbf{adv}(x_0, x_1)]$	“(Subj) advocated (DO)”	$(d, v, d, c, p, d, \dots)$ where d advocated v

We ignore the difference between definiteness and indefiniteness in this example, since the important thing is the dynamics of the sequences of discourse referents and the uniqueness or familiarity condition associated with ‘the’ will not affect this.

- The city council denied the demonstrators a permit. They feared violence.

formula	gloss	output
$\langle \alpha 0 \rangle; [\mathbf{cc}(x_0)];$	“The city council (Subj)”	(c, \dots)
$\langle \alpha 1 \rangle; [\mathbf{permit}(x_1)];$	“a permit (DO)”	(c, p, d, \dots)
$\langle \alpha 2 \rangle; [\mathbf{demo}(x_2)];$	“the demonstrators (IO)”	(c, p, d, \dots)
$[\mathbf{deny}(x_0, x_1, x_2)];$	“(Subj) denied (DO) to (IO)”	(c, p, d, \dots) where c denied p to d
$[\mathbf{es}(x_0, x_2)]; \langle \pi 0 x_0 \rangle;$	“look to Subj to explain”	(c, c, p, d, \dots) where c denied p to d
$\langle \pi 0 @ \mathbf{they} \rangle;$	“they (Subj)”	(c, c, c, p, d, \dots) since c is a they
$\langle \alpha 1 \rangle; [\mathbf{violence}(x_1)];$	“violence (DO)”	$(c, v, c, c, p, d, \dots)$
$[\mathbf{fear}(x_0, x_1)]$	“(Subj) feared (DO)”	$(c, v, c, c, p, d, \dots)$ where c feared v

We can reduce the difference in the minimal pair to an attentional shift associated with two different patterns of explanation, represented explicitly in the logical form.

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