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DEEP STRUCTURE AS LOGICAL FORM*

I

A *transformational derivation* of a sentence is a sequence of labeled phrase structure trees. The last tree in the sequence represents the *surface structure* of the sentence. The first tree represents the *deep structure* of the sentence.[1] Each later tree is derived from its predecessor via the application of exactly one transformational rule. The surface structure tree represents that syntactic structure relevant to the way in which the sentence is pronounced. It will be assumed here that the deep structure tree is a full semantic representation of the sentence.[2]

Until recently, transformational grammarians assumed that deep structures took the form *subject phrase followed by predicate phrase.* But considerable simplification results if deep structure takes the form *predicate followed by one or more arguments.* If auxiliary verb is ignored (as it will be throughout this paper), the difference is given in Figure 1.

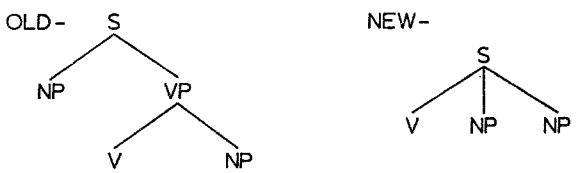

Fig. 1

On the new analysis, transformations such as passive, indirect-object inversion, and extraposition can move around the NPs that follow the V. Later, the first NP that ends up following the V is moved in front of the V and raised into a higher S. The result of such *subject raising* is shown in Figure 2.

This sort of surface structure is just like what one had on the old analysis, except that the node that was labeled VP on the old analysis is labeled S on the new.

Synthese **21** (1970) 275–297.

This points to one advantage the new analysis has over the old. It had been known that verb phrases in surface structure have the properties of embedded sentences. The relabeling permits a simplified statement of the relevant facts. A good example is *backwards pronominalization*, where a

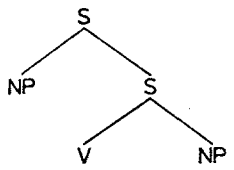

Fig. 2

pronoun precedes its antecedent. In many dialects this can occur when the pronoun is in either a subordinate clause, or a verb phrase, that does not also contain its antecedent. In my dialect, there can be backwards pronominalization in (1) and (2) but not in (3).

(1) When she smiled, Bob kissed Mabel.
(2) Bob kissed her, when Mabel smiled.
(3) *She kissed Bob, when Mabel smiled.

There is backwards pronominalization into a subordinate clause in (1) and into a verb phrase in (2). There can be no backwards pronominalization in (3) because the pronoun is in neither a subordinate clause nor a verb phrase. When verb phrases are labeled S, they become subordinate clauses in surface structure. Instead of saying that backwards pronominalization can occur in either of two circumstances, into subordinate clauses and also into verb phrases, we can simplify the rule: backwards pronominalization can occur into subordinate clauses.

More importantly, various transformations are simpler on the new analysis than they were on the old. For example, on the old analysis, the

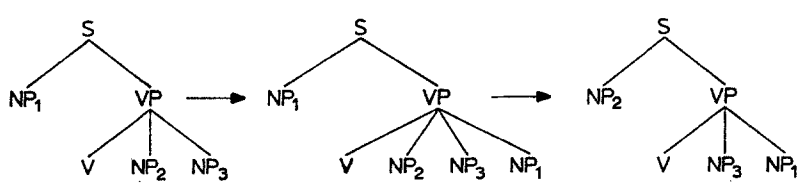

Fig. 3

passive transformation moved the subject of the sentence to the end of the verb phrase and then put the object where the subject used to be. (This way of putting things assumes that all NPs contain prepositions that may later get deleted. The subject contains the preposition *by*, the object *of*, the indirect object *to*, etc.) (Figure 3).

A problem for the old analysis arose from the assumption that transformations can be rather simply represented. Passive might have been written like this:

$$NP_1 - V - NP_2 - X \rightarrow NP_2 - V - X - NP_1$$

(Introduction of the verb *to be* is here ignored as are other considerations involving the auxiliary verb.) Given the accepted limitations imposed on the statement of transformations, it was not clear why the original subject should end up inside the VP rather than following it and attached directly to S, as shown in Figure 4.

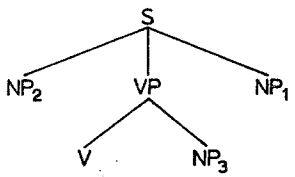

Fig. 4

Eventually, a rather *ad hoc* solution to this problem was adopted. It was assumed that the deep structure of a passive sentence was different from that of its corresponding active version in that it contained within the VP a constituent labeled 'PASSIVE' (Figure 5).

The passive transformation applied only to structures containing that special constituent. The subject NP would then be substituted for PASSIVE, and this was to explain how it ended up in the VP.[3]

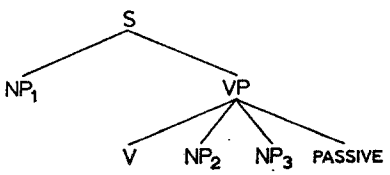

Fig. 5

The new view avoids this *ad hoc* treatment of passive. The passive transformation occurs before subject raising and moves NPs so that they remain within the same clause. After subject raising, this clause represents the verb phrase and contains what would have been the subject had passive not been used (Figure 6).

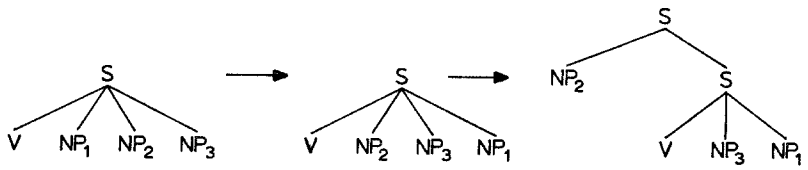

Fig. 6

A further advantage of the new analysis is that passive is no longer represented as two operations – moving subject, then moving object – but as one – moving first argument to the end of the clause.

But the full power of the new analysis does not really emerge until other transformations are considered. Extraposition is a good example. Extraposition yields sentences like

(4) It had surprised him that Bob was sick.

from a structure that could also yield

(5) That Bob was sick had surprised him.

Notice that *him* can refer to Bob in (5) but not in (4). To account for the impossibility of backwards pronominalization in (4), it must be supposed that the extraposed sentence 'that Bob was sick' occurs within the verb phrase. On the old analysis, extraposition would have to move the extraposed sentence from subject position outside the verb phrase into predicate position within the verb phrase. That raises the same problem for the old analysis that its treatment of passive does. And the new analysis permits the same sort of simplification. Extraposition moves the extraposed sentence to the end of the clause, leaving an 'it' behind. That 'it' may later be raised into subject position (Figure 7).

Infinitival clause separation is a kind of extraposition appropriate to

infinitive clauses. It leaves behind, not 'it', but whatever was in subject position. For example,

(6) Bob is believed by her to love Mary.

comes from a structure that could also have yielded

(7) *(For) Bob to love Mary is believed by her.

except that (7) is not well formed, for reasons not relevant to this discussion. The impossibility of backwards pronominalization in (6) shows that the phrase 'to love Mary' is contained within the verb phrase. There-

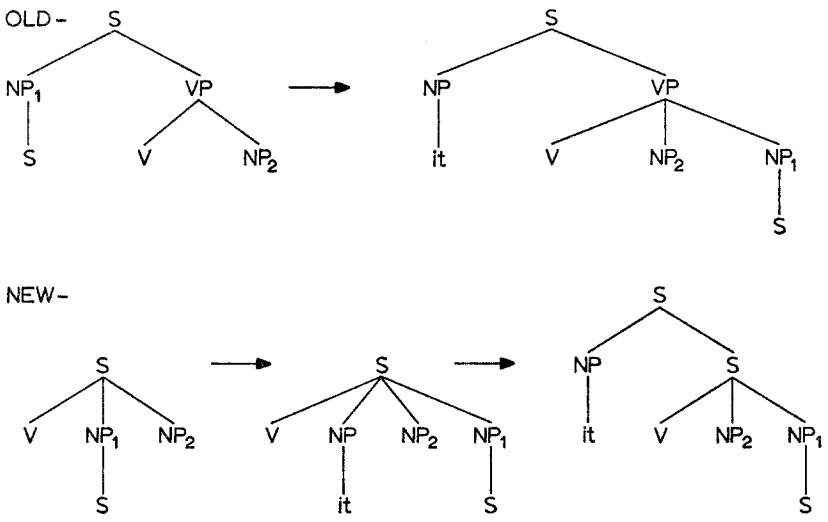

Fig. 7

fore, infinitival clause separation raises the same problem for the old analysis that passive or extraposition does; and the new analysis offers a similar simplification.

Actually, the simplification afforded is much greater than so far indicated. Both extraposition and infinitival clause separation can apply when the clause to be extraposed or separated does not appear in subject position. That means the old analysis will have to provide two quite different statements of these transformations, whereas only one statement of each is needed on the new analysis.

For example, infinitival clause separation must be used to obtain

(8) I believe myself to be honest.

For this sort of reflexive pronominalization (yielding 'myself') is possible only if the item thus pronominalized is separated out of the embedded sentence. Compare

(9) *I believe that myself am honest.

Furthermore, infinitival clause separation applies after passive, since (10) but not (11) is well formed.

(10) Bob is believed by me to be honest.
(11) *Bob is believed to be honest by me.

If passive could apply after infinitival clause separation, (11) would be well formed. Therefore, on the old analysis, infinitival clause separation must sometimes apply to clauses in subject position, in order to get (10), and sometimes to clauses not in subject position, in order to get (8). And that means there will have to be two different statements of infinitival clause separation on the old analysis.

A similar duplication must arise on the old analysis of extraposition, since a clause not in subject position may be extraposed. Compare

(12) I know it well.
(13) I know well that Bob is honest.

All such duplication is avoided on the new analysis. Extraposition and infinitival clause separation apply possibly after passive and before subject raising to move something to the end of the clause.

Many years ago philosophers went beyond an Aristotelian subject-predicate logic to develop a logic of relations. The distinction between subject and predicate was seen to be a matter of surface form, of no logical importance. For logic, the important distinction became that between a predicate and its arguments. It is interesting to observe that what holds for logic holds for deep structure as well. Here is a first example of benefits to be derived through the identification of deep structure with logical form.

II

For philosophers, the logical form of a sentence is given by a paraphrase

into quantification theory. This leads one to wonder whether anything in deep structure corresponds to the quantifiers of logic. Work by the linguist James McCawley and by the philosopher John Wallace suggests the following answer.

Quantifiers in deep structure differ from the familiar quantifiers of modern logic in their variety of type and in the restrictions they carry with them. First, there are many more kinds of quantifier than the simple universal and existential quantifiers mentioned in discussions of quantification theory. Types of quantifiers are roughly indicated by what linguists sometimes call the *determiners* of noun phrases, words such as *any*, *every*, *all*, *each*, *a*, *the*, *some*, *few*, *a few*, *several*, *many*, *much*, *most*, *one*, *seven*, etc. Second, the quantifiers in a natural language have a varying range whereas quantifiers used in logic are usually associated with a fixed range: the universe of discourse. Occasionally, a logician will let certain quantifiers range over one universe while others range over other universes, depending on the style of variable employed. In that case, a small number of different sorts of quantifier are envisioned with fixed ranges. On the other hand, the quantifiers in a natural language have a varying range, where this is determined by a restricting phrase that follows the word indicating quantifier type. For example, the quantifier represented by the noun phrase 'many arrows' ranges over arrows and not over all things in the universe of discourse. How many count as many depends on that restricting phrase. If there are not many green arrows, then many of the green arrows will not be many of the arrows: many of the green arrows can hit the target without many of the arrows hitting the target.

Consider

(14) Many arrows didn't hit the target.
(15) The target wasn't hit by many arrows.

On the old analysis, (14) and (15) are corresponding active and passive. Since (14) does not mean what (15) means, at least in some dialects, the old analysis must permit transformations to change meaning. If quantifiers are represented in deep structure, (14) and (15) can be assigned different deep structures. For example, (14) might be assigned a deep structure as shown in Figure 8 whereas (15) might be assigned a deep structure as given in Figure 9.

The relative scopes of *many arrows* and *not* are different in (14) and (15). These scopes are determined by the deep structure: the scope of a constituent in deep structure includes whatever is dominated by the constituent immediately dominating it.

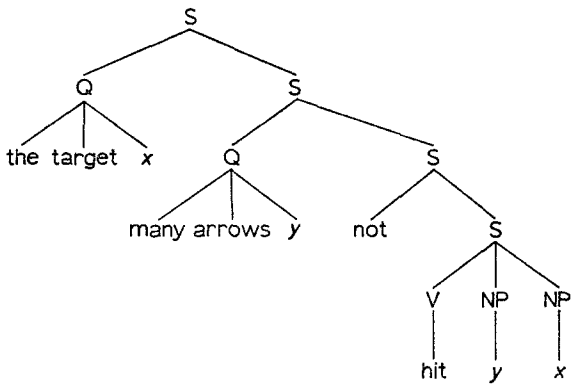

Fig. 8

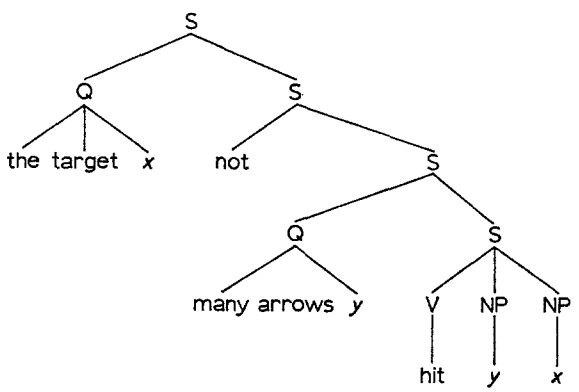

Fig. 9

(14) is derived from its deep structure by the following transformations in this order: subject raising, not-placement (changing *hit* to *didn't hit*), NP-placement (substituting *many arrows* for *y*), and another NP-placement (substituting *the target* for *x*). The order of these operations is determined by the *cyclic nature of transformational rules* which are to apply

to more deeply embedded sentences before they apply to less deeply embedded sentences. Similarly, (15) is derived from its deep structure by passive, subject raising, NP-placement, not-placement, and a final NP-placement.

(14) and (15) cannot be derived from each other's deep structure because of some general constraints on derivations that have been discussed by George Lakoff. In particular, for many operators, including certain quantifiers and negation, if in deep structure the scope of one includes a second, then in later stages of the derivation the first must precede the second whenever the second *commands* the first. (X commands Y if all S's dominating Y also dominate X.) This constraints would be violated with respect to *not* and *many* if (14) or (15) were derived from the other's deep structure.[4]

Quantifiers are variable binding operators. Sometimes a variable bound by a quantifier is replaced by the relevant noun phrase. Bound variables in deep structure that do not get replaced with noun phrases become pronouns:

(16) If any arrow is green, it will hit the target.
(17) If it is green, any arrow will hit the target.

(17) can be read as an instance of backwards pronominalization, in which case it is equivalent to (16). On the old view, pronominalization occurred when a noun phrase was 'identical' with its antecedent. (18) was supposed to have come from (19):

(18) If this arrow is green, it will hit the target.
(19) If this arrow is green, this arrow will hit the target.

(16) or (17) would have come from

(20) If any arrow is green, any arrow will hit the target.

Since (20) does not mean what (16) or (17) means, this provides another instance in which transformations do not preserve meaning on the old analysis.

A series of difficulties eventually undermined the old theory. One was that it could not account for the fact that

(21) Everyone loves everyone.

does not reduce via obligatory reflexive pronominalization to

(22) Everyone loves himself.

Another was that the theory sometimes seemed to lead to infinite regress.

(23) A boy who was fooling her kissed a girl that loved him.

According to the old theory, both *her* and *him* represent full NPs that are identical with their antecedents. (23) might come from

(24) A boy who was fooling a girl that loved him kissed a girl that loved a boy who was fooling her.

Even apart from the fact that (24) is not equivalent to (23), there is the added problem that it contains pronouns which – according to the old theory – represent full noun phrases identical with their antecedents. Obviously an infinite regress results. The old theory cannot account at all for sentences like (23).[5]

When semantic considerations are brought in, it becomes clear how linguistic theory benefits from the introduction of quantifiers and variables into deep structure. The *they* in

(25) If any arrows are green, they will hit the target.

cannot be the result of identical NP pronominalization, since (25) is not equivalent to

(26) If any arrows are green, any arrows will hit the target.

But *they* in (25) is easily taken as the trace of a variable:

(27) (Any arrows x) (if x are green, x will hit target).

Furthermore, when quantifiers appear in deep structure, ambiguity of scope becomes a form of syntactic ambiguity. The sentence

(28) Jones believes someone to be a spy.

may mean that there is someone in particular that Jones believes is a spy or it may mean that Jones believes there is at least one spy. On the new theory, this difference is reflected in there being two possible deep structures for (28): Roughly

(29) (Someone x) (Jones believes (x is a spy)).

(30) (Jones believes (Someone x) (x is a spy)).

Notice that in

(31) Someone is believed by Jones to be a spy.

the scope of *someone* cannot be read as confined to the embedded sentence, although it can be read that way in (28). We can account for this difference between (31) and (28) by supposing that the infinitival clause separation transformation can move only variables and sentences. For then (31) could be derived only from (29) and not from (30). Infinitival clause separation could not apply if *someone* has already been substituted for the relevant variable by NP-placement. Only a variable could be separated out from the rest of the infinitival clause. If *someone* has narrow scope, NP-placement will have to apply before infinitival clause separation can, this preventing the latter operation. If *someone* has wide scope, infinitival clause separation can apply before NP placement. Therefore, (31) can only be read with *someone* having wide scope, although (28) can be read either way.[6]

III

Improved grammars result from the identification of deep structure with logical form. Two points have been mentioned so far, the replacement of the subject-predicate form with predicate plus arguments and the introduction of quantifiers and variables. But mention of sentences like (28) and (31) suggests a problem about the analysis of *statements of propositional attitude*. Can the deep structure of such sentences be identified with their logical form?

Here are two sentences of propositional attitude:

(32) Jones believes that Ortcutt is a spy.
(33) Sam wants Ortcutt to be a spy.

Deep structures usually cited for such sentences contain as an embedded sentence, expanded in the usual way:

(34) Ortcutt is a spy.

But the most familiar philosophical analyses of the logical form of (32) or (33) suppose that (34) cannot appear as an embedded sentence in (32) or (33).

The problem is this. (34) and

(35) Ortcutt is the president of the local bank.

logically entail

(36) The president of the local bank is a spy.

But (32) and (35) do not logically entail

(37) Jones believes that the president of the local bank is a spy.

And (33) and (35) do not logically entail

(38) Sam wants the president of the local bank to be a spy.

(36) follows from (34) and (35) by the *substitutivity of identity*. The problem is to explain why contexts of propositional attitude block the substitutivity of identity.

One philosophical answer supposes that in (32) and (33) the word 'Ortcutt' does not refer to the same thing it refers to in (34). According to Frege, words that appear in a context of propositional attitude do not have the same meaning and reference they have outside that context. In (34) the word 'Ortcutt' refers to Ortcutt. In (32) and (33) it refers not to Ortcutt but to something else, e.g. to itself, or to the usual meaning of the word 'Ortcutt', or perhaps to the mental word 'Ortcutt'. What corresponds to (34) in (32) and (33) does not function semantically as a sentence but rather serves to refer to a sentence, a proposition, or a propositional attitude. Substitutivity of identity permits one to substitute one reference to a thing for another reference to the same thing. Given (35), 'Ortcutt' and 'the president of the local bank' refer to the same thing, but only in ordinary contexts. In a context of propositional attitude these phrases do not refer to the same thing, since e.g. they refer to the meaning of 'Ortcutt' and the meaning of 'the president of the local bank' respectively; so the substitutivity of identity does not authorize the replacement of one with the other.

An alternative answer, due to Donald Davidson, permits Ortcutt to have its usual reference in (32) and (33). But (32) and (33) are not taken to be sentences that contain (34) embedded within them. What corresponds to (34) in (32) and (33) is not taken to be part of the original sentence at all. Instead it accompanies the original sentence as an example or illustra-

tion referred to by that sentence. More perspicuously written, (32) and (33) would look like this:

(39) Jones believes that. Ortcutt is a spy.
(40) Sam wants (that). Ortcutt (is) to be a spy.

When someone asserts (39) or (40), he asserts the first sentence, not the second. In uttering the second sentence he produces an example of the sort of thing referred to in his first sentence. Similarly in (32) or (33). In uttering the words 'Ortcutt is a spy' or 'Ortcutt to be a spy', one gives an example of what one's assertion refers to. These words are not part of what one says when one utters (32) or (33) but are rather part of what one is talking about. In one's example, the word 'Ortcutt' does refer to Ortcutt; but substitutivity of identity cannot be applied to (32) or (33) with respect to 'Ortcutt' since that word does not occur in these sentences. It only occurs in something that accompanies them and to which they refer.

Neither of these philosophical answers to the problem of failure of substitutivity in these contexts fits in with the idea that deep structure is logical form. Deep structure is supposed to provide a full semantic representation of a sentence. There seems to be no syntactic alternative to the assumption that the deep structure of (34) appears embedded in the deep structures of (32) and (33). These philosophical answers would have us suppose that something that must function syntactically in deep structure as an embedded sentence does not function semantically as an embedded sentence. And that seems to violate at least the spirit of the idea that deep structure is full semantic representation. Thus, on Davidson's analysis, a structure that behaves syntactically as an embedded sentence in deep structure is semantically a sentence but is not semantically embedded. On Frege's analysis, that structure is semantically embedded but it is not semantically a sentence, although it behaves syntactically as a sentence. So both analyses conflict with the idea that at the deepest level syntactic and semantic structure coincide.

However, there is a way to account for the failure of substitutivity of identity in sentences such as (32) and (33) without supposing that syntactic and semantic structure diverge at the level of deep structure. The analysis of noun phrases and quantification already sketched above will do the trick. On that analysis all noun phrases come from quantifiers and therefore have a certain scope in deep structure. If the principle of the

substitutivity of identity is stated so as to apply only when the noun phrase in question has wide scope, it will automatically fail to apply in contexts of propositional attitude.

If (32) is understood like this

(41) Jones believes ((Ortcutt x) (x is a spy)).

then from (32) and (35) one cannot infer (37), because 'Ortcutt' does not have wide scope in (32). On the other hand, (32) can be understood like this

(42) (Ortcutt x) (Jones believes (x is a spy)).

In that case (32) and (35) do entail (37) because 'Ortcutt' has wide scope and substitutivity of identity applies.

Philosophers sometimes argue that an adequate analysis of logical form must permit a truth characterization. So it is important that a truth characterization of sentences of propositional attitude can be given if deep structure is identified with logical form. Into a Tarski-type theory of truth one might add principles for the denotation of names. Then one might take the representation of the object of a propositional attitude – which includes in deep structure an embedded S plus something more – to denote the embedded S itself or alternatively the proposition S expresses. The embedded S and its constituents retain their usual meaning. What is syntactically an embedded sentence is semantically an embedded sentence.[7]

IV

Finally, it is useful to consider what sort of theory results if deep structure is identified with logical form in the analysis of action sentences and causal sentences. Here there are competing philosophical theories of logical form as well as competing syntactic theories about the proper deep structures. Furthermore, all these theories are in a state of flux and development. The subject is too complex for detailed consideration here. All that can be done is to present a rather crude version of a theory of logical form that is being developed by Donald Davidson and then to compare that theory with standard grammatical analyses involving embedded sentences.

Consider these sentences:

(43) Jack opened the door with the key at ten o'clock.
(44) Fear caused Jack to open the door with the key at ten o'clock.

A semantic analysis of such sentences must account for the fact that (43) entails

(45) Jack opened the door with the key.
(46) Jack opened the door at ten o'clock.
(47) Jack opened the door.

One must also account for the fact that (44) and the following sentences can be understood so that (44) entails them.

(48) Fear caused Jack to open the door with the key.
(49) Fear caused Jack to open the door at ten o'clock.
(50) Fear caused Jack to open the door.

The problem is made more difficult by the fact that an indefinite number of adverbial phrases can occur in the verb phrase of (43). So it does not seem that one can account for the first set of entailments by supposing that e.g. (47) is a reduced form of

(51) Jack opened the door with something at some time ...

One might attempt to account for the second set of entailments in terms of the first set along with the principle that, if P entails Q, then *X causes P* entails *X causes Q*. But there is a difficulty here.

(52) A house that Jack built burned down.

entails

(53) Jack built a house that burned down.

but

(54) A short circuit caused a house that Jack built to burn down.

does not entail

(55) A short circuit caused Jack to build a house that burned down.

This does not refute the principle in question, since a defender of that principle can replay that the scopes of the noun phrases in (54) and (55) are wide, so that (52) and (53) do not actually occur in (54) and (55). But

then the problem becomes that of explaining why (54) and (55) cannot be understood in such a way that the relevant noun phrases have narrow scope and (52) and (53) do occur in them.

Davidson analyzes all these sentences as containing implicit quantification over events or actions. There is talk of Jack's opening of the door, where that is a particular event related in various ways to Jack, the door, the key, and ten o'clock. That event is caused by fear. In order to get a rough idea of the structure of his analysis, consider the following abbreviations:

(*Ex*) for *there is an event x such that*
Ox for *x is an opening* (*of something by someone*)
Bxy for *x is done by y* or *y is the agent of x.*
Fxy for *x is of* (*or done to*) *y* or *y is the object of x*
Wxy for *x is* (*done*) *with y* or *y is the instrument used in doing x*
Axy for *x is* (*done*) *at the time y*
Cxy for *x causes y*
j for *John*
d for *the door*
k for *the key*
t for *ten o'clock*
f for *fear*

Then Davidson's analyses of (43)–(50) are respectively

(56) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Wxk* & *Axt*).
(57) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Wxk* & *Axt* & *Cfx*).
(58) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Wxk*).
(59) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Axt*).
(60) (*Ex*) (*Ox* & *Bxj* & *Fxd*).
(61) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Wxk* & *Cfx*).
(62) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Axt* & *Cfx*).
(63) (*Ex*) (*Ox* & *Bxj* & *Fxd* & *Cfx*).

On these analyses, the fact that (43) entails (45), (46), and (47) is represented by the fact that (56) entails (58), (59), and (60) in elementary quantification theory. The fact that (44) entails (48) (49) and (50) is represented by the fact that (57) entails (61), (62), and (63). If with Davidson one treats these sentences as involving implicit quantification over events, one can give a perfectly straightforward account of the relevant entailments.

However, if Davidson's analyses are accepted, the semantic representation of (44) cannot contain embedded within it the semantic representation of (43). The semantic materials out of which (43) is constructed are also used in the construction of (44) but these materials are put together differently, so that (43) itself is not used in the construction of (44). The point stands out if the relevant materials are underlined when (56) is compared with (57):

(56) $\underline{(Ex)\,(Ox\ \&\ Bxj\ \&\ Fxd\ \&\ Wxk\ \&\ Axt).}$

(57) $\underline{(Ex)\,(Ox\ \&\ Bxj\ \&\ Fxd\ \&\ Wxk\ \&\ Axt}\ \&\ \underline{Cfx).}$

What corresponds to (56) in (57) is not quite a sentence: it lacks a left parenthesis – or, perhaps, it contains a gap right before its left parenthesis. That lack or gap is enough to keep (56) from appearing in (57). So, if Davidson's analysis is accepted and if deep structure is identified with logical form, one cannot say that the deep structure of (43) is embedded in that of (44) and the usual syntactic analyses of these sentences must be rejected.

As noted already, the situation is complicated by the existence of alternatives to Davidson's analysis and to the usual syntactic analyses. All analyses, including Davidson's, are in the process of being developed, elaborated, and modified. It is not possible to say at this time what the end result will be. It is to be expected that that result will be compatible with the identification of deep structure with logical form.

APPENDIX: PRONOMINALIZATION PROBLEMS

How is one to analyze (23)?

(23) A boy who was fooling her kissed a girl that loved him.

It is true that in some sense (23) is equivalent to

(64) (A boy x) ((a girl y) (x was fooling y and x kissed y and y loved x)).

But the quantifiers in (64) range over all boys and all girls respectively, while that does not seem true in (23). Karttunen makes an analogous point by considering the presuppositions of a sentence like

(65) The boy who was fooling her kissed the girl who loved him.

This sentence presupposes that there is exactly one pair consisting of a boy and a girl and such that he was fooling her and she loved him. Such presuppositions ought to be reflected in restrictions on appropriate quantifiers. This would not be so if (65) were analyzed as

(66) (The boy x) ((the girl y) (x was fooling y and x kissed y and y loved x)).

One needs something like

(67) (The boy x such that x was fooling y) ((the girl y such that y loved x) (x kissed y)).

But (67) is not correct since the first occurrence of y is not bound by the relevant quantifier.

The same problem emerges in clearer form in

(68) A boy who was fooling them kissed many girls who loved him.

Since *many* here must be associated with a narrower scope than that associated with the *a* of *a boy*, one is tempted to try:

(69) (A boy x such that x was fooling y) ((many girls y such that y loved x) (x kissed y)).

Again the first occurrence of y has not been bound by the relevant quantifier. Since the major quantifier ranges over boys who are fooling many girls who love them, one is tempted to try this:

(70) (A boy x: (many girls y: y loved x) ((x was fooling y)) (x kissed y).

[Here the colon is used for 'such that' introducing the restriction on a quantifier.] But now the final occurrence of y remains unbound by the relevant quantifier. If all occurrences of y are to be bound by a single quantifier, that quantifier will have to have wider scope. But, if *many* is given wide scope, the wrong meaning results; for then one is quantifying over girls who love some boy or other, not necessarily the same one.

One might consider a mixed analysis. For example, one might suppose that (68) comes from

(71) A boy who was fooling many girls who loved him kissed many girls who loved him

via identical NP pronominalization, whereas the pronouns in (71) are traces of bound variables. But this conflicts with the point noted in the main body of this paper, namely that identical NP pronominalization does not in general preserve meaning. Thus (68) and (71) are not equivalent. A boy who was fooling many girls who loved him might kiss many other girls who loved him. In that case (71) would be true but (68) could be false.

Indeed, it is not very clear what the logical form of (68) could be. It seems at least roughly equivalent to

(72) A boy who was fooling many girls who loved him kissed and was fooling many girls who loved him.

That suggests a deep structure roughly like this:

(73) (A boy x: (many girls y: y loved x) (x was fooling y)) ((many girls z: z loved x) (x was fooling z and x kissed z)).

But it is not at all obvious what transformations would be used to get (68) from (73).

An example that raises a similar problem is due to Geach:

(74) Almost every man who borrows a book from a friend eventually returns it to him.

A possible deep structure for (74) might be this:

(75) (Almost every man x: (a book y) ((a z: z is a friend of x) (x borrows y from z))) ((a book w: (a u: u is a friend of z) (x borrows w from u)) ((a v: v is a friend of x and x borrows w from v) (x eventually returns w to v))).

This would be to treat (74) as somehow a reduced form of

(76) Almost every man who borrows a book from a friend eventually returns a book that he has borrowed from a friend to a friend from whom he has borrowed it.

Again it is not clear that this gets the meaning right nor is it easy to see what transformations should be postulated to get (74) from (75). That suggests these analyses are wrong; but it is unclear what an alternative would be.

Here is an apparently similar problem which does seem to have a plausible solution. Recall that the *they* in

(25) If any arrows are green, they will hit the target.

represents the trace of a variable in

(27) (Any arrows x) (if x are green, x will hit the target).

Notice that

(77) If some arrows are green, they will hit the target.

can be read as equivalent to (25). Here too *they* cannot be the result of identical NP pronominalization, since (77) is not equivalent to

(78) If some arrows are green, some arrows will hit the target.

Furthermore, there seems to be no way to analyze *they* as the trace of a variable bound by *some arrows*. Thus

(79) (Some arrows x) (if x are green, x will hit the target).

gives a reading of (77) but not the intended reading on which (77) is equivalent to (25). Nor can we simply confine the scope of *some arrows* to the antecedent of the conditional, for then the *they* in the consequent would not fall under its scope:

(80) If (some arrows x) (x are green), x will hit the target.

A similar problem arises if *some* in (77) is replaced with *several*, *many*, *a few*, *two*, *seven*, etc.

One might try to argue that a third kind of pronominalization is at work here. (77) is equivalent with

(81) If some arrows are green, those arrows will hit the target.

Furthermore, one might take (81) as transformationally derived from

(82) If some arrows are green, those arrows that are green will hit the target.

by deleting *that are green*.

However, the problem with this solution is that the phrase *those arrows* in (81) would seem itself to be more a kind of pronoun, a variant of *they*,

than a reduced version of *those arrows that are green*. Compare (81) with

(83) If some arrows are such that those arrows are green, those arrows will hit the target.

The phrase *those arrows* seems to have the same function in (81) and in both of its occurrences in (83). But (83) cannot be read as

(84) If some arrows are such that those arrows that are green are green, those arrows that are green will hit the target.

So it is doubtful that in (81) *those arrows* represents a reduced form of *those arrows that are green.*

Similarly, consider

(85) Any arrows are such that, if those arrows are green, those arrows will hit the target.

Here *they* may replace *those arrows* on each of its occurrences without change of meaning. Furthermore, *those arrows* has the same function on each of its occurrences, and its occurrence in the antecedent is obviously not a reduced version of *those arrows that are green.* One can best account for these cases by assuming that bound variables that are not replaced by the NP of the quantifier binding them can become, not only pronouns, but also NPs of the form *the*, *these*, or *those Fs*, where *F* is a possibly reduced form of the restriction on the relevant quantifier.[8]

How then is one to account for the pronominalization in (77)? One plausible solution is to suppose that the deep structure quantifier in (77) is not *some arrows* but is rather *any arrows*. This is to suggest that both (25) and (77) have the same analysis:

(25) If any arrows are green, they will hit the target.
(77) If some arrows are green, they will hit the target.
(27) (Any arrows x) (if x are green, x will hit the target.

One must also suppose that *any* can sometimes be changed to *some* during NP-placement. This can only happen when an NP is placed into certain contexts, e.g. the antecedent of a conditional; however, it is not clear how one might give a general characterization of the relevant contexts.

This theory explains the otherwise puzzling difference between (77) and

(86) If they are green, some arrows will hit the target.

If *they* is treated as (cross) referring to the relevant arrows, (77) is ambiguous in a way that (86) is not. In (77) *some arrows* can be read as coming from an underlying *some arrows*, with wide scope, or from *any arrows*. In (86), since *some arrows* appears in the consequent, it can come only from an underlying *some arrows*, and not from *any arrows*.

This suggestion can be extended to examples in which *some* in (77) is replaced by *several*, *many*, *a few*, *two*, *seven*, etc. For example,

(87) (Any seven arrows x) (if x are green, x will hit the target).

can become any of the following:

(88) If any seven arrows are green, they will hit the target.
(89) If some seven arrows are green, they will hit the target.
(90) If seven arrows are green, they will hit the target.

So, the second problem seems solvable in a completely satisfactory way. Whether an analogous trick will take care of the first problem remains unclear.

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[1] The notion 'deep structure' is sometimes defined differently.
[2] This assumption is accepted by James McCawley, Paul Postal, Emmon Bach, Charles Fillmore, John Ross, George Lakoff, and Pieter A. M. Seuren. The presentation here is (selectively) based on their work, especially McCawley's. Noam Chomsky defends a theory not discussed here in which deep structure trees are not full semantic representations.
[3] PASSIVE appeared in the VP because it was taken to be a form of manner adverbial which appears in the VP. Thus, many manner adverbial phrases contain the preposition *by* which the subject is assigned when put into passive position. And verbs that take passive also take manner adverbial – and vice versa.
[4] Lakoff points out that these constraints are weak and vary from person to person, so (14) or (15) or both may be ambiguous for some readers.
[5] Not that such sentences are easy to handle on any theory. For more discussion, see the Appendix.
[6] Generalizing the movement constraint here placed on infinitival clause separation may shed light on movement constraints discussed by Ross and by Postal; but this point cannot be pursued here.
[7] The preceding paragraphs generalize points made by Smullyan. I am indebted here to John Wallace.
[8] Quine makes roughly this point. I should also note that backward pronominalization of this sort does not seem possible.