What Adverbials & Adverbial Clauses May Teach Us about Quantification

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Boolos (1981) observes quantifications like (1a), with the general form (1b).

(1) a. For every drop of rain that falls, a flower grows.
b. For every A, there is a B

B notes the 1st order representation for (1a) in (2a) is inadequate, being equivalent to (2b), which is too weak. (1a) requires branching quantifiers, or a 2nd order representation like (2b) (adapted from Rothstein 1995) w/existential quantification over **injections** f.

(2) a. $\forall x[\text{raindrop}(x) \,\&\, \text{falls}(x) \rightarrow \exists y[\text{flower}(y) \,\&\, \text{grows}(y)]]$
b. $\exists x[\text{raindrop}(x) \,\&\, \text{falls}(x)] \rightarrow \exists y[\text{flower}(y) \,\&\, \text{grows}(y)]$
c. $\exists f \forall x[\text{raindrop}(x) \,\&\, \text{falls}(x) \rightarrow \exists y[\text{flower}(y) \,\&\, \text{grows}(y) \,\&\, \mathbf{y = f(x)}]]$

An injection is a function mapping each element of its domain to a unique image in its co-domain. Wrt (1a), f maps each raindrop (r_i) to a unique flower (f_i), in effect, matching the first with the second (3).

(3)

DOM(raindrops)		CO-DOM(flowers)
r_1	→	$f_1 = f(r_1)$
r_2	→	$f_2 = f(r_2)$
r_3	→	$f_3 = f(r_3)$
⋮		⋮
r_n	→	$f_n = f(r_n)$
		f_{n+1}
		⋮

Since (3) allows for items in the co-domain (e.g., f_{n+1}) that aren't the image of any element in the domain, (2c) correctly captures the core assertion of (1a-b) that **there are at least as many Bs as As**.

Rothstein (1995) proposes that adverbial quantifications like (4a-d) have a logical status parallel to (1a-b).

(4) a. Every time Mary phones, John answers.
b. I met a friend every time I went to the bakery.
c. Every time I pay a phone bill, I lose the receipt later.

d. Mary complains about it every time she takes a math exam.

R argues convincingly that the truth conditions of (4a-d) involve matching events quantified over by the universal adverb with events described by the matrix clause. Adapting (2c), (4a) can be represented as in (5a), with "matching" as in (5b):

(5) a. $\exists f \forall e[\text{phoning}(e) \,\&\, \text{AGENT}(e) = \text{Mary} \rightarrow$
$\exists e'[\text{answering}(e') \,\&\, \text{AGENT}(e') = \text{John} \,\&\, e' = f(e)]]$ (where f is an injection)

b.

DOM(phonings)		CO-DOM(answerings)
e_1	→	$e'_1 = f(e_1)$
e_2	→	$e'_2 = f(e_2)$
e_3	→	$e'_3 = f(e_3)$
⋮		⋮
e_n	→	$e'_n = f(e_n)$
		e'_{n+1}
		⋮

Matching is part of the semantic structure of (4a-d) and not pragmatic, as R shows.

Key Question 1: Where does the "matching function" f come from in (1a)/(4a-d)? What contributes it to semantic composition?

In this talk, I pursue this simple question to some exotic conclusions.

Outline:

- In Section 1, I review Rothstein's answer to the KQ1 and some concerns about it. I sketch an alternative, quite different answer.
- In Section 2, I argue that quantifications express states; i.e., quantifications introduce their own Davidsonian eventuality variables.
- In Section 3, I explore the idea of neo-Davidsonianizing quantificational states. I suggest the matching function is a thematic role in neo-Davidsonianized quantification resembling the Theme role of Krifka (1993,1999).

1.0 Whence the Matching Function?

1.1 Rothstein (1995)

Rothstein (1995) doesn't assign to (6a) the representation in (6b) (where f is an injection), but rather the alternative in (6c).

(6) a. Every time Mary phones, John answers.

b. ∃ƒ∀e[phoning(e) & AGENT(e) = Mary → ∃e'[answering(e') & AGENT(e') = John & **e' = ƒ(e)**]]

c. ∀e[phoning(e) & AGENT(e) = Mary → ∃e'[answering(e') & AGENT(e') = John & **M(e') = e**]]

Here M is a contextually understood function from events to events. <u>But</u>:

- Instead of being a total function from phonings (e) to answerings (e'), M is a partial function from answerings (e') to phonings (e).
- In addition to being injective, M is onto (7).

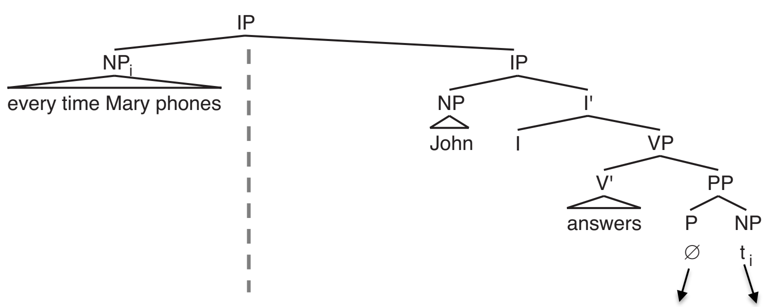
(7) CO-DOM(phonings) DOM(answerings)

e_1 = M(e_1) ← e'_1
e_2 = M(e_2) ← e'_2
e_3 = M(e_3) ← e'_3
⋮ ⋮
e_n = M (e_n) ← e'_n
e'_{n+1}
⋮

These assumptions correctly entail there to be at least as many answerings as phonings. But the analysis is peculiar in reversing the intuitive direction of mapping. Why does R do this?

R's Answer to KQ1: The pairing function is contributed by a prepositional element in the main clause.

(8) Every time Mary phones, John answers.



∀e[phoning(e) & AGENT(e) = Mary → ∃e'[answering(e') & AGENT(e') = John & **M(e') = e**]]

(9) a. *every time Mary phones* ⟹ λP∀e[phoning(e) & AGENT(e) = Mary → P(e)]

b. *John answers* ⟹ λe_i∃e'[answering(e') & AGENT(e') = John & **M(e') = e$_i$**]

(10) a. John flew his space ship to the Evening Star.

b. ∃e[flying(e) & **AGENT(e) = John** & **THEME(e) = his spaceship** & **TO(e) = the Evening Star**]

Concerns About R's Analysis:

i. How do we extend R's account to (1a)? *For* (≈ M) is syntactlcally/semantically unassociated with the indefinite subject (*a flower*), whether pied-piped (11a) or LF-reconstructed (11b). How can *for* end up pairing flowers with rain drops??

(11) a. [$_{PP}$ **For** every drop of rain that falls] [a flower grows [$_{PP}$ __].

b. [$_{NP}$ Every drop of rain that falls], [a flower grows [$_{PP}$ **for** __].

ii. How do we analyze adverbials not involving a P? (12a) seems semantically identical to (2a), but [$_P$ Ø] is not motivated here (12b).

(12) a. Always if/when Mary phones, John answers.

b. Always if/when Mary phones [John answers **[$_{PP}$ Ø t]**]. ???

iii. Taking Ps & θ-roles as functions from events to individuals is questionable; it requires counter-compositional functions, where the object of P/θ is not its first argument (13a-c). A parallel analysis of M is correspondingly dubious.

(13) a. λyλx[R(y)(x)]

b. λxλe[TO(e)= x]

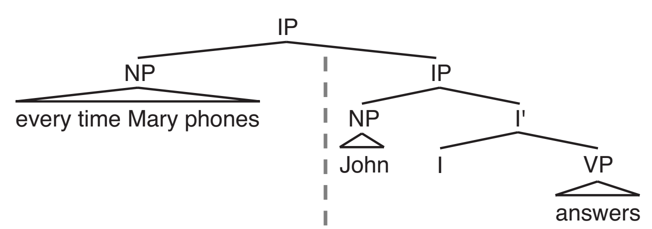
c. λxλe[AGENT(e) = x]

1.2 An Alternative

I suggest a different analysis based on a different answer to our key question about semantic composition.

My Answer to KQ1: The pairing function is contributed by the quantifier itself.

(14) Every time Mary phones, John answers



∃ƒ∀e[phoning(e) & AGENT(e) = Mary → ∃e'[answering(e') & AGENT(e') = John **& e' = ƒ(e)**]]

(15) a. *every* $\Rightarrow$ $\lambda Q\lambda P\forall x[Q(x) \rightarrow P(x)]$
b. (*for*) *every* $\Rightarrow$ $\lambda Q\lambda P\exists f\forall x[Q(x) \rightarrow \exists y[P(y) \& y = f(x)]]$

(16) a. *every time Mary phones* $\Rightarrow$
$\lambda P\exists f\forall x[\text{phoning}(x) \& \text{AGENT}(x) = \text{Mary} \rightarrow \exists y[P(y) \& \mathbf{y = f(x)}]]$
b. *John answers* $\Rightarrow$ $\lambda z[\text{answering}(z) \& \text{AGENT}(z) = \text{John}]$

Discusssion:

i. Although distinct, (15a-b) are closely related; (15b) entails (15a) when f is the identity function (i.e., when $f(x) = x$):

(17) $\lambda Q\lambda P\forall x[Q(x) \rightarrow \exists y[P(y) \& \mathbf{y = x}]] \vDash \lambda Q\lambda P\forall x[Q(x) \rightarrow P(x)]$

(15b) can therefore be viewed as the "generalized universal" of which the "classical universal" (15a) is a special case.

Generalized Universal: "There are at least as many Ps as Qs."
Classical Universal: "There are at least as many Ps as Qs that are also Ps."

ii. The nominal & adverbial domain exhibit both kinds of quantification. Boolos examples like (1a) show the generalized universal in the nominal domain. (18a-b) (from Rothstein 1995) show the classical universal in the adverbial domain:

(18) a. Every time Mary sees a horror movie, she sees it with John.
b. Every time I drink whisky, I drink Laphroaig.

iii. The domain/co-domain of f can be different; f: things → events (19a), and f: events → things (19b). The variables in (15b) must therefore be understood as **unsorted**.

(19) a. For every "A" Mary gets on her report card, John donates $5 to charity.
(grades → donation events)
b. Every time Mary steps, there is a foot print.
(stepping events → foot prints)

RE: Concerns w/ Rothstein (1995)

i. The quantifier analysis generalizes directly to Boolos cases like (1a).

(20) a. *for every raindrop that falls* $\Rightarrow$
$\lambda P\exists f\forall x[\text{raindrop}(x) \& \text{falls}(x) \rightarrow \exists y[P(y) \& \mathbf{y = f(x)}]]$
b. *a flower grows* $\Rightarrow$
$\lambda z[\text{flower}(z) \& \text{grows}(z)]$

ii. The quantifier analysis extends directly to *always* (21).

(21) *Always* $\Rightarrow$ $\lambda Q\lambda P\exists f\forall e[Q(e) \rightarrow \exists e'[P(e') \& \mathbf{y = f(e')}]]$

iii. The quantifier analysis doesn't locate the matching function (f) in a P.

Key Question 2: Why is there an injection inside the interpretation of quantifiers?

2.0 Quantificational States

Davidson (1967a) suggests the semantics of Vs should go from (22a) → (22b). Similarly (in principle) for relational As (23a-b), Ps (24a-b) & Ns (25a-b).

(22) Shem **kicked** Shaun.
a. **kick**(x, y)
b. **kick**(x, y, **e**)

(23) Shem is **envious** of Shaun.
a. **envious-of**(x, y)
b. **envious-of**(x, y, **e**)

(24) Shem is **near** Shaun.
a. **near**(x, y)
b. **near**(x, y, **e**)

(25) Shem is a **relative** of Shaun.
a. **relative-of**(x, y)
b. **relative-of**(x, y, **e**)

Consider now quantifiers, widely taken to express relations between properties (26a)/(27a). Are eventuality variables motivated here too (26b)/(27b)?

(26) **All** men complain.
a. **ALL**(P , Q)
b. **ALL**(P , Q, **e**)

(27) Men **always** complain.
a. **ALWAYS**(P , Q)
b. **ALWAYS**(P , Q, **e**)

In fact, we can find motivation for this move in constructions that express relations to eventualities: causatives, perception verbs and adverbial quantifiers.

2.1 Causing Quantificational States

Davidson (1967b) proposes that causation is a relation between eventualities (28) (which include both events and states). (29) illustrates the idea concretely.

(28) CAUSE(e , e')

(29) a. John's sneezing made Mary leave.
b. John's sneezing $\Rightarrow$ $\iota e[\text{sneeze}(\text{John},e)]$
c. Mary leave $\Rightarrow$ $\exists e'[\text{leave}(\text{Mary},e')]$
d. John's sneezing made Mary leave $\Rightarrow$
$\exists e'[\text{leave}(\text{Mary},e') \& \underline{\textbf{CAUSE}(\iota e[\text{sneeze}(\text{John},e)], e')}]$

Accepting this, reference to Q-states seems motivated. Consider (30-31) from Johnston (1994):

(30) a. Leopold always robs a bank because he needs money fast.
b. Frankie always misses the bus because he is a slow runner.
(cf. *Because he is a slow runner Frankie always misses the bus*.)

(31) John always sold shares because he needed the money.
a. 'Each event of John's selling shares was caused by a state of John's needing money'
b. 'John's need for money caused a certain behavioral pattern, viz.: John's always selling shares.'
(cf. *Because he needed the money John always sold shares.*)

In (30a)/(31a) individual states cause individual events. But (30b)/(31b), a state causes a "quantificational pattern". Consider also (32):

(32) a. [a dog's biting him in childhood] made
[John always become nervous when a dog was near him].
b. [Fido's conditioning] caused his salivating.

Always binds all events variables in its scope. Hence without a state corresponding to *always* itself, **CAUSE** will have no second event to relate to (33). We appear to need something like (34):

(33) **CAUSE**(ιe[a-dog's-biting-John(e)] , **??**) ↓
ALWAYS({e": John-become-nervous(e")} , {e*: a-dog-near-John(e*)})

(34) ∃**e** [**CAUSE**(ιe [a-dog's-biting-John(e)] , **e**) & ↓
ALWAYS({e": John-become-nervous(e")} , {e*: a-dog-near-John(e*)} , **e**)

2.2 Perceiving Quantificational States

Higginbotham (1983) and Vlach (1983) argue that perception is a relation between individuals (*x*,*y*) (35), where the latter (*y*) can be an eventuality (36).

(35) SEE/HEAR(x , y , e)

(36) a. John heard Mary leave.
b. Mary leave. ⇒ ∃e' [leave(Mary,e')]
d. John heard Mary leave ⇒ ∃e∃e'[leave(Mary,e') & **<u>HEAR</u>**<u>(John, e' , e)</u>]

Again, accepting this, reference to Q-states seems natural. Consider (37a,b).

(37) a. John heard Mary frequently complain about her job.
(≠ John frequently heard Mary complain about her job.)
b. John saw Mary often leave before 5:00pm.
(≠ John often saw Mary leave before 5:00pm.)

In both John sees/hears, not specific events, but instead a regular pattern of behavior on Mary's part - a state.

Frequently binds all events variables in its scope. Thus without a state corresponding to *frequently* itself, **HEAR** has no second event to relate to (38). We appear to need something like (39):

(38) ∃e' [**<u>HEAR</u>**(John , **??** , e') & ↓
FREQ({e": Mary-complain-about-job(e")} , {e*: C(e*)})

(39) ∃**e** ∃e' [**<u>HEAR</u>**(John , **e** , e') & ↓
FREQ({e": Mary-complain-about-job(e")} , {e*: C(e*)}, **e**)

2.3 Quantifying Over Quantificational States

Adverbial quantifiers quantify over eventualities (Rothstein 1995; Herburger 2000). In GQ terms, this means relating sets (40)/(41a-b).

(40) **ALWAYS**({e: P(e)} , {e*: Q(e*)})

(41) a. John **always** eats in the hotel restaurant.
b. **ALWAYS**({e: John-eats-in-HR(e)} , {e*: C(e*)})

Assuming this is correct, consider sentences involving multiple adverbial Qs (42a,b).

(42) a. **Usually** (when he is staying at the Four Seasons)
John **always** eats in the hotel restaurant.
b. **Often** (when he in feeling down)
John will **frequently** visit a casino./John will frequent casinos.

In both we seem to say of a certain behavioral pattern on John's part – his always eating somewhere, his frequently visiting something, etc. – that it's attested with a certain frequency – that it is usual in certain circumstances, that it is frequent, etc.

Always binds all eventuality variables in its scope. Hence without a state corresponding to *always* itself, binding by $e^{\dagger}$ in the first arg of *usually* is vacuous (43). We appear to need something like (44):

(43) **USUALLY(**
{ **e**†: **ALWAYS**({e: John-eats-in-HR(e)} , {e*: C(e*)}) } , { e‡: John-stay-at-4S(e‡)} **)**

e† ??

(44) **USUALLY(**
{ **e**†: **ALWAYS**({e: John-eats-in-HR(e)} , {e*: C(e*)}, **e**†)},
{ e‡: John-stay-at-4S(e‡)} , e* **)**

3.0 Neo-Davidsonian Quantificational States

Neo-Davidsonians take the semantics of Vs further, from (45a) → (45b). Similarly (in principle) for relational As (27a-b), Ps (28a-b) and Ns (29a-b).

(45) Shem **kicked** Shaun.
a. **kick**(x, y, **e**)
b. **kicking**(**e**) & θ_1(**e**, x) & θ_2(**e**, y)
"ARGUMENT SEPARATION"

(46) Shem is **envious** of Shaun.
a. **envious-of**(x, y, **e**)
b. **envy**(**e**) & θ_1(**e**, x) & θ_2(**e**, y)

(47) Shem is **near** Shaun.
a. **near** (x, y, **e**)
b. **proximity**(**e**) & θ_1(**e**, x) & θ_2(**e**, y)

(48) Shem is a **relative** of Shaun.
a. **relative-of**(x, y, **e**)
b. **kinship**(**e**) & θ_1(**e**, x) & θ_2(**e**, y)

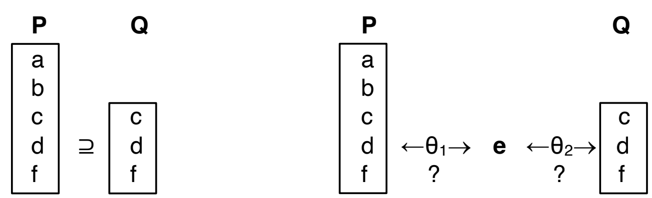
If event variables are indeed motivated with quantifiers (49a)/(50a), is argument separation possible here as well (49b)/(50b)?

(49) **All** men complain.
a. **ALL**(P , Q, **e**)
b. **All**(**e**) & θ_1(**e**, P) & θ_2(**e**, Q)

(50) Men **always** complain.
a. **ALWAYS**(P , Q, **e**)
b. **All** (**e**) & θ_1(**e**, P) & θ_2(**e**, Q)

Problem: Qs express pure relations between sets of <u>individuals</u>:
cardinalities, proportions, etc. (51a)
What happens to this relation with a state interposed (51b)?

(51) a. **ALL**(P , Q) b. θ_1(**e**, P) & θ_2(**e**, Q)



It's here that "matching" quantification guides us.

(52) a. Everyone who sneezed left.
b. Every time John sneezes, Mary leaves.

(53) a. {y: sneezes (y)} ⊇ {x: left(x)}
b. {e: leaving(e) & Ag(e,**m**)} ⊇ {e': sneezing(e) & Ag(e,**j**)} X

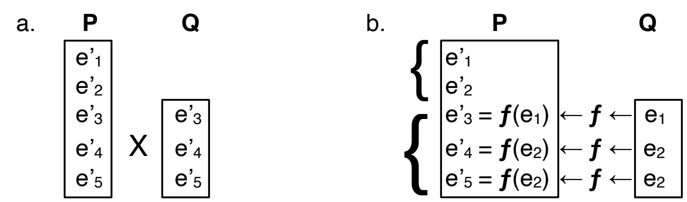
Davidsonian events are **thematically unique**; a given event can have at most one agent, theme, goal, etc. This means no event of Mary leaving can also be an event of John's sneezing. The first set <u>cannot</u> <u>contain</u> <u>the</u> <u>second</u>.

This result is general for adverbial Qs understood as quantifying over events.

(54) a. If it snows, Mary usually stays inside.
b. MOST(P,Q) iff | Q ∩ P | > | Q – P |
c. | {e: Snowing(e)} ∩ {e': Stay-inside(e') & Th(e',**m**)} | >
| {e: Snowing(e)} – {e': Stay-inside(e') & Th(e',**m**)} | X

How is this point accommodated?

(55) **MOST**(P , Q)



(56) a. 'The image under *f* of the snowing events (Q) in the staying-inside events (P) is larger than its complement in the staying-inside events.'
b. | ***f***({e: Snowing(e)}**)** | >
| {e': Stay-inside(e') & Th(e',**m**)} – ***f***({e: Snowing(e)}**)** |

Adverbial Qs thus typically present a situation <u>opposite</u> to nominal Qs: we precisely <u>can't</u> compare sets Q and P directly. Comparison of P is to a subset *f*(Q) that is the injective image of Q.

3.1 Executing Argument Separation

Comparing images suggests a way of neo-Davidsonianizing quantifiers, as a generalization of (55b).

Idea1: Quantificational eventualities represent a uniform codomain where quantifies of (possibly different) kinds of objects are compared via their images under injections. Quantificational e = a common "image space".

Idea2: Quantificational θ-roles represent different injections to the eventuality image space.

(55) Combining Q (the restriction): f is an injection

e		Q
e_1		
e_2		
$e_3 = \boldsymbol{f}(\alpha)$	$\leftarrow \boldsymbol{f} \leftarrow$	α
$e_4 = \boldsymbol{f}(\beta)$	$\leftarrow \boldsymbol{f} \leftarrow$	β
$e_5 = \boldsymbol{f}(\gamma)$	$\leftarrow \boldsymbol{f} \leftarrow$	γ

(56) Combining P (the scope): $\boldsymbol{g}$ is an injection st CO-DOM($\boldsymbol{f}$) ⊇ CO-DOM($\boldsymbol{g}$)

P		e		Q
		e_1		
a	$\rightarrow \boldsymbol{g} \rightarrow$	$\boldsymbol{g}(a) = e_2$		
b	$\rightarrow \boldsymbol{g} \rightarrow$	$\boldsymbol{g}(b) = e_3 = \boldsymbol{f}(\alpha)$	$\leftarrow \boldsymbol{f} \leftarrow$	α
c	$\rightarrow \boldsymbol{g} \rightarrow$	$\boldsymbol{g}(c) = e_4 = \boldsymbol{f}(\beta)$	$\leftarrow \boldsymbol{f} \leftarrow$	β
d	$\rightarrow \boldsymbol{g} \rightarrow$	$\boldsymbol{g}(d) = e_5 = \boldsymbol{f}(\gamma)$	$\leftarrow \boldsymbol{f} \leftarrow$	γ

Idea3: Quantificational states hold in virtue of the relations among the f & g images.

(57) a. every/always(e) & $\boldsymbol{g}$(P,e) & $\boldsymbol{f}$(Q,e) iff $|\boldsymbol{f}(Q) - \boldsymbol{g}(P)| = 0$
b. some(e) & $\boldsymbol{g}$(P,e) & $\boldsymbol{f}$(Q,e) iff $|\boldsymbol{f}(Q) \cap \boldsymbol{g}(P)| \neq 0$
c. no(e) & $\boldsymbol{g}$(P,e) & $\boldsymbol{f}$(Q,e) iff $|\boldsymbol{f}(Q) \cap \boldsymbol{g}(P)| = 0$
d. most(e) & $\boldsymbol{g}$(P,e) & $\boldsymbol{f}$(Q,e) iff $|\boldsymbol{f}(Q) \cap \boldsymbol{g}(P)| > |\boldsymbol{f}(Q) - \boldsymbol{g}(P)|$

"Classical quantification" on our earlier matching view: the matching function f is the identity function (f(x) = x; recall 17)

"Classical quantification" on the neo-Davidsonianized view: the composed function $g^{-1} \circ f$ is the identity function ($g^{-1}(f(x)) = x$).

3.2 A Surprisingly Familiar Picture!

Neo-Davidsonianized quantifers resemble neo-Davidsonianized verb sets in which the roles are the same, but the action is different (58a-d):

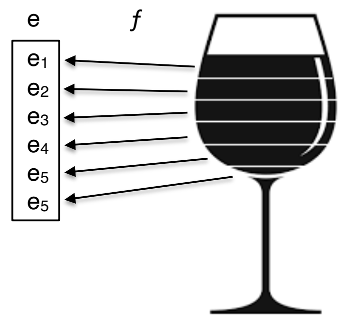
(58) a. hitting(e) & Agent(x,e) & Patient(y,e)
b. slapping(e) & Agent(x,e) & Patient(y,e)
c. tapping(e) & Agent(x,e) & Patient(y,e)
d. patting(e) & Agent(x,e) & Patient(y,e)

Likewise in (57a-d), the roles (f, g) are the same, but the Q-state is different.

Krifka's (1989, 1992, 1999) analysis of telicity: θ_{THEME} homomorphically injects the the mereological structure of the object into the verbal event. In (59a), a glass of wine is injected into a drinking event e (59b).

(59) a. Hans drank a glass of wine.

b.



Boundness/quantization in wine creates a bounded/quantized image in drinking, which becomes accessible to measure adverbs like *in an hour*). Krifka's **incremental theme** θ-relation looks very like a version of f.

Davidson (1967a) argues that a great many sentences are underlying event quantifications. It thus would be unsurprising to find that the event analysis of quantifiers underlies the event analysis of familiar, verbal predication.

4.0 Wrapping Up

- Some nominal quantifications & typical examples of adverbial quantification appear to involve pairing/matching elements of one set with those of another.
- Matching is part of the semantic structure of the quantifier in those cases.
- Matching quantifiers are generalized versions of classical quantifiers.
- Quantifiers appear to introduce quantificational states, which can be caused, perceived & quantified-over.
- A neo-Davidsonianization of quantifiers/quantificational states suggests an answer to where "matching" comes from & why it represents the general case in quantification.
- The resulting picture of quantifiers appears to be a natural one in various respects.