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PRINCIPLES OF ABSTRACTION FOR EVENTS AND PROCESSES[1]

Davidson's analysis of event sentences[2] is offered, in the first place, in order to explain the validity of a certain type of inference, sometimes referred to as "adverb dropping". E.g. 'Herodotus journeyed to Egypt in winter' implies 'Herodotus journeyed to Egypt'. The validity of this kind of move is accounted for by recasting the sentences in first-order form where the adverb or adverbial phrase is turned into a predicate of events, so that the inference can be recognised as valid according to first-order logic. In the case of the example the form of the premise may be shown by the paraphrase 'There was a journeying to Egypt by Herodotus which was in winter'.

Davidson himself makes it quite clear that this type of explanation is not applicable with all adverbs. E.g. 'quickly' is set aside and no attempt is made to provide a similar (or a different) explanation for the validity of inferences where 'quickly' is the adverb dropped on the way to the conclusion. Intuitively, inferences 'x F-ed quickly; so x F-ed' and 'x F-ed in winter; so x F-ed' are of the same kind, and their validity is to be explained in the same way. Now this can indeed be done within Davidson's framework if one is willing to acknowledge different events whenever Davidson recognises just one event identified by non-equivalent descriptions. But for many Davidson's view that one and the same event may be referred to by quite distinct descriptions (that e.g. a swimming of the Channel may be identified with a crossing of the Channel) has a stronger appeal than Davidson's analysis of all event sentences in terms of first order constructions. For them it is unsatisfactory that adverbs like 'quickly' are treated differently from the rest. Unless a reason can be provided why different explanations must be given for different instances of what is apparently the same inferential pattern, a single explanation of the validity of the pattern is to be looked for. Since Davidson's explanation is applicable only to a subclass of the inferences of the pattern,

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and cannot be extended to cover all instances, it appears that the explanation fails, perhaps for the reason that, focussing on a specific property of a group of adverbs, that they are construable or paraphrasable as predicates of events, it misses something more general that would explain all instances of the pattern.

There may not be agreement on what to expect of an explanation in this area. It appears to me though that it would be natural to suggest, for the Herodotus example, something like 'To journey somewhere in winter is (*ipso facto*) to journey there'. This will have to be generalised appropriately in order to explain the inference pattern. It should be emphasised that we are given here not merely a restatement of the inference to be explained. There are other (types of) inferences that are also accounted for. So, 'Herodotus never journeyed to Egypt: Herodotus never journeyed to Egypt in winter' and 'Twice Herodotus journeyed to Egypt in winter ∴ Herodotus journeyed to Egypt at least twice'.

The principle suggested has to be formalised so as to permit a general explanation of such arguments. It has to cover 'For the river to burst its banks in winter is (*ipso facto*) for it to burst its banks' and the like, and of course it has to be general with respect to adverbs and adverbial phrases. The following formulation may achieve this: 'For something to happen φ-ly is (*ipso facto*) for it to happen.'

Accepting the suggested explanation has the advantage that semantic intuitions can be preserved which e.g. see nouns and noun phrases as referring expressions and do not attribute to verbs such a role. Davidsonian paraphrases appear inappropriate as they introduce reference to entities, certain events, not to be found in the original sentence. 'There was a journeying to Egypt by Herodotus' speaks of certain journeyings while 'Herodotus journeyed to Egypt' does not.

Given an alternative explanation for the class of inferences that prompted Davidson's analysis, and possibly a systematic semantics for event sentences that does not employ quantification over events, that analysis can be rejected on the grounds that it misrepresents the referential implications of large numbers of event sentences. This quickly leads to a new question, namely about the relationship between, say, 'Herodotus journeyed to Egypt' and 'There was a journeying to Egypt by Herodotus'. There is obviously something correct about the paraphase. While the two sentences are semantically distinct on account of their different referential implications they have the same truth conditions, they are true, or false, in the same circumstances. The second sentence refers to journeyings in addition to those entities that are also referred to in the first sentence. We may say that the two sentences describe the same reality, but articulate it in different ways. My suggestion is that the second sentence is obtainable from the first by way of abstraction, or a process analogous to abstraction. In this manner, reference to certain events is introduced just as with the usual abstractive steps reference to classes can be introduced.

On this view a count noun should be seen as referring to each one of the objects that fall under it. So, 'horse(s)' refers to all and only horses (not to the class of horses). Count nouns provide domains for quantifiers. So, e.g. 'Every *G* . . .', 'The *G* . . .'.

An analogous referential role is to be attributed to mass nouns: 'water' refers to all and only water; and a mass noun can specify a domain of quantification for mass quantifiers, e.g. 'All *M* . . .', 'Much *M* . . .'. The semantic function of mass nouns is relevant in connection with sentences that deal with processes. So the mass noun 'swimming' occurs in the sentence 'For two hours there was swimming in the river by Alphonse'. Again I hold that this sentence, though equivalent to 'Alphonse swam in the river for two hours', is not semantically identical with it, precisely because of the reference to swimming which is absent from the second sentence.[3]

The view that count nouns and mass nouns are referrring expressions and the subsequent claim that a sentence containing a general term represents the world differently from a sentence that does not contain the term even if it is true in the same circumstances must be argued for in terms of the overall adequacy of a semantic system that incorporates this view. Here I will point out only one feature that indicates the referential role of general terms. In a modal context a referring expression can function in such a way as to result in a *de re* assertion about the objects referred to. In connection with the earlier example we can distinguish 'Two of the journeyings to Egypt by Herodotus had to take place in winter' from 'It was necessary that two journeyings to Egypt by Herodotus take place in winter'. The latter is equivalent to 'It was necessary that Herodotus journey to Egypt twice in winter' while the content of the former, *de re*, statement cannot be reproduced in a sentence that uses the verb 'journey(s)' and not the general term 'journeyings'. Because general terms refer, they are suitable for the making of modal *de re* assertions, while verb phrases are not.[4]

Of course it is also part of our natural semantic understanding that nouns refer and verbs do not. So I am suggesting, contra Davidson, that "surface structure" be taken at face value as far as possible. This does not mean that every noun and nominal phrase must be construed referentially. It may well be that, e.g. 'Ugliness fascinates' is to be analysed and construed as consisting of a second order predicate attached to a first order predicate 'is ugly'[5] because no sufficient grounds exist for counting ugliness and the like as entities.[6] Davidson's account leads of course in the opposite direction, namely to the attribution of reference to verbs.

Where new referring expressions are introduced by abstraction it can be expected that these can subsequently be employed in sentences which are not, equivalently, expressible in the original vocabulary, i.e. without the new referring expressions. And such sentences may then in turn be subject to reformulation in accordance with the relevant principles of abstraction. Class abstraction is a notorious example of the inherent iterative potential of abstraction. Since classes as objects fall themselves under various predicates further classes (some of) whose members are classes, can be obtained.

The situation is similar with the abstraction of events and processes. When events themselves fall under predicates of the event verb type then further steps of abstraction are possible. So 'Two of Herodotus' journeyings to Egypt were filmed more than once' or 'Raoul's playing of the moonlight sonata was interrupted three times' lend themselves to further abstraction by which general terms for further events are introduced. This process can, in principle, be repeated indefinitely. It should be noted also that the two example sentences cannot be expressed, equivalently, without reference to journeyings or sonata playing. The predicates 'is filmed more than once' and 'is interrupted three times' cannot, it seems, be expressed as adverbs.

The major part of this paper is concerned with the identification of the appropriate principles of abstraction and their application to more complex sentences reporting that things change in certain ways.

It should be mentioned that in this paper the general question as to what the identity conditions of events are is not answered. Event identity is indeed explained in terms of the holding of a certain equivalence that can be specified for event verbs. But it is assumed that we know what is required for the equivalence to hold in each case; no attempt is made to obtain an analysis of the equivalence, i.e. a general characterisation of the conditions under which it holds.

1. EVENT CLAUSES AND PROCESS CLAUSES

According to Davidson's treatment of sentences reporting happenings, the sentence

(1) Hilary climbed Mt Everest

is analysed as

(2) There is[7] a climbing of Mt Everest by Hilary

and this sentence in turn is forced into the form of a first-order formula by treating 'climb' as a 3-place predicate relating, in this case, Hilary, Mt Everest, and a certain event.

Similarly,

(3) Hilary climbed Mt Everest three times

would be given the analysis

(4) There are three climbings of Mt Everest by Hilary

which is again assimilated to a formula of predicate logic with identity.

In order to investigate the semantic relationship between sentences like (3) and their counterparts, such as (4), some grammatical labels will be needed. A phrase like 'Hilary climbed Mt Everest' will be called an event clause. The following grammatical criterion is proposed:

> In combination with a numerical adverb (e.g. 'three times') an event clause forms a complete sentence.

I suggest that even in those cases where such a phrase, occurring by itself, seems to effect a complete statement, as in (1) above, the full sentence would be, say,

(5) At least once Hilary climbed Mt Everest.

The existential quantifier in (2) bears witness to this.

A second grammatical category, of process clauses, is characterised by the condition that together with certain adverbs, introducing measures, a complete sentence is formed.[8] Examples of such quantitative adverbs are: 'much', 'a little', 'a lot', 'for several hours'. E.g. the sentence 'Alphonse walked a lot' contains the process clause 'Alphonse walked'.[9] When there is no explicit adverb then 'some' as in 'Alphonse walked some' has to be understood.

As indicated before, I want to suggest that (2) cannot be an analysis of (1) since (1) and (2) have different ontological implications. (2) contains a reference to certain events, namely climbings by Hilary of Mt Everest, while (1) does not contain such a reference. (1) and (2) are indeed equivalent, have the same truth conditions, but they are not semantically identical.

A similar situation obtains with the pair of sentences

Cecily is a trumpeter
Cecily belongs to the class of trumpeters

and again with the pair

There are more *A*s than *B*s
The number of *A*s is greater than the number of *B*s.

The two sentences of a pair have the same truth conditions; and yet they are semantically distinct in as much as the first, unlike the second, contains no reference to sets or numbers.

Indeed I think that the step from (1) to (2) involves abstraction. In a similar way abstraction is involved in the move from

(6) Alphonse worked little (for two years)

which contains a process clause, to

(7) There was little (there were two years of) working by Alphonse.

(7) contains reference to a process: working by Alphonse, whereas (6) does not contain such a reference.

In order to formulate the principles of abstraction that are at work the semantics of sentences containing event or process clauses should perhaps be known. Part of the reason for accepting Davidson's analysis of action sentences is of course that otherwise no satisfactory semantic account of the original sentences themselves is known. What is clear is that event clauses cannot be treated semantically like sentences. 'Alphonse yawns' would then have as semantic value a truth value or a set of possible worlds,[10] and from such a semantic value the number of times Alphonse yawns cannot be recovered. More precisely, two event clauses '*A*' and '*B*' could have the same semantic value even if the number of times *A* is different from the number of times *B*. So there is a gap to be filled if Davidson's analysis is not accepted. I shall sketch semantics for event clauses at the end of this paper. But in the main text I will not invoke formal semantics but rely on some intuitively clear implicational relationships. I think that these are not subject to doubt, that they could in fact be treated as test cases for any proposed semantics.

Sentences like (2) and (4) have a familiar structure. The gerund 'climbings' functions syntactically as a noun; and in general one-place quantifiers such as 'there are (*n*) . . .' require a noun or a noun phrase.[11] The role of the qualifications 'by Hilary' and 'of Mt Everest' remains to be determined. My suggestion is that we regard 'climbings of Mt Everest by Hilary' as a complex noun phrase obtained by filling the two argument places in the functor 'climbings of . . . by . . .' with 'Mt Everest' and 'Hilary', respectively. I want to emphasise the semantic and syntactic similarity of 'climbings of *x* by *y*' with 'suburbs of . . .' and 'multiples of *x* and *y*' and so on. The complex noun phrases obtained by filling the (one or more) argument places of the functors refer to certain suburbs, multiples and climbings, respectively.

The structure of (7) is analogous. The l-place mass quantifier 'there is little' is attached to the complex mass noun 'working by Alphonse'. (The usual grammatical tests reveal that this is indeed a mass noun.) This in turn contains the functor (with one argument place) 'working by' and its argument 'Alphonse'. 'Working by' should be assimilated to '(the) property of'; and just as 'property of Alphonse' refers to all (the) property of Alphonse (distributively), 'working by Alphonse' refers to all working by Alphonse (distributively).

2. EVENTS

If nouns referring to events can indeed be obtained from event clauses by abstraction then we expect that an equivalence expression can be formulated, where the terms are event clauses, which determines identity among the events introduced by abstraction. So that, if '*A*' and '*B*' are event clauses, and the equivalence obtains, then the *A*-ings are identical with the *B*-ings.

An equivalence expression that suggests itself is this: 'For it to happen that *A* is for it to happen that *B* and for it to happen that *B* is for it to happen that *A*', or something similar. An instance might be: 'For Alphonse to cook dinner is for Alphonse to cook a four course meal and vice versa'. The satisfaction of this condition is, one would think, both sufficient and necessary for the identity of the appropriate classes of events, i.e. in this case, the identity of the events each of which is a cooking of dinner by Alphonse and those which are, each, a cooking of a four course meal by him, and in the general case, the identity of the *A*-ings with the *B*-ings.

The intended meaning can also be circumscribed in other ways: 'Whenever *A*, *eo ipso B* and whenever *B*, *eo ipso A*' conveys the same equivalence and so does a more complex expression which employs the connective 'or'. If '*A*' and '*B*' are event clauses then so is '*A* or *B*'. If it holds that

A as often as *A* or *B*

then, intuitively, the *B*-ings are included among the *A*-ings. Take it as given, for example, that one cooks dinner as often as one either cooks dinner or cooks a four course meal; then this means that one's cookings of a four course meal are included among one's cookings for dinner.

Consequently, '*A* as often as *A* or *B* and *B* as often as *A* or *B*' is another way of formulating the equivalence that underlies the identity of *A*-ings with *B*-ings. It must be noted however that this method of formulating the equivalence works only as long as *A*-ings and *B*-ings are finite in number.

Unfortunately, none of the three formulations is free from ambiguity. The main reason for this is that often we are interested in counting occasions on which something happens rather than the happenings themselves. So '*A* as often as *B*' may at times mean '*A* on as many occasions as *B*', and to the extent that it may happen that *A* (happen that *B*) more than once on the same occasion the truth conditions are then not that there are as many *A*-ings as *B*-ings.[12] Consequently, on this understanding '*A* as often as *A* or *B* and *B* as often as *A* or *B*' merely asserts that *A*-ings and *B*-ings occur on the same occasions.

In the same way 'Whenever *A*, *B*' and 'For it to happen that *A* is for it to happen that *B*' may be understood as 'On every occasion on which *A*, *B*', i.e. as saying that *B*-ings occur on all occasions on which *A*-ings occur, rather than that all *A*-ings are *B*-ings. By way of illustration assume that Maurice visits Alphonse just (on those occasions) when Alphonse cooks dinner. All three of my proposed formulations of the intended equivalence can be so understood as to be true when one takes 'Alphonse cooks dinner' and 'Maurice visits him' for '*A*' and '*B*'.

Moreover, even when it is clear that not mere co-occurrence is at issue, 'Whenever *A*, *eo ipso B*' may be taken to be true if every *A*-ing, while not itself a *B*-ing, has a proper part that is a *B*-ing, as when Alphonse never cooks dinner without preparing a dessert.

Seeing that unwanted readings of my proposed formulations are possible I must take the attitude that these can be identified by circumlocutions and ruled out as unintended so that the wanted reading of those formulations stands out. For it would certainly weaken my case if there was no natural formulation of the equivalence that, as I want to claim, underlies event identity.

Let then '$\prec$' signify the semantic ordering among event clauses which, I shall assume, is sufficiently characterised by stipulating that the meaning of '$A \prec B$' is 'For it to happen that *A* is for it to happen that *B*' or, in other words, 'Whenever *A*, *eo ipso B*' or, again, '*B* as often as *A* or *B*', once the unwanted meanings of these locutions have been ruled out.

Given the ordering $\prec$, one can define

(Df 1) $\quad A \succ\!\prec B \quad \text{for} \quad (A \prec B) \;\&\; (B \prec A)$

$A \succ\!\prec B$ is an equivalence which in many contexts allows substitution and which allows the formulation of the principles of abstraction for events.

As concerns abstraction, I suggest this schema:

$$\text{(E1)} \qquad A \succ\!\prec (\exists A\text{-ings } x)\ x \text{ occurs}$$

As before, 'A' represents event clauses. The type of expression on the right hand side of '$\succ\!\prec$' must also be that of event clauses, which means that 'e occurs' is an event clause, not a complete sentence. The 2-place quantifier '$(\exists\_\_\_\_x) \ldots x \ldots$' amounts to the same as a restricted quantifier in a many-sorted calculus. The range of the quantifier is provided by the general term which fills the gap '____', here 'A-ings'.[13]

The function of the abstraction schema (E1) can be appreciated by comparing it with the abstraction schemata for classes and attributes:

$$(\forall x)(Fx \equiv x \in \{y \mid Fy\}) \text{ and}$$

$$(\forall x)(Fx \equiv x \text{ HAS } \lambda y(Fy)).$$

In each case two syntactic devices are introduced simultaneously; one transforms an expression of the original type (a predicate 'F', an event clause 'A') into a term ('$\{y \mid Fy\}$', '$\lambda y(Fy)$', 'A-ings'), one effects the converse categorial change ('$\in$', 'HAS', 'occurs').

Next, identity conditions for events have to be specified. As we have already seen, $A \succ\!\prec B$ is both necessary and sufficient for the identity of the A-ings with the B-ings. For the sake of brevity I define for count nouns G, H generally

$$\text{(Df 2)} \quad G = H \quad \text{for} \quad (\forall G\ x)(\exists H\ y)\ x = y \ \&\ (\forall H\ x)(\exists G\ y)\ x = y$$

so that the intended identity condition for events is

$$\text{(EI1)} \qquad A \succ\!\prec B \Leftrightarrow A\text{-ings} = B\text{-ings}$$

But this is not sufficient to guarantee that there is the right number of events (of A-ings) derived from the event clause A. The number of A-ings must be the same as the number of times A. (There are n yawnings by Alphonse just when Alphonse yawned n times.) We can guarantee this numerical correspondence by postulating that every event occurs exactly once and, given two events, that one or the other happens is itself something that occurs more than once.

(E2.1) $(\forall G\ x)$ at least once (x occurs)

(E2.2) $(\forall G\ x)$ at most once (x occurs)

(E2.3) $(\forall G\ x)(\forall H\ y)$ ((at least once (x occurs) & at least once (y occurs) & once (x occurs $\vee$ y occurs)) $\Rightarrow x = y$)

or, equivalently, in the presence of (E2.2),

(E2.3′) $(\forall G\ x)(\forall H\ x)$ (at least once (x occurs) & (x occurs $\prec$ y occurs) $\Rightarrow x = y$)

('G' and 'H' are schematic letters for general event terms.)

The following principle (EI2) is a consequence of (E2.1) and (E2.3). By this I mean that we can appreciate that (EI2) follows in virtue of our understanding of event clauses, numerical adverbs and other logically relevant parts of sentences. The adequacy of any formal semantics for event clauses is to be judged, partially, by whether or not it validates such inferences.

(EI2) $((\exists G\ x)\ x$ occurs $\rtimes\!\ltimes$ $(\exists H\ y)\ y$ occurs$) \Rightarrow G = H$

(EI1) is then a consequence of (EI2), its converse, which is a logical truth, and (E1). In obtaining (EI1) appeal is made only to the equivalence properties of '$\rtimes\!\ltimes$'.[14]

Our original concern was with equivalences of the kind exemplified by (3) and (4), i.e. generally

(8) n times $A \Leftrightarrow$ there are n A-ings

These equivalences are guaranteed by the abstraction principles, since

n times A

$\Leftrightarrow$ n times: $(\exists A\text{-ings}\ x)\ x$ occurs
[in virtue of (E1)]

$\Leftrightarrow$ $\left(\exists_n A\text{-ings}\ x\right)$ at least once: x occurs
[Here we appeal to truths of the logic of event clauses. For intuitively it is obvious that 'n times some G occurs' is equivalent to 'there are n Gs, each of which occurs at

least once', given that every G occurs at most once (E2.2) and that when one G and another G occur then this means that twice a G occurs (E2.3)]

$\Leftrightarrow$ there are n A-ings
[If exactly n Gs have a property which is universal among Gs then there are just n Gs, and vice versa; '. . . occurs at least once' is such a property ((E2.1))]

In the same way we obtain

(9) at least once $A \Leftrightarrow$ there are A-ings

An example of this equivalence we encountered earlier: (1) and (2).

3. PROCESSES

For processes too, abstraction is based on an equivalence, an equivalence that is stated with the help of process clauses. E.g. if it is true that for Maurice to be swimming in summer is for him to be swimming in the sea and vice versa then Maurice's swimming in summer is his swimming in the sea. In order to characterise the equivalence one can again begin with a semantic ordering '$\prec$'. '$D \prec E$' is to mean that for it to be happening that D is for it to be happening that E, or, in other words, that always when it is happening that D then it is *eo ipso* happening that E, or that E as much as D or E.

'D as much as E' is perhaps not defined for all process clauses. There is, apparently, no common measure of, say, singing and sleeping; and hence no criterion for judging whether somebody sings as much as she/he sleeps, except in terms of time taken. Note however that we cannot substitute 'D for as long as E' for 'D as much as E'. For '(Either Max sings or Maurice sings) for as long as Maurice sings' is true when Max and Maurice always sing together, while '(Either Max sings or Maurice sings) as much as Maurice sings' is false, there being twice as much singing by Max or Maurice as there is singing by Maurice. However, truth conditions of 'D as much as E' are determinate if D-ing is a part of E-ing (i.e. if all D-ing is E-ing) or E-ing a part of D-ing, and these are just the cases that are of interest. So we may take '$D \prec E$' as false when 'D as much as E' does not have determinate truth conditions.

The equivalence is then

(Df 3) $D \rightarrowtail\!\!\!\!\leftarrowtail E$ for $(D \prec E) \,\&\, (E \prec D)$

and the following schema is appropriate for process clauses:

(P1) $D \rightarrowtail\!\!\!\!\leftarrowtail$ (Some D-ing p) p takes place[15]

(The mass quantifier 'Some' is the counterpart of the thing quantifier '$\exists$')[16].

Next, we are looking for a principle that underlies the correspondence between the quantitative adverbs ('a lot', 'little', etc.) and the mass quantifiers ('there is a lot', 'there is little', etc.), i.e. a principle from which the equivalences

(10) a lot $D \Leftrightarrow$ there is a lot of D-ing

and the like would follow.

We can begin with the truth that all of a process takes place.

(P2.1) (All M p) some (p takes place)

('M' here is a schematic letter for process nouns.) This corresponds to (E2.1), which says that any event occurs. The adverb 'some' in (P2.1) is required, since '(All M p) p takes place' is a process clause, not a complete sentence.

The condition corresponding to (E2.3) is

(P2.3) (All M p) some (p takes place)
& ((Some M p) p takes place $\prec$ (Some N p) p takes place) $\Rightarrow$ All M is N

and to (E2.2) corresponds

(P2.2) (All D-ing p) p is E-ing $\Rightarrow D \prec E$[17]

Adopting (P1) and (P2) is not enough to obtain equivalences such as (10). In order to compare the quantitative scale indicated by the quantitative adverbs ('much', 'little') with the quantitative scale invoked by mass quantifiers ('there is much', 'there is little') the theory of measurement has to be appealed to, or so it seems. This would mean that it has to be ensured that (1) unit measures on the two scales correspond to one another, (2) ratios of measures correspond, and it would have to be assumed that the meaning of, say, 'there is a lot of' can be expressed in terms of 'there is r times as much of . . . as of . . .'.

However, I don't believe that anything like a system of measures underlies our use of the quantitative adverbs, or the corresponding mass quantifiers, at least in this context. Indeed their conditions of application are quite vague. So instead of appealing to a system of measures I prefer to assume that the required equivalences are understood one by one, that we have, consequently, to stipulate an open-ended but small class of equivalences

(P3) a lot: (Some M p) p takes place $\Leftrightarrow$ (A lot of M p) some (p takes place)

little: (Some M p) p takes place $\Leftrightarrow$ (Little M p) some (p takes place)

much: (Some M p) takes place $\Leftrightarrow$ (Much M p) some (p takes place)

some: (Some M p) p takes place $\Leftrightarrow$ (Some M p) some (p takes place)

⋮

The clauses of (P3) exhibit the correspondences between quantitative adverbs and mass quantifiers. The latter specify how much (of a certain process, say singing) there is, the former to what extent it takes place. The correspondence is a simple one because of the characteristics of the process verb 'p takes place' stated in (P2). In fact (P2.1) does not play a role here. Only the features of 'p takes place' that are expressed in (P2.2) and (P2.3) are relevant.

Finally, we come to the identity conditions for processes. To abbreviate, let '$M = N$' be short for 'All M is N and all N is M'. I.e.

(Df 4) $M = N$ for (All M p) p is N & (All N p) p is M

Then

(PI2) (Some M p) p takes place $\rightarrowtail\!\!\!\leftarrowtail$ (Some N p) p takes place $\Leftrightarrow M = N$

follows from (P2.1) and (P2.3) and implies, together with (P1),

(PI1) $D \rtimes\!\!\!\ltimes E \Leftrightarrow D\text{-ing} = E\text{-ing}$

The postulated properties of process abstraction and the verb '*p* takes place' suffice to derive equivalences similar to those whose form is given in (8):

$$(11) \qquad \left.\begin{matrix}\text{some}\\ \text{a lot}\\ \text{little}\end{matrix}\right\} D \;=\; \left.\begin{matrix}\text{there is}\\ \text{there is a lot of}\\ \text{there is little}\end{matrix}\right\} D\text{-ing}$$
$$\begin{matrix}\vdots & \qquad\qquad & \vdots\end{matrix}$$

As an example take the equivalence between 'It rains little' and 'There is little raining'.

Equivalences of the form (11) are justifiable like this:

A lot *D*

$\Leftrightarrow$ A lot: (Some *D*-ing *p*) *p* takes place
[in virtue of (P1)]

$\Leftrightarrow$ (A lot of *D*-ing *p*) some (*p* takes place)[18]
[invoking one of the clauses (P3)]

$\Leftrightarrow$ There is a lot of *D*-ing
[according to (P2.1) 'some (*p* takes place)' is true of all *D*-ing; hence if a lot of *D*-ing has this property there must be a lot of *D*-ing]

4. COMPLEX CLAUSES

In most cases event and process clauses are semantically complex. In these cases the events or the process in question can be referred to, usually, by terms which are semantically complex in a corresponding manner. In this section some of the more important structural features of event and process clauses will be discussed and in the following section I shall turn to adverbs.

(a) *Arguments*

Typically, an event clause, or a process clause, consists of a verb with a number of arguments. So we had 'Hilary climbed Mt Everest' in (1) and 'Alphonse walked' in (6). When the argument positions are transparent, as they commonly are, i.e.

$$(12) \qquad t = s \Rightarrow V(t_1, \ldots, t, \ldots, t_n) \succ\!\prec V(t_1, \ldots, s, \ldots, t_n)$$

(here t, s, $t_1, \ldots, t_n$ are singular terms and V a verb), then it follows in the case of event clauses that

$$t = s \Rightarrow (V(t_1, \ldots, t, \ldots, t_n))\text{-ings} = \\ = (V(t_1, \ldots, s, \ldots, t_n))\text{-ings}$$

Consequently, it is possible to define a function V^{ings} by

$$(\text{Df } 5) \qquad V^{\text{ings}}(x_1, \ldots, x_n) = (V(x_1, \ldots, x_n))\text{-ings}$$

This is a function whose arguments are just the arguments of the verb, and which, for given arguments $t_1, \ldots, t_n$, has as values certain events, namely the $(V(t_1, \ldots, t_n))$-ings. As I have pointed out, such functional expressions are standardly used in English; e.g. 'climbings by x_1 of x_2'.

In the case of process clauses, a function W^{ing} can be defined

$$(\text{Df } 6) \qquad W^{\text{ing}}(x_1, \ldots, x_n) = (W(x_1, \ldots, x_n))\text{-ing}$$

'Teaching by x_1 of x_2 to x_3' is an example of such a function in English.

(b) *'Or' and 'Some'*

We have encountered 'or' as a connective which combines two event clauses into a complex event clause, or two process clauses into a complex process clause. This is not the truth-functional sentential connective 'or', nor can it, it seems, be explained in terms of the sentential connective, in the sense in which the significance of the disjunctively complex predicate 'ϕ or ψ' can be explained by saying that it applies to an individual if either 'ϕ' applies or 'ψ' applies. But the clause connective 'or' has the lattice operational properties of a join relative to the ordering due to '$\prec$', and I shall represent it by '$\vee$'.

When now '$A \vee B$' is a complex event clause then, intuitively, the $(A \vee B)$-ings are just the A-ings together with the B-ings. We may use '$\cup$' (in English usually 'and', at times 'or') to form out of the general terms G and H the general term '$G \cup H$' which refers to every G and every H and nothing else.

When $V(x)$ is an event clause with one argument place the following equivalences are obviously valid

$$(13a) \qquad (\exists G \cup H\ x)V(x) \succ\!\!\prec (\exists G\ x)V(x) \vee (\exists H\ x)V(x)$$

From this follows the intuitively correct identification of $(A \vee B)$-ings with A-ings $\cup$ B-ings. On the one hand,

$$A \vee B \succ\!\!\prec (\exists (A \vee B)\text{-ings } x)\ x \text{ occurs [by (E1)];}$$

on the other

$$\begin{aligned} A \vee B &\succ\!\!\prec (\exists A\text{-ings } x)\ x \text{ occurs} \vee (\exists B\text{-ings } x)\ x \text{ occurs} \\ &\qquad \text{[also by (E1), exploiting the fact that ` } \vee \text{ ' is} \\ &\qquad \text{extensional with respect to the equivalence} \\ &\qquad \text{`} \succ\!\!\prec \text{']} \\ &\succ\!\!\prec (\exists (A\text{-ings} \cup B\text{-ings})\ x)\ x \text{ occurs} \\ &\qquad \text{[by (13a)].} \end{aligned}$$

Consequently the condition of identity of $(A \vee B)$-ings with (A-ings $\cup$ B-ings), as stated in (EI2), obtains. This is involved in the equivalence of, e.g., 'Max beat or kicked Maurice many times' and 'There were many beatings or kickings of Maurice by Max'.

If an event clause is of the form '$(\exists G\ x)V(x)$' then the events that are $((\exists G\ x)V(x))$-ings are the V-ings by some G. We can convince ourselves of this by similar reasoning. We can use '$(\bigcup G\ x)Q(x)$' to refer to every Q of any G (and nothing else). '$Q(x)$' is here an expression with one argument place which becomes a general term when that argument place is filled. As an example take 'children of . . .'. Then ($\bigcup$ politicians x) children (x) are the children of politicians. Hence '$(\bigcup G\ x)Q(x)$' refers to any individual which is, for some G, say a, among the $Q(a)$.[19]

Given these stipulations, the following is correct, where $V(x)$ is again an event clause with one argument,

$$(13b) \qquad (\exists (\bigcup G\ y)Q(y)\ x)V(x) \succ\!\!\prec (\exists G\ y)(\exists Q(y)\ x)V(x)$$

This helps us to see that the $((\exists G\ x)V(x))$-ings are the same events as the $(\bigcup G\ x)V^{\text{ings}}(x)$:

$$(\exists G\ x)V(x) \asymp (\exists((\exists G\ x)V(x))\text{-ings } y)\ y \text{ occurs [by (E1)]}$$

Also

$$(\exists G\ x)V(x) \asymp (\exists G\ x)(\exists V^{\text{ings}}(x)\,y)\ y \text{ occurs}$$

[this time the extensionality of the quantifier expression with respect to '$\asymp$' is exploited]

$$\asymp (\exists(\bigcup G\ x)V^{\text{ings}}(x)\,y)\ y \text{ occurs}$$

[according to (13b)]

In conjunction with principle (EI2) this means that

$$((\exists G\ x)V(x))\text{-ings} = (\bigcup G\ x)V^{\text{ings}}(x)$$

i.e. the events obtained by abstraction from the complex event clause '$(\exists G\ x)V(x)$' are the V^{ings} by some G or other. 'Five times an angler caught a fish' becomes equivalently 'There are five catchings of a fish by an angler', $\underset{5}{\exists}((\bigcup G\ x)(\bigcup H\ y)V^{\text{ings}}(x, y))$, which is to be distinguished of course from 'There is an angler and a fish such that the former caught the latter five times', i.e. 'There are five catchings of a particular fish by a certain angler':

$$(\exists G\ x)(\exists H\ y)\ \underset{5}{\exists}\ V^{\text{ings}}(x, y).$$

Quite analogous moves can be made with respect to process clauses. If 'M', 'N' are mass nouns we introduce '$M \cup N$' to refer to all that 'M' refers to as well as to all that 'N' refers to and nothing else. And for expressions '$P(x)$' with one argument place that become mass nouns when that argument place is filled let '$(\bigcup G\ x)P(x)$' refer to all P of any G.

Given this understanding of '$\cup$' and '$\bigcup$' we have

(14a) $$(\text{Some } (M \cup N)\ p)W(p) \asymp (\text{Some } M\ p)W(p) \vee (\text{Some } N\ p)W(p)$$

(14b) $$(\text{Some } (\bigcup G\ y)P(y)\ p)W(p) \asymp (\exists G\ y)\ (\text{Some } P(y)p)W(p)$$

So we can obtain

$$D \vee E \asymp (\text{Some } (D \vee E)\text{ing } p)\ p \text{ takes place [by (P1)]}$$

as well as

$$\begin{aligned} D \vee E &\asymp (\text{Some } D\text{-ing } p)\ p \text{ takes place } \vee (\text{Some}\\ &\qquad E\text{-ing } p)\ p \text{ takes place}\\ &\qquad \text{[again (P1), and the extensionality of `}\vee\text{'}\\ &\qquad \text{with respect to `}\asymp\text{']}\\ &\asymp (\text{Some } (D\text{-ing} \cup E\text{-ing})\ p)\ p \text{ takes place}\\ &\qquad \text{[by (14a)].}\end{aligned}$$

So, the identity condition for processes (PI2) yields

$$(D \vee E)\text{-ing} = D\text{-ing} \cup E\text{-ing}$$

Again,

$$\begin{aligned}(\exists G\ x)\,W(x) &\asymp (\text{Some } ((\exists G\ x)\,W(x))\text{-ing } p)\ p \text{ takes}\\ &\qquad \text{place}\\ &\qquad \text{[by (P1)]}\end{aligned}$$

and

$$\begin{aligned}(\exists G\ x)\,W(x) &\asymp (\exists G\ x)\ (\text{Some } W^{\text{ing}}(x)\ p)\ p \text{ takes place}\\ &\qquad \text{[relying on the extensionality of `}\asymp\text{']}\\ &\asymp (\text{Some } (\textstyle\bigcup G\ x)\ W^{\text{ing}}(x)\ p)\ p \text{ takes place}\\ &\qquad \text{[by (14b)]}\end{aligned}$$

Consequently, (PI2) gives us the identity

$$((\exists G\ x)\,W(x))\text{-ing} = (\textstyle\bigcup G\ x)\,W^{\text{ing}}(x)$$

The equivalences (14a) and (14b) are involved, respectively, in these two pairs of sentences: 'Maurice walked or ran little' :: 'There was little walking or running by Maurice'; and 'For five hours Maurice interviewed applicants' :: 'There are five hours of interviewing of applicants by Maurice'.

Apart from disjunctive event clauses conjunctive clauses are possible; but they are not normally formed by the simple 'and'.[20] One might, rather, use 'and thereby'. (But more than just Boolean intersection is conveyed by 'and thereby').

Negation cannot be meaningfully applied to event or process clauses. It seems to me that apparent cases of event verb negation can as a rule be explained as involving the negation of a numerical adverb. So 'he did not jump' is to be understood as 'not: at least once: he jumped'. In 'Three times he did not jump' we count occasions of a certain kind, contextually indicated, on which he did not jump even once, and not events of non-jumping.

5. ADVERBS

(c) *The correspondence between adverbs and predicates*

The role of adverbs has been of particular interest in the discussion of action sentences. On Davidson's analysis, many adverbs and adverbial phrases become predicates of events. Davidson's analysis then provides an explanation, in terms of the principles of inference of first-order logic, of the validity of "adverb dropping". E.g. the inference from 'Alphonse knocked loudly' to 'Alphonse knocked' would be accounted for.

Of interest in this connection are only those adverbs (and adverbial phrases) which when combined with an event or process clause form a clause of the same kind. Syntactically, then, adverbs are considered to be functors operating on event or process clauses and yielding such clauses. Usually, however, adverbs are regarded as verb modifiers. The fact that makes this possible is that the application of adverbs seems always to preserve transparent argument positions. So if t_1, $\ldots$, t_n are the terms that occur in A and occupy transparent positions (i.e. $t^* = t_i \Rightarrow A \rightarrowtail\!\!\!\!\leftarrowtail A^*$, where A^* is like A except that t^* replaces t_i) then these positions remain transparent in the event clause 'φA' which contains the adverbial functor 'φ'.

I shall be considering only those adverbs for which it generally holds that

(EA1) $\varphi A \prec A$
(if 'φ' operates on event clauses), or

(PA1) $\varphi D \prec D$
(if 'φ' operates on process clauses).

It is these principles that I alluded to when I discussed Davidson's analysis of action sentences and his account of the validity of "adverb dropping". They express conceptual truths about the adverbs for which they are true. They cannot be regarded as formally valid principles. Adverbs like 'allegedly' do not conform to them.[21]

According to the principles of abstraction the satisfaction of (EA1) and (PA1) means that all (φA)-ings are A-ings and all (φD)-ing is D-ing. In other words, the (φA)-ings are a kind of A-ings; or (φD)-ing is a kind of D-ing. This means that there is associated with the adverb 'φ' an operation which from a general term yields a general term whose referents are among those of the original term. And this is typically the role of noun modifiers (e.g. most adjectives).

Consequently, for every adverb 'φ' that satisfies (EA1) a noun modifier '$\hat{\varphi}$' can be defined by

(Df EA1) $\hat{\varphi}A$-ings $=$ (φA)-ings

Entirely analogous considerations prompt, in the case of adverbs qualifying process clauses, the definition

(Df PA1) $\hat{\varphi}D$-ing $=$ (φD)-ing

The usual way, in English, of forming the appropriate noun modifier from an adverb ending in '-ly' is to drop that ending '-ly'. E.g. the events that occur when one *claps loudly* are the *loud clappings*. And what takes place when one *walks slowly* is *slow walking*.

We can now justify equivalences like

(15) Twice Alphonse shut the door quietly $\Leftrightarrow$
There were two quiet shuttings of the door by Alphonse

But the sentence on the right hand side is still not of the form that Davidson's analysis would have produced. According to that analysis 'quiet' would be construed as a predicate rather than a noun modifier so that the inference to

(16) Two shuttings of the door by Alphonse were quiet

is justified.

Not every noun modifier corresponds to a predicate, i.e. can be taken to introduce a property. Some noun modifiers are sensitive to the sense of the noun in question so that even though the G are the H

the μG are not identical with the μH. 'Good' is thought to be such a modifier. With other modifiers the extension of the reference of the noun is relevant, so that an individual that is a G and also an H may be a μG but not a μH. 'Big' may illustrate this case.

If a modifier is to introduce a property it must at least not be dependent in these ways on the sense or the extension of the noun. I.e., firstly, the noun modifier has to be extensional:

$$\text{(G2)} \qquad G = H \Leftrightarrow \mu G = \mu H$$

and, secondly, it must generally be the case that if an individual is a G and also an H then it is a μG just when it is a μH. This is guaranteed if the noun modifier distributes over partitions of the classes of things that the nouns refer to. This is what the following conditions amount to.

$$\text{(G3.1)} \qquad \mu(G \cup H) = \mu G \cup \mu H$$

$$\text{(G3.2)} \qquad \mu(\bigcup G\, x)Q(x) = (\bigcup G\, x)\mu Q(x)$$

(For example 'big' does not satisfy (G3.1): the big animals are not the big horses and the big fleas and the big . . . and . . . .)

A functor that satisfies (G2), (G3) and

$$\text{(G1)} \qquad (\forall \mu G\, x)(\exists G\, y)x = y$$

(Every μG is a G), a *distributive noun modifier*, does indeed introduce a property. For a given individual i consider any general term 'G' under which it falls (i.e. i is one of the things 'G' refers to). If 'H' is another term under which i falls then the G are the things that are both G and H plus the G that are not H. If now i is among the μG it must be among the $\mu(G \cap H)$, because of (G1) and (G3). H in turn consists of the $H \cap G$ $(= G \cap H)$ plus the H that are not G; and since i is among the $\mu(H \cap G)$, (G3) shows that it is a μH. So, whether or not the individual is a μ-thing, depends only on the individual (and μ); hence, being a μ- . . . amounts to a property. An individual i has the property if it is among the μG whenever it is among the G. Because of (G1) the μG are the G that have the property.

Now the conditions (G1)–(G3) on noun modifiers translate of course into conditions on adverbs, since these yield noun modifiers in the process of abstraction (see (Df EA1), (Df PA1)). Corresponding to (G1), condition

(EA1) $\varphi A \prec A$

has already been noted. For (G2) there is

(EA2) $A \succ\!\prec B \Rightarrow \varphi A \succ\!\prec \varphi B$

Even if there should be adverbs whose application does not preserve the transparency of argument positions, those adverbs for which (EA2) holds certainly do.

The conditions (G3) become

(EA3.1) $\varphi(A \vee B) \succ\!\prec \varphi A \vee \varphi B$

(EA3.2) $\varphi((\exists G\ x) V(x)) \succ\!\prec (\exists G\ x) \varphi V(x)$

Any adverb that qualifies event clauses and satisfies these conditions (to be called a *distributive* adverb) gives rise to a predicate of events, as the following transformations show.

$\varphi A \succ\!\prec \varphi((\exists A\text{-ings } x)\ x \text{ occurs})$
[in virtue of the extensionality of φ((EA2)) and (E1)]

$\succ\!\prec (\exists A\text{-ings } x)\, \varphi(x \text{ occurs})$
[by (EA3.2)]

If we now define a predicate of events $\bar{\varphi}(x)$ by

(Df EA2) $\bar{\varphi}(x)$ for at least once: $\varphi(x \text{ occurs})$

then the Davidsonian paraphrases emerge promptly:

n times: $\varphi A \Leftrightarrow$ n times: $(\exists A\text{-ings } x)\, \varphi(x \text{ occurs})$
[in virtue of what has just been derived]

$\Leftrightarrow \left(\underset{n}{\exists}\ A\text{-ings } x\right)$ at least once: $\varphi(x \text{ occurs})$
[Compare the derivation of (8) in Section 2. Because of (EA1), $\varphi(x \text{ occurs}) \prec x$ occurs. Consequently, (E2.2) and (E2.3) remain true when 'x occurs' is replaced by '$\varphi(x \text{ occurs})$'. So,

given that every G occurs φ-ly at most once and that when one G and another G both occur φ-ly then this means that twice a G occurs φ-ly, it follows that 'n times some G occurs φ-ly' is equivalent to 'there are n Gs, each one of which occurs φ-ly at least once'.]

$$\Leftrightarrow (\underset{n}{\exists}\ A\text{-ings } x)\ \bar{\varphi}(x)$$
[by (Df EA2)]

I.e. we have

(17) n times: $\varphi A \Leftrightarrow (\underset{n}{\exists}\ A\text{-ings } x)\ \bar{\varphi}(x)$

In accordance with this schema we can understand ordinary language equivalences like that of 'Twice Alphonse met Sylvia in the garden' and 'Two meetings by Alphonse of Sylvia occurred in the garden'[22] or 'Two meetings by Alphonse of Sylvia were in the garden'.

Quite analogously certain adverbs modifying process clauses (*distributive* adverbs of this type) yield predicates of processes. They satisfy conditions which parallel those that were just discussed:

(PA1) $\varphi D \prec D$

(PA2) $D \succ\!\prec E \Leftrightarrow \varphi D \succ\!\prec \varphi E$

(PA3.1) $\varphi(D \vee E) \succ\!\prec \varphi D \vee \varphi E$

(PA3.2) $\varphi((\exists G\ x) W(x)) \succ\!\prec (\exists G\ x) \varphi W(x)$

(PA3.3) $\varphi((\text{Some } M\ p)\ W(p)) \succ\!\prec (\text{Some } M\ p)\ \varphi W(p)$

That adverbs satisfying these conditions indeed give rise to process predicates is shown by the following.

$$\varphi D \succ\!\prec \varphi((\text{Some } D\text{-ing } p)\ p \text{ takes place})$$
[in virtue of (PA2) and of course (P1)]

$$\succ\!\prec (\text{Some } D\text{-ing } p)\ \varphi(p \text{ takes place})$$
[by (PA3.3)]

This helps us to establish that

(18)
$$\left.\begin{array}{l}\text{some } \varphi D\\ \text{a lot } \varphi D\\ \text{little } \varphi D\end{array}\right\} \Leftrightarrow \left.\begin{array}{l}(\text{Some } D\text{-ing } p)\\ (\text{A lot of } D\text{-ing } p)\\ (\text{Little } D\text{-ing } p)\end{array}\right\} \text{ some } \varphi(p \text{ takes place})$$

For

a lot: $\varphi D \Leftrightarrow$ a lot: (Some D-ing p) φ(p takes place)

$\Leftrightarrow$ (a lot of D-ing p) some: φ(p takes place)
[Because of (PA1), (All M p)(φ(p takes place) $\prec$ p takes place). Therefore (P2.2) and (P2.3) remain true if 'p takes place' is replaced by 'φ(p takes place)', and so do the equivalences (P3).]

$\Leftrightarrow$ (a lot of D-ing p) $\bar{\varphi}(p)$
[by the definition that follows]

(Df PA2) $\bar{\varphi}(p)$ for some: φ(p takes place)

The equivalence (18) can be illustrated by an example like this: 'Max sings a lot in the attic' to 'A lot of singing by Max takes place in the attic'[23] to 'A lot of singing by Max is in the attic'.

(b) *Temporal qualifiers*

There is a close connection of events and processes with time. It is always appropriate to ask when something happened, in what period of time. In this section I shall consider how temporal characterisations are to be construed. I shall have in mind sentences such as 'It rained all day', 'He broke his arm twice in 1980', 'She slept in the afternoon'. I shall suggest that constructions of this type as well as any others to do with the temporal location of processes and events can be understood in terms of an adverbial modification of process clauses and event clauses.

So let '$\alpha(t)$' be a particular relational adverb that can modify process clauses. It is relational in that it carries with it an argument place, marked by 't'. 't' is intended to range over time, not over moments of time. No reading of '$\alpha(t)$' is suggested, since I believe that this adverb is not by itself realised in English. Its meaning is contained in that of other expressions; but it can be conveyed, I hope, by stating that for all time t, $(\alpha(t)D)$-ing is D-ing that occurs at t.

With D a process clause and τ indicating a time period

(19) (All τ t) some: $\alpha(t)D$

will be a complete sentence: E.g. 'All day it rained'. Indeed we may regard the expression 'some $\alpha(t)$' as a complex quantitative adverb which can be read 'at t'. 'at $t:D$' is then an expression of the type of a predicate, a predicate applicable to time. Since 't', contrary to normal practice, does not range over instants, but over time, 'at $t:D$' belongs to the category of mass predicates. For all time t, 'at $t:D$' is true of t iff some D-ing occurs at t. (19) becomes

(20) (All τ t) at t: D

When quantificational expressions that convey measures of time (amount quantifiers) are attached to 'at $t:D$', the result are sentences of a familiar form which were used earlier as part of a grammatical test for distinguishing process clauses from event clauses. E.g.

(21) (2 hours of time t) at $t:D$

which one can read as 'For a total of two hours D', say 'On Wednesday it rained for two hours altogether' with the process clause 'It rained on Wednesday'. It has been observed by Dowty[24] that 'For a time of duration d . . .' may either mean that the total period of time during which . . . is of length d, where that period need not be a connected period, i.e. an interval, or that a certain interval of length d is one during which . . . and such that . . . neither immediately before nor immediately after that interval. In this second use 'For a time of duration d' is not a quantitative adverb that together with a process clause 'D' forms a sentence. Rather 'For a time of duration d: D' is an event clause and requires a numerical adverb to form a sentence. E.g. 'Many times Maurice lectured for two hours'.[25] '(2 hours of time t) at t' analyses the first sense of 'For two hours'.

By attaching '(Some τ t)' to '$\alpha(t)D$' one obtains of course a process clause '(Some τ t)$\alpha(t)D$', i.e. something of the same category as 'D' itself. ((Some τ t)$\alpha(t)D$)-ing is D-ing that occurs at some time of the period τ, i.e. during τ. '(Some τ t)$\alpha(t)$' is then as a whole a complex adverbial phrase which is to be read as 'during τ'. So

(22) A lot (Some of April t)$\alpha(t)$ it rained

means 'It rained a lot during April'.

'$\alpha(t)$' is clearly a distributive adverb. If now the process clause 'D' consists of a verb and one or more singular terms which are grammatical subject and object or objects to the verb (i.e. an expression '$V(t_1, \ldots, t_n)$' that would traditionally be regarded as an n-place predicate with n singular terms as arguments) then '$\alpha(t)$' can also be viewed as modifying primarily the verb V rather than the whole phrase 'D'.[26] The result would then be a (complex) verb-like expression with $n + 1$ argument places. Seeing matters this way provides us with an obvious rationale for the common practice of accounting for temporal locutions by providing predicates with an extra argument place for time. This proposed analysis goes back to Frege. However let me repeat that while 't' is commonly thought of as ranging over moments of time, it signifies in the present treatment a variable ranging over time.

I anticipate that all temporal qualifications, connectives etc. that relate to process clauses, e.g. 'when', can be defined in terms of '$\alpha(t)$'.

Now a brief look at sentences in which process nouns occur. From

(23) much (during $\tau : D$) (e.g. 'It rained much during April')

we obtain

(24) (Much D-ing p) some: during τ (p takes place)
('Much raining was during April').

In the case of event clauses we may take 'during τ' as a not further analysable relational adverb. The advantage that was gained, in the case of process clauses, by postulating '$\alpha(t)$' as an adverb that enters into more complex expressions is not found with event clauses. There are no sentences 'For two hours . . .' to be accounted for. Rather with event clauses we find 'In two hours . . .' and the like.[27] 'In a time of duration d A' is an event clause; hence 'In a time of duration d' itself an adverbial phrase. Its meaning can be explained in terms of 'during τ'.

From the adverbial phrase 'during τ' one obtains the predicate of events 'at least once x occurs during τ'. Other temporal notions can be explained in terms of this predicate; e.g. the period of time that an event e takes to happen, the "proper time" of the event in Aristotle's phrase, can be defined as the shortest period during which e happens.

APPENDIX. SKETCH OF SEMANTICS FOR EVENT AND PROCESS CLAUSES

Event clauses are proposition-like expressions in that they have truth conditions. Such conditions however may be realised repeatedly. Moreover there is the possibility that the (distinct) truth conditions of two such event clauses are realised simultaneously.

In a meaning theory the appropriate theorem for an event clause 'A' would be

> 'A' is true $\rightarrowtail\!\!\!\!\!\leftarrowtail$ A
> Whenever 'Alphonse cooks' is true then *eo ipso* Alphonse cooks and whenever Alphonse cooks then *eo ipso* 'Alphonse cooks' is true.

Of course 'is true' must here be a predicate that is not simply either instantiated or not but which may be instantiated several times by a clause.

On the other hand, for a general term 'A-ings' the clause in a meaning theory would be something like this:

> 'A-ings' refers to (all and only) A-ings.

The question then is how to reflect these different types of meaning in recursive semantics. Standardly, individual items (usually sets) are assigned as semantic values to expressions. While for singular terms semantic value and referent coincide, for other types of expression their semantic values cannot be regarded as their referents. A connective, e.g., has a semantic value a function from truth values to truth values; although it does not refer to such a function, as it is not a referring expression. So the circumstance that in the semantics below event clauses are assigned certain objects as values does not signify that they are referring expressions (say general terms) after all, even though those objects are construable as events or sets of events.

The semantic value of a sentence is usually taken to be a function from possible worlds to truth values, or a set of possible worlds. The set consists of those worlds at which the sentence is true. Since event clauses are not just true or false at a world, since an event clause may be true several times at the same world, it is inappropriate to take the world itself as that in virtue of which the event clause is true; what accounts for this instance of the clause's being true must be different from what accounts for that instance of its being true. No further characterisation of the items that account for the event clause's being true and of how they are related to possible worlds emerge from these formal considerations; but nothing prevents us from construing them in terms of familiar relationships. So let us say that what makes an event clause true, several times, at a possible world are several *parts* of that world. Then the semantic value of an event clause is a set of parts of possible worlds. If the language is extensional then for a sentence truth or falsity at the actual world suffices as semantic value; for an event clause we need instead the set of parts of the actual world for which it is true.

Process clauses too are not simply true (or false) at a world, but true so and so much; so and so much of the world makes true the process clause in question. Any part of a part of the world for which such a process clause is true itself makes it true; and the mereological sum of two such parts is again a part for which the clause is true. So one can take the maximal part of the actual world for which the clause is true as its semantic value.

The part of an interpretation that concerns event clauses is then a class $\mathscr{T}$ and a semantic function $\mathscr{I}$. The elements of $\mathscr{T}$ are those "parts of the actual world" in virtue of which event clauses are true. If we are dealing with process clauses at the same time then $\mathscr{T}$ is the set of elements of the lattice $\mathscr{L}$ mentioned below. $\mathscr{I}$ assigns to every simple event clause A a subset $A_{\mathscr{I}}$ of $\mathscr{T}$ and to every distributive adverb φ a function $\varphi_{\mathscr{I}}$ from the subsets of $\mathscr{T}$ to the subsets of $\mathscr{T}$, a function that must satisfy these conditions:

(1) $\qquad \varphi_{\mathscr{I}}(X) \subseteq X \quad \text{for} \quad X \subseteq \mathscr{T}$

(2) $\qquad \varphi_{\mathscr{I}}(X \cup Y) = \varphi_{\mathscr{I}}(X) \cup \varphi_{\mathscr{I}}(Y)$

(3) $\qquad \varphi_{\mathscr{I}}\left(\bigcup_{i \in T} X_i\right) = \bigcup_{i \in T} \varphi_{\mathscr{I}}(X_i)$

where $\{X_i\}_{i \in T}$ is any class of subsets of $\mathscr{T}$.

'x occurs' is to be interpreted as a function from individuals to subsets of $\mathscr{T}$. The principles of abstraction (E1) and (E2) determine more precisely the character of that function.

Given the interpretation of simple event clauses and adverbs, $\mathscr{I}$ can be extended to all event clauses in accordance with rules like these:

If A is $B \vee C$ then $A_{\mathscr{I}} = B_{\mathscr{I}} \cup C_{\mathscr{I}}$

If A is φB then $A_{\mathscr{I}} = \varphi_{\mathscr{I}}(B_{\mathscr{I}})$

In this way to every event clause a subset of $\mathscr{T}$ is assigned.

The connection with the rest of the semantics, assumed to be standard first-order, is made by clauses of the type:

'n times A' is true just when $A_{\mathscr{I}}$ has n elements

'A as often as B' is true when $A_{\mathscr{I}}$ and $B_{\mathscr{I}}$ have the same number of elements

and, consequently, given the definition of $\asymp$,

'$A \asymp B$' is true, when $A_{\mathscr{I}} = B_{\mathscr{I}}$.

For process clauses the interpretation contains a complete distributive lattice $\mathscr{L}$, the "parts of the world" with their part-of relation. The lattice need not be a complemented one (i.e. a Boolean algebra) since event and process clauses are not negatable. In addition to $\mathscr{L}$ there is an interpretation function $\mathscr{I}$ and a comparative relation $\sqsubseteq$. The interpretation function $\mathscr{I}$ assigns to every simple process clause D an element $D_{\mathscr{I}}$ of the lattice $\mathscr{L}$ and to every distributive adverb φ a function $\varphi_{\mathscr{I}}$ from $\mathscr{L}$ into itself. $\varphi_{\mathscr{I}}$ must satisfy

(1) $\qquad \varphi_{\mathscr{I}}(a) \leqslant a \quad \text{for} \quad a \in \mathscr{L}$

(2) $\qquad \varphi_{\mathscr{I}}(a \cup b) = \varphi_{\mathscr{I}}(a) \cup \varphi_{\mathscr{I}}(b)$

(3) $\qquad \varphi_{\mathscr{I}}\left(\bigcup_{i \in T} a_i\right) = \bigcup_{i \in T} \varphi_{\mathscr{I}}(a_i)$

where $\{a_i\}_{i \in T}$ is any set of elements of $\mathscr{L}$.

The relation $\sqsubseteq$ is transitive and reflexive. It further holds that $a \sqsubseteq b$ or $b \sqsubseteq a$, for any $a, b \in \mathscr{L}$ and if $a < b$ then $a \sqsubset b$ ('$a \sqsubset b$' for '$a \sqsubseteq b$ & $b \not\sqsubseteq a$').

Quantitative adverbs 'much', 'little', ' a lot', 'some', etc. are interpreted as sets of elements of $\mathscr{L}$, subject to conditions such as:

$a \in \text{much}_{\mathscr{I}}$ and $b \in \text{little}_{\mathscr{I}}$, only if $b \sqsubset a$;

$a \in \text{some}_{\mathscr{I}}$ iff $a \neq 0$.

The extension of $\mathscr{I}$ to complex process clauses is governed by the same clauses as before. And the truth values of sentences containing such phrases are then determined by conditions like these:

'Much D' is true when $D_{\mathscr{I}} \in \text{much}_{\mathscr{I}}$

'D as much as E' is true when $D_{\mathscr{I}} \sqsubseteq E_{\mathscr{I}}$ and $E_{\mathscr{I}} \sqsubseteq D_{\mathscr{I}}$

'D more than E' is true when $E_{\mathscr{I}} \sqsubset D_{\mathscr{I}}$

'some D' is true when $D_{\mathscr{I}} \neq 0$

etc.

'$D \rightarrowtail\!\!\!\leftarrowtail E$' is true, as expected, when $D_{\mathscr{I}} = E_{\mathscr{I}}$.

I have given a detailed account of the semantics of mass terms elsewhere.[28] For an understanding of the semantics of process clauses the following features should be sufficient.

Mass nouns are interpreted as quantities; mass predicates as sets of quantities, namely those to which the predicate, wholly, applies. '(All M $p)\phi(p)$' is true if the quantity assigned to 'M' is in the set of quantities assigned to 'ϕ'. (Some M $p)\phi(p)$' is true when the set of quantities assigned to 'ϕ' contains some sub-quantity of the quantity assigned to 'M'. Other mass-quantifiers, such as 'Much', need to be treated in a somewhat more complex way. 'Much' is interpreted as a set of quantities: those which there is much of. Then '(Much M p) $\phi(p)$' is true if there is a sub-quantity of the quantity assigned to 'M' that is both in the set assigned to 'Much' and in the set assigned to 'ϕ'.

Fitting in with this semantic treatment, 'p takes place' is to be interpreted as a function from quantities to elements of the lattice. 'some (p takes place)' being a predicate, must be assigned a set of quantities. A quantity belongs to this set if all of its sub-quantities are mapped onto non-zero elements of the lattice by the function assigned to 'p takes place'. This function is further characterised by the principles (P1) and (P2).

The relational adverb '$\alpha(t)$' is interpreted as a two-argument function δ whose values are elements of the lattice. In its first argument the function ranges over the elements of the lattice; in its second over certain quantities, namely the periods of time. For any fixed period the conditions on distributive adverbs must be satisfied; and there are similar conditions when the first argument is held fixed. In sum there are the following conditions.

(1) $\delta(a, \tau) \leqslant a$

(2) $\delta(a \cup b, \tau) = \delta(a, \tau) \cup \delta(b, \tau)$

(3) $\delta\left(\bigcup_{i \in T} a_i, \tau\right) = \bigcup_{i \in T} \delta(a_i, \tau)$

(4) $\delta(a, \tau \cup \sigma) = \delta(a, \tau) \cup \delta(a, \sigma)$, $\tau \cup \sigma$ being the total period consisting of τ and σ.

(5) $\delta\left(a, \bigcup_{j \in S} \tau_j\right) = \bigcup_{j \in S} \delta(a, \tau_j)$.

NOTES

[1] I am grateful to the referees for very helpful criticism and suggestions.

[2] D. Davidson, 'The logical form of action sentences' in *Essays on Actions and Events*, Oxford 1980.

[3] The view that nominalisations of event verbs are count nouns and nominalisations of process verbs are mass nouns is not new. See e.g. Note 8.

[4] I do not want to raise the question which features of events are essential properties, e.g. whether an event's time of occurrence is an essential property. What matters here is only that such questions can be formulated only with the help of nouns that refer to events.

[5] This may be what some writers on nominalisation have in mind when they suggest that nominalisations have the same semantic values as the verb phrases from which they are derived. See e.g. G. Chierchia, 'Nominalisation and Montague grammar: A semantics without types for natural languages' *Linguistics and Philosophy* **5** (1982), 303–354. It is also possible that they propose to treat all expressions as referential, perhaps because of a confusion of semantic value with reference.

[6] See M. Dummett, *Frege Philosophy of Language*, London 1973, Ch. 14.

[7] No attention will be paid to the tenses of verbs in this paper.

[8] A detailed and illuminating discussion of grammatical and semantic aspects of event predication and process predication can be found in Alexander P. D. Mourelatos, 'Events, processes and states', *Linguistics and Philosophy* **2** (1978), 415–434. Mourelatos notes that process predication gives rise to nominalisations that require mass-quantifiers. The correspondence between process predication and mass nouns is also emphasised in Barry Taylor, 'Tense and continuity', *Linguistics and Philosophy* **1** (1977), 199–220.

[9] The same expression can be an event clause in some occurrences, a process clause in others. E.g. 'Maurice turned the mill stone twice' vs. 'Maurice turned the mill stone for hours'.

[10] This line is pursued in M. Cresswell, 'Adverbs of space and time', in *Formal Semantics and Pragmatics for Natural Language*, ed. F. Guenthner *et al.*, 1978, 171–191, where he assigns to event verbs functions from possible worlds and individuals to truth values.

[11] I treat quantifiers as attaching to general terms to form sentences (1-place quantifiers), or as forming sentences out of a general term and a predicate (2-place quantifiers). 'There are many (horses)' and 'There is much (uranium)' are 1-place thing-quantifier and 1-place mass-quantifier, respectively. 'Every (horse) x, x (is black)' and 'All (snow) p, p (is white)' are a 2-place thing quantifier and a 2-place mass-quantifier.

It is arguable that 1-place quantifiers are definable and can be dispensed with. So, 'There are many horses' would be rendered 'Many things are horses' and 'There is much uranium' as 'Much stuff is uranium', where 'thing' would be the universal count noun, and 'stuff' the all-embracing mass noun. Whether or not this is so has no bearing on the present discussion.

I have discussed the semantics of mass-quantifiers in 'Semantics for mass terms with quantifiers', *Noûs* **17** (1983), 251–265.

[12] As an example of a case where both events and occasions are counted consider the sentence 'John knocked on the door four times three times'. (Adapted from an example of Mourelatos' in his article referred to in Note 8). According to the analysis that I am proposing 'John knocks' is an event clause, together with which 'three times' forms a complete sentence. And there should be no place for a second numerical adverb 'four times' since such adverbs are not sentential operators but expressions which complete event clauses into sentences. The first thing to notice is that the sentence 'John knocked four times three times' does not merely draw attention to (certain) 12 knockings, temporally distributed in any way you like. Rather the three knockings occur in each case on a single occasion. Hence 'On four occasions John knocked three times', i.e. '(There are 4 occasions x) 3 times: John knocked on occasion x', where 'on occasion x' is an adverbial expression, similar to temporal adverbs (see Sec. 5(b)).

[13] For the logic of restricted quantifiers see, e.g., Neil Tennant, 'Natural Deduction for First-Order Logic with Identity, Description and Restricted Quantification', in *Contributed Papers of the 5th International Congress of Logic, Methodology and Philisophy of Science, Part I*, London, Ontario, 1975, 51–52. Note however that there the distinction between general terms and one-place predicates is not observed.

[14] Events as here discussed are not the only entities that can be introduced on the basis of action sentences. J. Hornsby ('Donald Davidson: Essays on actions and events', *Ratio* **24** (1982), 87–94) has noted and emphasised the different type of entities (*things done*) that are talked about when one says that X and Y did the same thing or that X did so and so three times. Identity conditions for these entities are stricter than for events. Instead of (EI1) one might have

$$\text{Necessarily } (\forall \text{ agents } x)(A(x) \rightarrowtail\!\!\!\leftarrowtail B(x)) \Rightarrow$$
$$\text{the thing done when one } A\text{-s} = \text{the thing done when one } B\text{-s.}$$

Here $A(x)$ and $B(x)$ are event clauses with one designated argument place for agents.

[15] My choice of 'occurs' for events, and 'takes place' for processes is quite arbitrary. No selectivity of locution is actually observed in English.

[16] The mass quantifier 'Some' (capital letter) is to be distinguished from the quantitative adverb 'some' (as in 'She walked *some*') and the thing quantifier '∃', which may be pronounced identically. More generally, note that the same expression, e.g. 'much',

may appear in different syntactic roles: 1. as a quantitative adverb, as in 'She did not sleep much'; 2. in the one-place mass-quantifier 'there is much', as in 'There is much coal in Lorraine'; 3. as a two-place quantifier, as in 'Much space is empty'.

[17] (P2.2) is implied by (P1), and (P2.3), although an independent condition, also does not have the power of its counterpart (E2.3). This is indicative of the limitations of a language (generalised first-order logic whose quantifiers are mass-quantifiers) that does not admit the identity relation. (P2.3) could be strengthened with the help of second order quantifiers.

[18] Evidently one would say 'a lot of raining took place' rather than 'a lot of raining took place some'. But semantically a quantitative adverb is required here.

[19] I distinguish '$\bigcup$' from '$\exists$' since the two operations will be treated differently in standard semantics; the quantifier operates on sentences while '$\bigcup$' operates on general terms. It is however possible, by changing the semantic values attributed to sentences, to give a single formulation of the semantic significance of both '$\exists$' and '$\bigcup$'. This explains perhaps why in English the same word 'some' (or 'an') plays the role of both '$\exists$' and '$\bigcup$'.

[20] When 'and' (in English) conjoins event clauses it does not normally have a Boolean function like 'or'. Take e.g. 'Max leaped and fell'. It is not a matter here of reporting an event which can be classified both as a leaping and as a falling. The leaping and the falling are distinct events; they happen at different times and they may well take different times. The (Max leaped and Max fell)-ings are not the events which belong to the leapings by Max as well as the fallings by Max. (Whereas the (Max leaped *or* Max fell)-ings are the events which belong to either the leapings by Max or the fallings by Max.) Rather, what is reported to have happened (or to have happened n times, many times, etc.) is that a leaping by Max was followed by a falling by Max.

'And', when it conjoins event clauses, is a two-place adverb; 'A and B' is a complex event clause. But how similar it is to other adverbs (which will be discussed in the next section) is not too clear. In particular whether (A and B) $\prec$ A holds or not may be undecided or a matter of context. What the question comes to is whether, e.g., the (Max leaped and fell)-ings are among the leapings by Max or whether, rather, the (Max leaped and fell)-ings are events that consist of a leaping and a falling following one another. I would favour the latter view; unlike the sentential connective 'and', in its present use 'and' is not symmetrical. A temporal sequence is indicated, the B-ing occurs after the A-ing, or at least not before.

Corresponding to this use of 'and', which makes (A and B)-ings composite, consisting each of an A-ing and a B-ing, there is a use of the quantifier expressions 'every' and 'all', as e.g. in 'Max watered all the tomatoe plants' and 'Max quickly drank all the coffee'. The event in question, watering by Max of all the tomatoe plants, consists of a succession of waterings of individual plants; and Max's drinking of all the coffee is similarly composed of drinkings of parts of the coffee. 'All' here is not a counterpart of the use of the existential quantifier discussed in (b).

[21] Note that 'allegedly' can modify both sentences and event clauses. We can say 'Allegedly Maurice escaped twice' and also 'Twice Maurice allegedly escaped'.

[22] Note that 'at least once' is suppressed in standard English.

[23] See Notes 18 and 22.

[24] D. R. Dowty, *Word Meaning and Montague Grammar*, 1973, pp. 332–334.

[25] So, 'For a time of druation d' in this sense belongs to a category of expressions that transform process clauses into event clauses. Interestingly, the reverse transformation is

also possible by means of temporal expressions, namely those specifying frequencies. 'Maurice visits Alphonse twice a week' is a process clause, as shown e.g. by 'All last year Maurice visited Alphonse twice a week'. Cf. Dowty, *op. cit.*, p. 332.

[26] Compare remarks at the beginning of Section 5, concerning adverbs as verb modifiers.

[27] Dowty, *op. cit.*, 332ff.

[28] In 'Semantics for mass terms with quantifiers', *Noûs* **17** (1983), 251–265.

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