Time and Event Measure

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Durative adverbs like *for two hours* have typically been analyzed within the framework of interval semantics, according to which sentences are evaluated with respect to time intervals, and temporal measure adverbs quantify over the parts of those intervals. Example (1) gives typical analyses for the sentence *John slept for two hours*.

(1) John slept for two hours
   a. $\exists t[PAST(t) \& two-hours(t) \& \forall t'[t' \subseteq t \rightarrow AT(t', sleep(j))]]$ (Dowty (1979))
   b. $\exists t[two-hours(t) \& \forall t'[t' P t \rightarrow \exists e[\text{sleep}(e, j) \& AT(e, t') \& PAST(t)]]]$ (Moltmann (1991))

According to Dowty (1979) *John slept for two hours* is true iff there is some time interval $t$ that is past with respect to the moment of evaluation, that is two hours long, and is such that each subinterval contains sleeping by John. Moltmann (1991, 1997) suggests a similar analysis, but introduces events located at time intervals. A crucial feature of both analyses is that the "stuff" measured by durative phrases is time. At each portion of the "time-stuff" there is sleeping by John.

In this talk I suggest an alternative to the standard interval-based account. Specifically, following ideas by Cartwright (1975) on the semantics of nominal measure phrases, I propose that durative adverbs do not measure time, but rather event-stuff in the general sense of Davidson (1967). I’ll begin with two simple questions that arise for the interval account. I then go on to introduce Cartwright’s analysis, and its extension to the temporal case.

1.0 Two Questions for the Standard Account

1.1 Reification. As many authors have noted, durative temporal adverbs in the verbal system are analogous to temporal measure phrases in the nominal system. Thus *sleep for two hours* is analogous to *two hours of sleep*. In surface grammar, phrases like *two hours of sleep* are parallel to mass noun measure nominals like *two feet of rope*, so that (2a) is parallel to (3a). (Note that both cases also have parallel count noun forms, as shown in the (b) cases):

(2) a. two hours of sleep  
    b. a two-hour (long) sleep

(3) a. two feet of rope  
    b. a two-foot (long) rope

To the best of my knowledge, no one has analyzed a nominal like (4a) as in (4b), where length is reified as an entity to be measured. That is, we don’t analyze *two feet* as measuring some "length stuff" such that "at" each part of that stuff there is rope, etc.:

(4) a. A two-foot rope appeared.
    b. $\exists l[two-feet(l) \& \forall t'[l' P l \rightarrow \exists e[\text{rope}(x) \& \text{appear}(e, x) \& AT(x, l')]]$
Rather two-foot is taken to measure the stuff given by the common noun - rope in this case. The same holds for other measure nominals like two spoonfuls of sugar, or two pounds of sugar. We don’t take ourselves to be measuring abstract volume entities or abstract mass entities, with which real entities like sugar are associated. Rather we are measuring out sugar, with spoonfuls and pounds providing the units and the scale.

This raises a simple question: if we don’t assume abstracts stuffs with examples like (3a), why should we do so with examples like (2a)? Why do we not take ourselves to be measuring just what we see - sleeping activity in the latter case?

1.2 Temporal Anaphora. In an article on temporal & event anaphora, Glasbey (1993) notes that the presence of an overt temporal adverb like in July is needed to support co-temporal anaphoric reference by then (5a,b). Thus while (5a) can be understood as asserting that Daniel and Gareth climbed mountains in the same month, (5b), which lacks an explicit temporal antecedent, cannot easily be understood this way.

(5) a. Daniel climbed Ben Nevis in July
    Gareth climbed Snowdon then (= Glasbey’s (1a,b))

b. Daniel climbed Ben Nevis
    #Gareth climbed Snowdon then (= Glasbey’s (2a,b))

Glasbey observes that not all temporal adverbials will support temporal anaphora with then. Specifically, inclusive in-adverbials and durative for-adverbials won’t do so (6).

(6) Daniel climbed Ben Nevis (in four hours / for four hours)
    #Gareth climbed Snowdon then (= Glasbey’s (3a,b))

Geis (1970) notes very similar facts. Once again, despite the presence of an explicit adverbial, temporal anaphora with then is not possible with various duratives (7):

(7) a. #John studied for four hours and George studied then too.

b. #John studied until Bill arrived and George studied then too.

   #John has lived here since his father died and George has lived here then too.
   ((7b,c) = Geis’s (60), (61))

These points raise another simple question for the standard analysis: if durative adverbs invoke a time interval (the one over which they quantify), why do they not license temporal anaphora? Why is the relevant interval not made available as a “discourse entity” for later anaphoric reference?
2.0 The Semantics of Measure Phrases (Cartwright 1970, 1975)

Departing from the standard analysis, I propose an account of measure phrases that makes no essential appeal to time points or time intervals, but rather analyzes them as more directly analogous to nominal measure expressions. The crucial element of this account is the semantics for mass terms and measure proposed by Helen Cartwright (1970,1975). Summarizing very briefly, Cartwright takes both count nouns and mass nouns to divide their reference. But whereas count nouns divide their reference over familiar, spatio-temporally coherent objects, mass nouns divide their reference over what she calls "quantities", entities that need not be physically coherent. We enumerate the objects that a count noun applies to and obtain their number. We sum the quantities that a mass noun applies to and obtain their amount.

Cartwright (1975) analyzes nominal measure phrases as counting the quantity of their associated mass noun and yielding an amount. So an example like (8a), is analyzed as in (8b). Here "p spoonfuls" is an extensive measure function that applies to the maximal quantity of sugar bought by Mary; it partitions this quantity by spoonfuls and yields a number expressing the amount of sugar:

(8) a. Mary bought two spoonfuls of sugar.
   b. p spoonfuls[the x: sugar(x) & buy(Mary,x)] = 2
      ‘Measured in spoonfuls, the amount of sugar bought by M is 2’

My proposal is that we extend Cartwright’s account, using the event semantics of Davidson (1967) (cf. also Krifka 1989). Many authors have remarked on the analogies between mass nouns on the one hand, and non-telic verbs on the other (Bach 1986, Jackendoff (1991) Mourelatos 1981, Taylor 1977, Vlach 1993). Following Cartwright, I propose that we understand such verbal predicates as referring to quantities of events, and that we understand measure phrase adverbials as counting the quantity of event-stuff in their associated verb.

To illustrate, consider first the nominal measure phrase in (9a). Under the Cartwright + Davidson proposal, this would be analyzed as in (9b). Here “p hours” is an extensive measure function that applies to the maximal quantity of walking-activity observed by Mary. The function partitions this quantity by hours and yields a number expressing the amount of walking, here 2:

(9) a. Mary observed two hours of walking.
   b. p hours[the e: walking(e) & observe(Mary,e)] = 2
      ‘Measured in hours, the amount of walking observed by M is 2’

This idea can now be directly generalized to measure phrase adverbials. Two hours of corresponds to the measure adverbial for two hours (10a). So the latter can be analyzed via temporal measure functions on event-quantities (10b):

(10) a. Mary walked for two hours.
   b. p hours[the e: walking(e) & Agent(Mary,e)] = 2
      ‘Measured in hours, the amount of walking by M is 2’
This analysis directly addresses the questions raised above for the standard analysis. First, it does not divorce the semantics of temporal measure form that of other kinds of measure by reifying the measure-space. The analyses in (9b) and (10b) do not invoke time points - no more than the analysis in (8b) invokes an abstract space of spoonful points or volume points.

Second, the analysis makes no reference to time points or temporal intervals, only to temporal measure functions. Durative adverbs therefore do not invoke such discourse entities in any direct way. Under the proposals by Glasbey (1993), where \( \text{then} \) requires an explicit temporal antecedent making reference to a time or time interval, there will be no expectation that duratives should support temporal anaphora.

### 2.1 Extensions and Comparisons

The view proposed here has a number of attractive consequences, which I will sketch here briefly.

#### 2.1.1 Other Measure Adverbs

Mass nouns typically allow their amounts to be measured along a number of different dimensions. So we get \( \text{two spoonfuls of sugar} \) but also \( \text{two pounds of sugar} \). We get \( \text{two cubic yards of concrete}, \text{two tons of concrete}, \text{and two miles of concrete} \), etc. In a similar way with event measure, we get not only measurement by time but also measurement by distance (11). And beyond time and measure there are also more exotic forms of duratives, such as that cooked up in (12) (where, for simplicity, \( \text{this amplifier} \) is interpreted by the constant \( a \)):

\[
\begin{align*}
11. & \text{ a. Mary walked \textbf{for two miles}.} \\
& \text{\( P_{\text{miles}}[\text{the e: walking(e) & Agent(Mary,e)] = 2} \) } \\
& \text{‘Measured in miles, the amount of walking by M is 2’}
\end{align*}
\]

\[
\begin{align*}
12. & \text{ a. (This amplifier is accurate up to 10,000Hz)} \\
& \text{It is unstable \textbf{for (the next) 5,000 Hz}.} \\
& \text{(It fails entirely at 16,000Hz)} \\
& \text{\( \text{p_{Hz}[the e: being-unstable(e) & Theme(a,e)] = 5,000} \) } \\
& \text{‘Measured in Hz, the amount of unstable signal state is 5,000’}
\end{align*}
\]

The analysis advanced here generalizes directly to these other measures. In Cartwright’s system, \( \text{Mary walked for two miles} \) invokes the same kind of event-stuff as \( \text{Mary walked for two hours} \), just as \( \text{two spoonfuls of sugar} \) measures the same stuff as \( \text{two pounds of sugar} \). The difference is simply in the measure function used. Similar remarks apply to (12a,b), where we use a rather exotic measure to assess the amount of a state of instability.

#### 2.1.2 N-times Measure Phrases

The examples in (13) and (14) involve "\( n \)-times adverbials" where \( n \) is a numeral (e.g., \( \text{seven times} \)). Adverbs of this sort typically occur with predicates that are telic by the usual tests (13a,b). But such phrases can also occur with predicates that test out as atelic (14a-c):
(13)  a. Mary built a house seven times in an hour/*for an hour.  
   b. Mary walked to the store seven times in an hour/*for an hour.

(14)  a. Mary skipped rope seven times/*in an hour/for an hour.  
   b. Mary played chess seven times/*in an hour/for an hour.  
   c. Mary walked in the park seven times/*in an hour/for an hour.

In the latter cases, the \textit{n-times} phrase appears to be functioning, not as a specifier of \textit{how many} things were done, but rather \textit{how much} of a given thing was done: how much rope-skipping was done, how much chess-playing was done. And so.

\textit{N-times} measure phrases can be brought within the analysis suggested here by appeal to the intuitive semantic connection that exists between (15a) and (15b) :

(15)  a. Mary skipped rope seven times.  
   b. Mary took seven turns of skipping rope.  
   c. $p_\alpha[\text{the e: rope-skipping(e) & Agent(Mary,e)}] = 7$  
      'Counted in units $\alpha$ (given by context), the number of rope-jumpings by M is 7'

Intuitively, both (15a,b) require Mary to engage in seven occasions of rope-skipping, where what counts as an occasion or turn of rope-skipping is determined by context. The context dependence seen with these adverbials appears analogous to what we see in the case of nominal expressions like Mary added seven dashes of pepper, or Mary suffered seven bouts of illness, where what counts as a 'dash' or a 'bout' is likewise vague and contextually determined.

2.1.3 \textit{From-to} Phrases. A final extension involves \textit{from-to} phrases. Measuring linear quantities (like distance) involves \textit{from-to} arguments:

(16)  a. This boat measures forty feet from its bow to its stern.  
   b. This boat is forty feet long, measured from its bow to its stern.

Notice now that temporal \textit{from-to} arguments appearing after an expression of amount don't refer to time points directly. Instead they refer to events.

(17)  a. The competition lasted two hours from opening ceremonies to the final gun.  
      *The competition lasted two hours from 2:00 pm to 4:00 pm. (no "comma intonation" !)  
   b. The musical is two hours long, measured from overture to final curtain.  
      * The musical is two hours long, measured from 2:00 pm to 4:00 pm.

This result is natural for us: one spatially measures an object from one part of it to another - the \textit{from-to} arguments refer to the same kind of entity as that being measured. Likewise, one temporally measures an event from one part of it to another - the \textit{from-to} arguments refer to the same kind of entity as that being measured.
2.2 "Adding Measures" (Krifka (1989))

The time-measure and event-measure analyses are not equivalent but seem to make divergent predictions in certain cases involving addition of quantities and their measure. An important property of predicates that denote quantities is that they are **cumulative** in the sense shown in (18a). And an important requirement on functions that measure quantities is that they be **additive** in the sense shown in (18b). So consider P to be the predicate *water*. *Water* is cumulative: if x and y are quantities of water, then sum \( x \oplus y \) formed by pouring them together is also water. Furthermore, we want any measure function m for water to be additive. For example, if we add a quantity x measuring 2 gallons to a quantity y measuring 3 gallons, we certainly want the sum \( x \oplus y \) to measure out at 5 gallons:

\[
\begin{align*}
(18) & \quad \text{a. } P \text{ is cumulative iff } \forall xy[P(x) & \land P(y) \rightarrow P(x \oplus y)] \\
& \quad \text{b. } m \text{ is additive iff } m(x) + m(y) = m(x \oplus y) \\
& \quad \text{c. } \text{if quantities } x \text{ and } y \text{ overlap, } x \oplus y \text{ is } x \oplus y' \text{ (where } y' \text{ is } y \text{ minus the overlap)}
\end{align*}
\]

Notice that to get our measuring to turn out right, the entities measured must be non-overlapping, otherwise their overlap will end up be counted twice. Whenever we have a pair of overlapping quantities x, y, and are interested in measuring their sum, we must appeal to a derived pair x, y’, where y’ is y with the overlap subtracted out (17c).

Now in a version of the standard analysis, Krifka (1989) proposes that durative adverbs express additive measure functions; but instead of measuring event-quantities directly, they measure the "temporal traces" of events: the time intervals over which the events occur. This point has an interesting consequence in the case of distinct events that happen to temporally overlap. Consider the case of two separate singing events. John sings from 2:00 pm to 4:00 pm and Mary sings from 3:00 pm to 5:00 pm. How much singing (measured in hours) has occurred in this scenario?

Since the temporal traces of the events overlap, Krifka’s account requires us to subtract the common portion. This means that we must consider the total amount of singing by John and Mary, considered collectively, to be 3 hours, as shown in diagram (19). But despite Krifka’s assertion to the contrary, this simply does not reflect what native speakers judge to be the case. Every speaker that I have consulted judges the total amount of singing in this case to be 4 hours, not 3. In order to get kind of judgment Krifka offers one has to ask something very specific (and quite derivative) about the time-span, like "What is total time-span that these events occupy or take up?" Etc.
Hence appeal to temporal traces seems to yield a flatly wrong result.[1]

The results are different if we measure events directly. Overlap between events is a complex issue but one widely held view is that thematic roles like Agent must be unique in a given event (see Carlson (1982) for discussion). This means that if we have two events of singing with separate agents (John and Mary) they must be distinct, non-overlapping events. Since there is no overlap, we can take the sum of their temporal measures without subtraction. Hence we get the correct result where
\[ m(e_1) + m(e_2) = m(e_1 \oplus e_2) = 4 \text{ hours}. \]

Direct measurement of events not only predicts the adding of measures correctly in this case, but it also seems to predict when overlap will be relevant. Suppose there is kissing by Mary from 2:00 pm to 4:00 pm, and kissing of John from 3:00 pm to 5:00 pm. How many total hours kissing has there been? Native speakers judge this case to be one in which there may well be only three total hours of kissing. Intuitively, since the relevant thematic roles are complementary, we recognize that part of the first quantity of kissing by Mary might have been kissing of John. And part of the second quantity of kissing of John might have been kissing by Mary. That is, the two events may well overlap, in which case we must indeed subtract the overlap to calculate the sum correctly. Thus direct appeal to events appears to get the right result, and for the right reasons.
Conclusion

In this paper I have suggested an analysis of temporal measure phrases making no reference to time points. It’s an interesting question as to how far such a proposal can be pushed with respect to other aspects of temporal semantics, such as tense. The appeal to measure here has a direct echo to operationalism in physics where talk about abstract time and space is replaced by talk about temporal and spatial measurements. Whether such an ambitious program can be carried through in linguistic semantics is an open, but interesting question.

Notes

1. A similar, and equally wrong result will occur with spatial measure phrases. If John and Mary travel by the same road and John drives for 100 miles and Mary drives for 100 miles, then if there is overlap on their routes it will follow by Krifka’s analysis that they collectively traveled less than two hundred miles total. But this result is not intuitively correct.
References


