

Division and Distributivity: The case of Hungarian *-nként*

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Model-theoretic semantics

$$\llbracket \phi \rrbracket^{\mathcal{M}}$$

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$$\mathcal{M} = \langle \mathcal{D}, \mathcal{I} \rangle$$

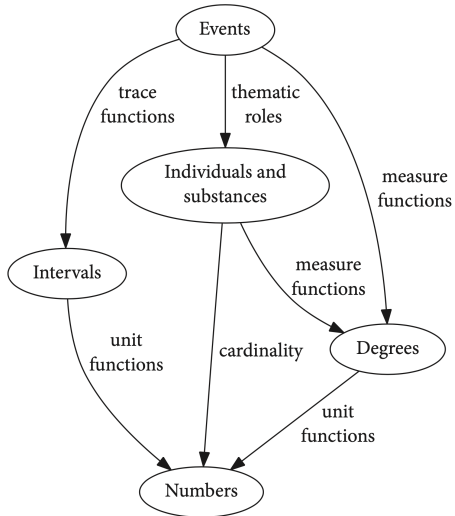


FIG. 2.2 The world (some details omitted).

(Champollion, 2017)

Model-theoretic semantics and the ontology of degrees

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$$\mathcal{M} = \langle \mathcal{D}^{\mathcal{T}}, \mathcal{I} \rangle$$

where $\mathcal{T} = \{e, v, i, d, n\}$

e: individuals *v*: events *i*: intervals *d*: degrees *n*: numbers

Model-theoretic semantics and the ontology of degrees

$$\llbracket \phi \rrbracket^{\mathcal{M}}$$

$$\mathcal{M} = \langle [\mathcal{D}_e, \mathcal{D}_v, \mathcal{D}_i, \mathcal{D}_d, \mathcal{D}_n], \mathcal{I} \rangle$$

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Model-theoretic semantics and the ontology of degrees

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$$\mathcal{M} = \langle [\langle \mathcal{D}_e, \oplus_e \rangle, \langle \mathcal{D}_v, \oplus_v \rangle, \langle \mathcal{D}_i, \oplus_i \rangle, \langle \mathcal{D}_d, \dots \rangle, \langle \mathcal{D}_n, +, * \rangle], \mathcal{I} \rangle$$

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e: individuals *v*: events *i*: intervals *d*: degrees *m*: dimensions

Outline

Per: a distributivity marker?

Minimal size requirement

Uniformity requirement

Indefinite share requirement

Term uses

English *per*

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Quotient operator analysis

Dimension quotient analysis

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A distributivity marker analysis

Evidence for a ratio marker analysis

Proposal

English *per* and *each*

Adnominal *each* requires a licenser, and not just any will do (cf. Safir & Stowell 1988). English *per* has similar licensing requirements.

- (I) a. They ate two/several olives $\left\{ \begin{array}{l} \text{each} \\ \text{per person} \end{array} \right\}$.
- b. ??They ate those/most olives $\left\{ \begin{array}{l} \text{each} \\ \text{per person} \end{array} \right\}$.
- c. ??They decided to leave $\left\{ \begin{array}{l} \text{each} \\ \text{per person} \end{array} \right\}$.

Gil (1995): 'share per key'

Analysis of distributivity marker *each*

They ate two olives each

(Champollion 2017)

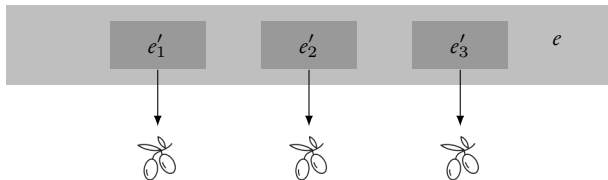


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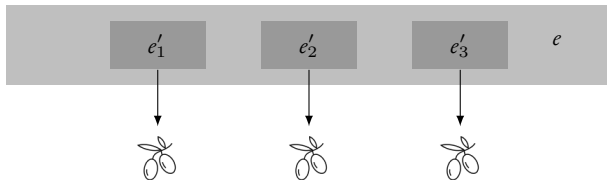
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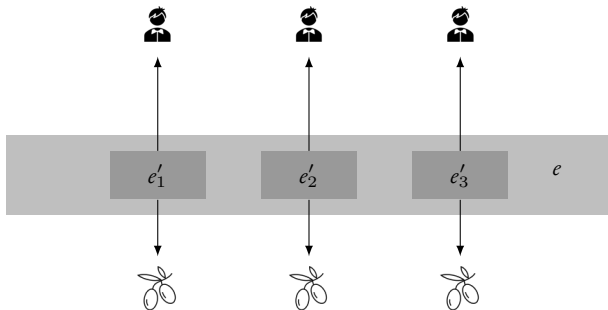


$$e \in * \lambda e' . * \text{eat}(e') \wedge * \text{olive}(* \text{theme}(e')) \wedge \mu(* \text{theme}(e')) = 2 \wedge$$

Analysis of distributivity marker *each*

They ate two olives each

(Champollion 2017)



$$e \in * \lambda e' . * \text{eat}(e') \wedge * \text{olive}(* \text{theme}(e')) \wedge \mu(* \text{theme}(e')) = 2 \wedge \text{atom}(* \text{agent}(e'))$$

Romanian *de* and Italian *per*

Romanian:

- (2) James Bond a mâcat două măslin**e** **de** martini
James Bond has eaten two olives DE martini
'James Bond ate two olives per martini'

Italian:

- (3) James Bond ha mangiato due olive **per** martini
James Bond has eaten two olives PER martini
'James Bond ate two olives per martini'

Panaiteescu & Tovená (2019, 226):

“Preposition *per/de* is a share-key relator.”

But different events: drinking vs. eating

Panaitescu & Tovená's Inspiration

(4) James Bond ate two olives per martini.

Boolos (1981), 'For every x there is a y'

(5) For every martini, James Bond ate two olives.

Rothstein (1995), 'Adverbial quantification over events'

(6) Every time James Bond drank a martini, he ate two olives.

Distributivity marker analysis

James Bond ate two olives per martini

(Panaitescu & Tovená 2019)

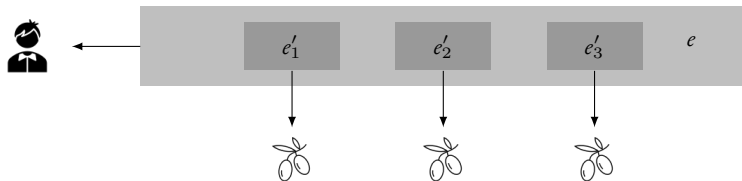


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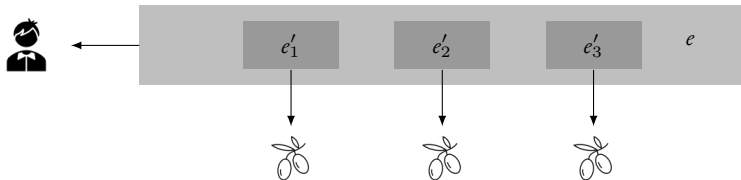
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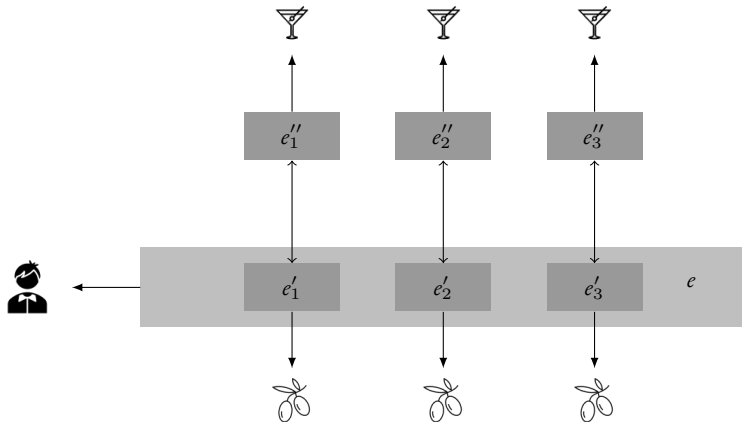


$$e \in * \lambda e' . * \text{eat}(e') \wedge * \text{olive}(* \theta_{\text{share}}(e')) \wedge \mu(* \theta_{\text{share}}(e')) = 2 \wedge$$

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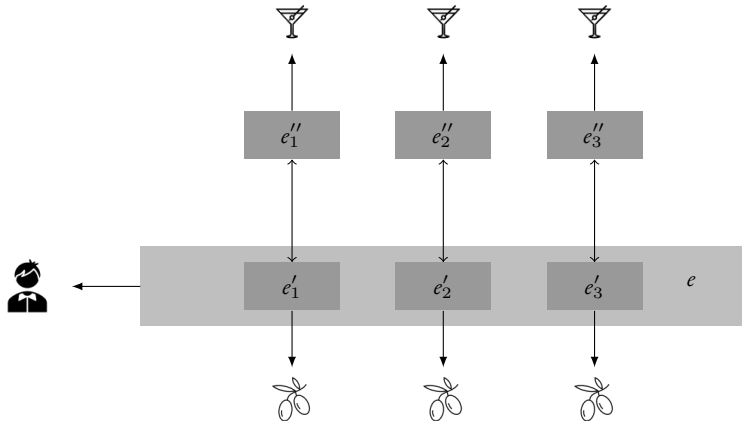


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$$e \in * \lambda e' . * \text{eat}(e') \wedge * \text{olive}(* \theta_{\text{share}}(e')) \wedge \mu(* \theta_{\text{share}}(e')) = 2 \wedge$$
$$* \text{drink-martini}(\text{match}(e'), * \theta_{\text{key}}(\text{match}(e'))) \wedge \mu(* \theta_{\text{key}}(\text{match}(e'))) = 1$$

Ratio marker analysis

James Bond ate two olives per martini

$$\frac{\text{olives}}{\text{martini}} = \frac{\text{olives eaten in } e}{\text{martinis drunk in } e}$$



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Predictions of the distributivity marker analysis

- ▶ **Minimal size requirement:** The eventuality described by the clause should be divisible into one or more ‘key’-sized chunks.
- ▶ **Uniformity requirement:** The eventuality described by the clause should be divisible into subevents that uniformly manifest both the share and the key.
- ▶ **Indefinite share requirement:** A *per* phrase should only be able to modify (cardinal) indefinites.
- ▶ **Event predicates not terms:** A *per* phrase, together with its licensor, creates a predicate characterizing an event, and not a (degree-denoting) term.

No minimal size requirement: Sub-unit uses

Unlike with *each*, the event is not always divisible into 'key'-sized chunks with *per*:

- (7) James Bond drove 100 km per hour.
≠ ??For each hour, James Bond drove 100 km.
(Event could last five minutes.)

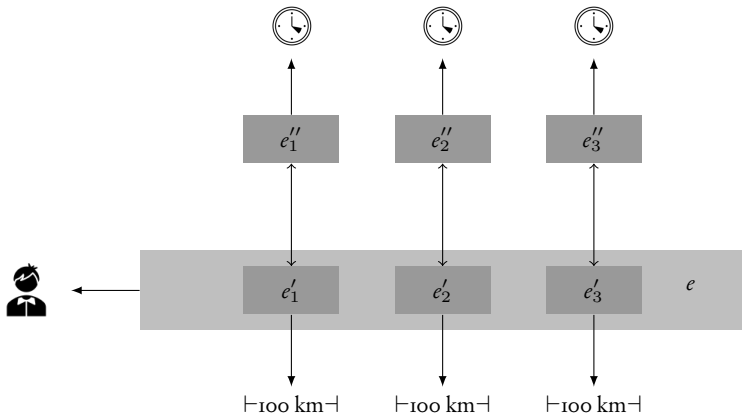
No minimal size requirement: Sub-unit uses

Unlike with *each*, the event is not always divisible into 'key'-sized chunks with *per*:

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≠ ??For each hour, James Bond drove 100 km.
(Event could last five minutes.)
- (8) James Bond drove 100 km per hour for five minutes.
Cf. **(for) an/every hour, *in an/every hour*

Distributivity analysis: Sub-unit uses should be bad

James Bond drove 100 km per hour



... Although sub-unit uses can be controversial

Schwarz & Bale (2022) claim that there is a contrast in acceptability between these two:



- (9) a. That half-liter sample weighs 0.9 grams per milliliter
- b. #That half-liter sample weighs 0.9 kilograms per liter

ChatGPT says

EE

What is the weight of a half-liter sample that weighs 0.9 kilograms per liter?



To find the weight of a half-liter sample that weighs 0.9 kilograms per liter, we can use the following formula:  

Weight = Volume x Density

Here, the volume of the sample is 0.5 liters, and the density is 0.9 kilograms per liter.

Plugging these values into the formula, we get:

Weight = $0.5 \times 0.9 = 0.45$ kilograms

Therefore, the weight of a half-liter sample that weighs 0.9 kilograms per liter is 0.45 kilograms.

More sub-unit examples

- (I0) You can do this by taking short choppy steps and doing arm swing drills at 240 steps per minute for 20 seconds.
- (II) \$16,000 is invested at 12.5% per year for 6 months. How much interest is earned on the investment?

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Non-uniform contexts: Attested example

A student was asked to log her steps for a class.

Week 1 Total: 72,195

high day was 13,286 steps, low day was 7,328 steps

Week 2 Total: 70,200

high day was 13,911 steps, low day was 3,360 steps

(12) As shown in the log, I reached my weekly goal of hitting 70,000 per week, or 10,000 steps per day

Non-uniform contexts: Attested examples

- (13) The Montreal Canadiens scored 2.82 goals per game in 2020-21.
- (14) The San Francisco 49ers have scored just 22 points per game this season.
- (15) Legendary veteran Anup Kumar scored 5.79 points per match in his career.

Complement of verb *average*

On hair growth:

- (16) I average a half inch $\left\{ \begin{array}{l} \text{per} \\ \text{?every} \end{array} \right\}$ month, but it varies depending on the season.

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No indefinite 'share'

Gradable predicates:

- (I7) The guests found it quite expensive $\left\{ \begin{array}{l} \# \text{each} \\ \text{per person} \end{array} \right\}$.
- \nRightarrow #For each person, the guests found it quite expensive.

No indefinite 'share'

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 \nRightarrow #For each person, the guests found it quite expensive.

Dimension nouns like *cost* (denoting measure functions):

- (I8) The guests minimized the cost $\left\{ \begin{array}{l} ?? \text{each} \\ \text{per person} \end{array} \right\}$.
 \nRightarrow #For each person, the guests minimized the cost.

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Differential arguments

- (19) For every degree the body's internal temperature rises, the heart beats about 10 beats per minute **faster**.
- (20) There are tables of various woods that put mahogany 200 kg per cubic meter **denser** than poplar.

(Cf. Rawlins 2013 on differential arguments)

Summary

None of these predictions of the distributivity marker analysis are borne out:

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Quotient function analysis of *per*

Lexical entries for English words:

(21) *kilometer(s)* \rightsquigarrow km

(22) *hour(s)* \rightsquigarrow hour

km, hour: type *d*

Quotient function analysis of *per*

Lexical entries for English words:

(21) *kilometer(s)* \rightsquigarrow km

(22) *hour(s)* \rightsquigarrow hour

km, hour: type *d*

(23) *per*₀ \rightsquigarrow $\lambda d \lambda q . \frac{q}{d}$

Quotient function analysis of *per*

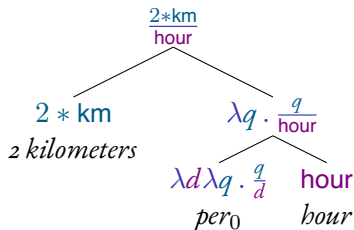
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(22) *hour(s)* \rightsquigarrow hour

km, hour: type d

(23) per_0 \rightsquigarrow $\lambda d \lambda q . \frac{q}{d}$



(Coppock, 2021)

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Challenge for the quotient function analysis

(24) It's estimated that 150 species per day go extinct.

Challenge for the quotient function analysis

- (24) It's estimated that 150 species per day go extinct.
150 species per day is a high rate.

Challenge for the quotient function analysis

- (24) It's estimated that 150 species per day go extinct.
150 species per day is a high rate.
#Therefore, a high rate is among those going extinct.

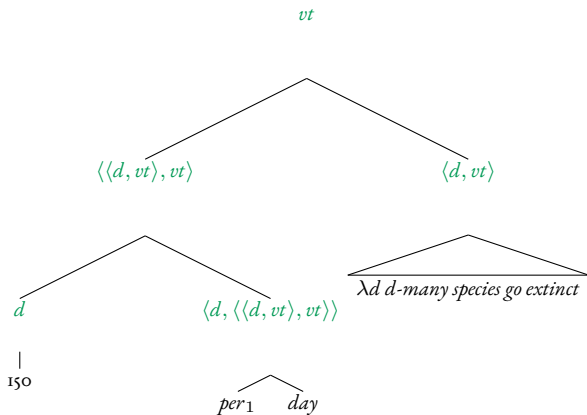
Challenge for the quotient function analysis

- (24) It's estimated that 150 species per day go extinct.
150 species per day is a high rate.
#Therefore, a high rate is among those going extinct.

Target truth conditions:

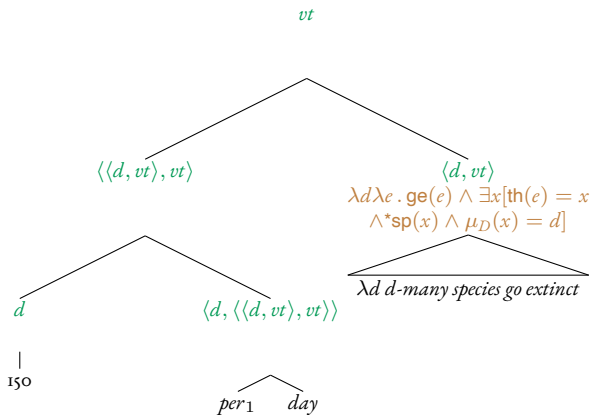
$$\text{Gen } e . \frac{\text{the number of species that go extinct in } e}{\text{the duration of } e} = \frac{150}{\text{day}}$$

Compositional derivation for quotient operator use



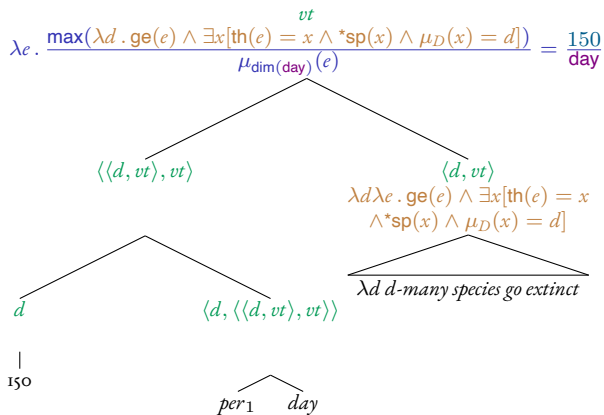
(Coppock, 2022)

Compositional derivation for quotient operator use



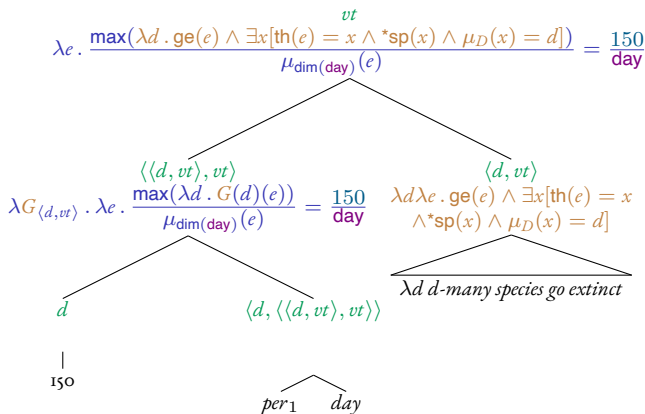
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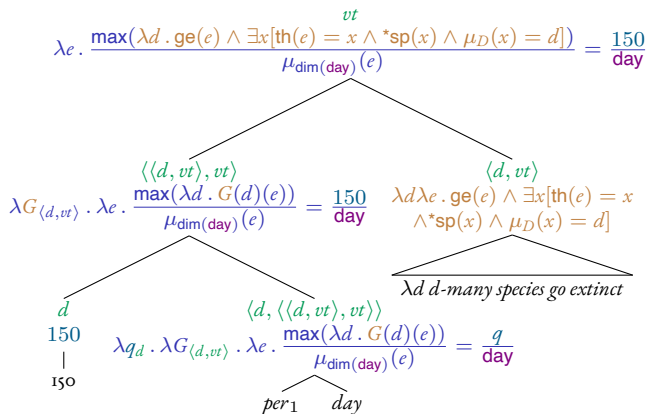
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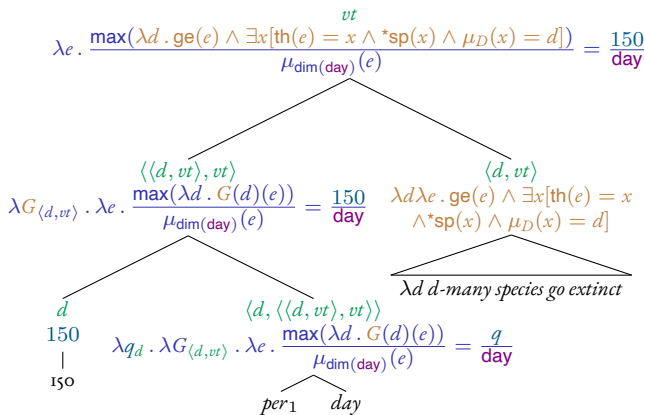
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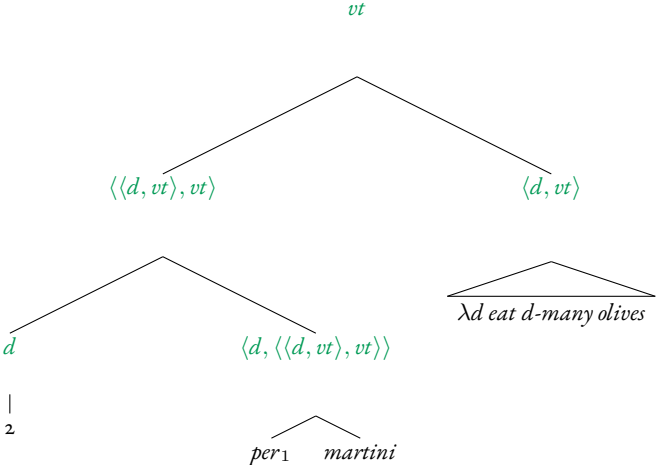
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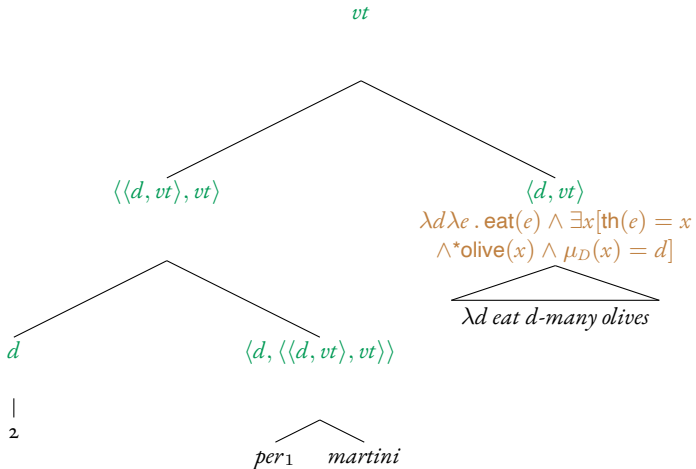
$$per_1 \rightsquigarrow \lambda d. \lambda q_d. \lambda G_{\langle d, vt \rangle}. \lambda \alpha. \frac{\max(\lambda d'. G(d'))(\alpha)}{\mu_{\text{dim}(d)}(\alpha)} = \frac{q}{d}$$

(Coppock, 2022)

James Bond ate two olives per martini

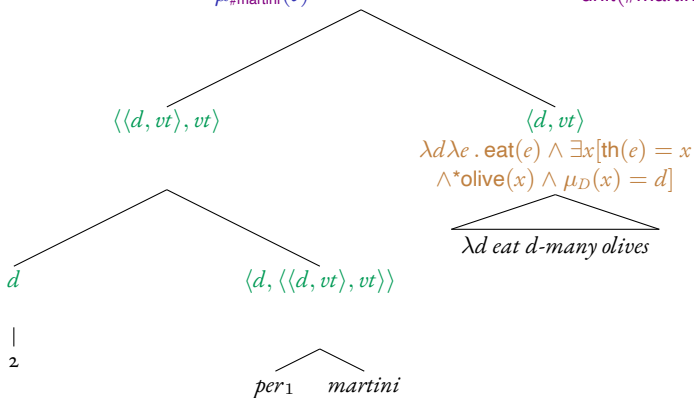


James Bond ate two olives per martini



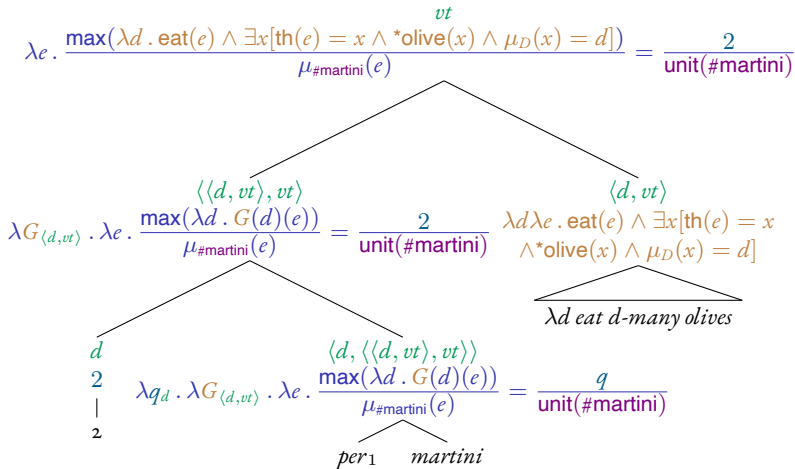
James Bond ate two olives per martini

$$\lambda e. \frac{\max(\lambda d. \text{eat}(e) \wedge \exists x[\text{th}(e) = x \wedge \overset{vt}{*}\text{olive}(x) \wedge \mu_D(x) = d])}{\mu_{\#martini}(e)} = \frac{2}{\text{unit}(\#martini)}$$



‘The ratio of how many olives are eaten in e to the measure of e along the number-of-martinis dimension is equal to 2 divided by one martini.’

James Bond ate two olives per martini



‘The ratio of how many olives are eaten in e to the measure of e along the number-of-martinis dimension is equal to 2 divided by one martini.’

Another challenge for the quotient function analysis

Measure function verbs like *weigh*:

(25) Water weighs 1 kg per liter.

Schwarz & Bale (2022) point out that it does not suffice to treat ‘1 kg per liter’ as degree-denoting term here; what water weighs is not a ratio of weight to volume.

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$$\text{weight}(x) \neq \frac{1 * \text{kg}}{\text{liter}}$$

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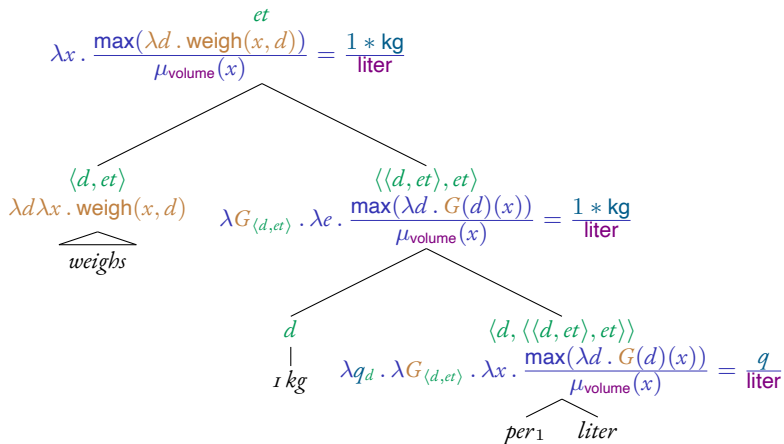
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$$\text{weight}(x) \neq \frac{1 * \text{kg}}{\text{liter}}$$

$$\dim(\text{weight}(x)) = M \qquad \dim\left(\frac{1 * \text{kg}}{\text{liter}}\right) = \frac{M}{L^3}$$

Compositional derivation for measure function verb case

Water weighs 1 kg per liter



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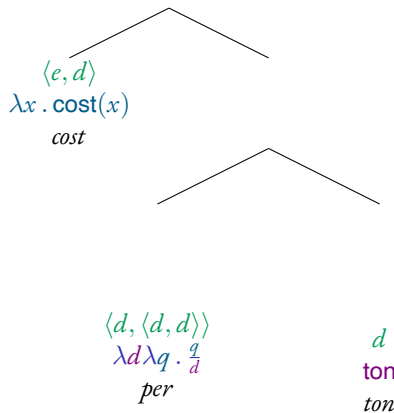
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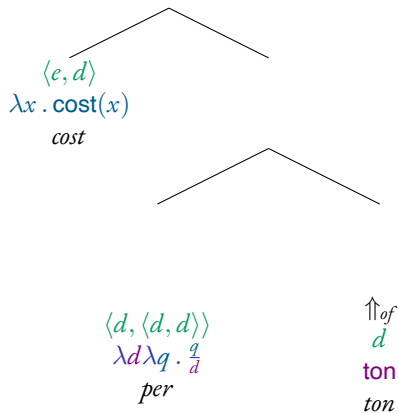
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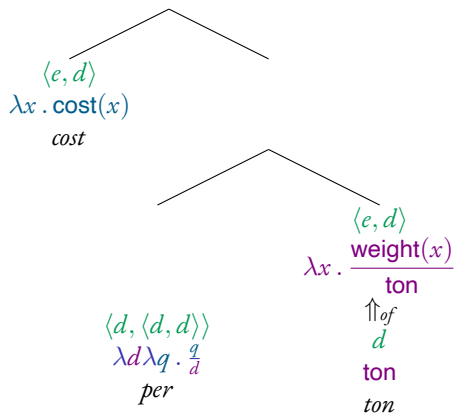
Dimension quotient analysis



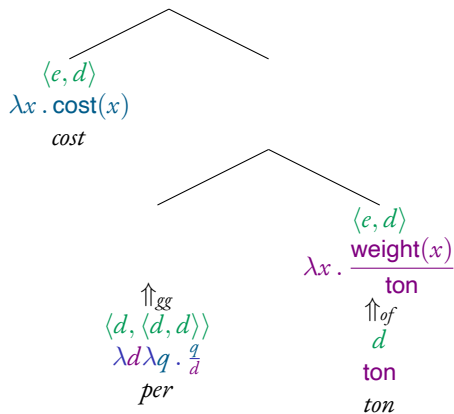
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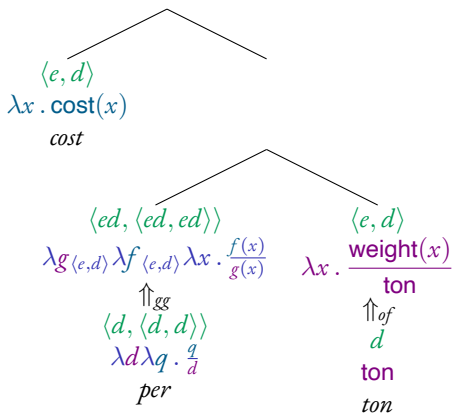
Dimension quotient analysis



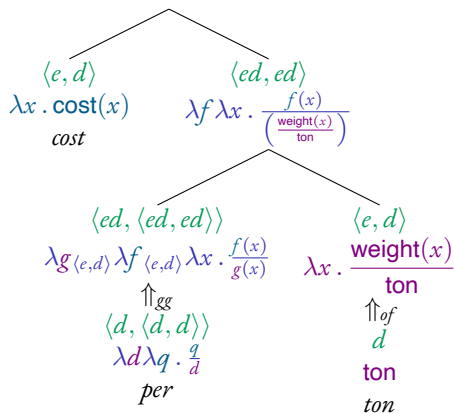
Dimension quotient analysis



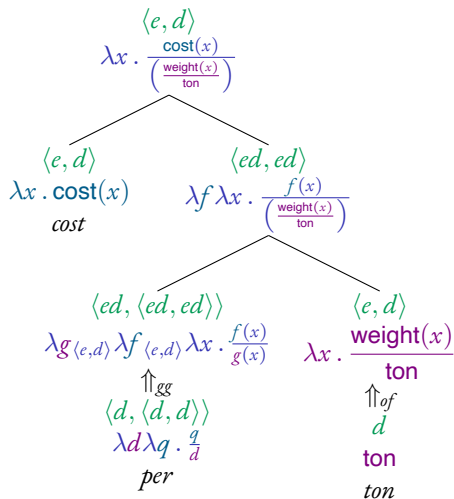
Dimension quotient analysis



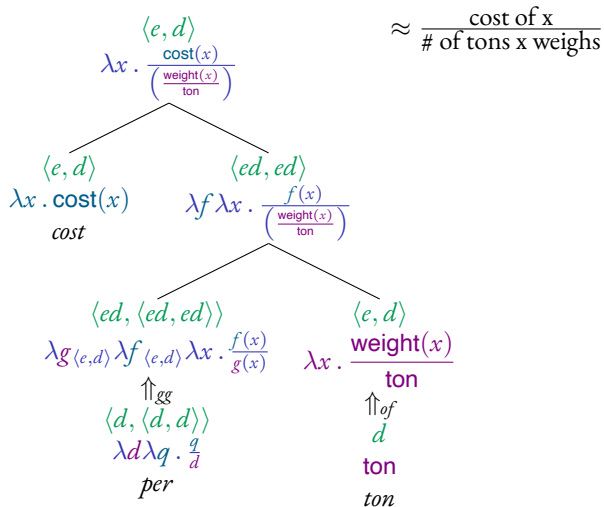
Dimension quotient analysis



Dimension quotient analysis



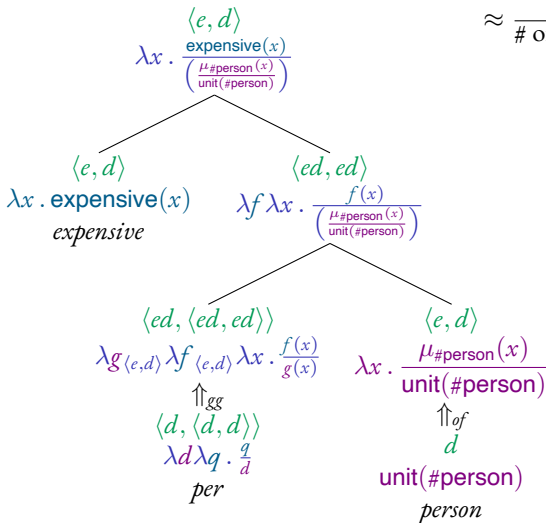
Dimension quotient analysis



Gradable predicates

(how) expensive per person

$$\approx \frac{\text{cost of } x}{\# \text{ of people } x \text{ measures}}$$



Contrast with preposing (Bale & Schwarz)

- (26) a. The weight of that sample was more than two grams per milliliter.
b. The weight of that sample, per milliliter, was more than two grams.
- (27) a. The density of that sample was more than two grams per milliliter.
b. #The density of that sample, per milliliter, was more than two grams.

Possible diagnostic for quotient function vs. quotient operator analysis.

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Per: a distributivity marker?

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Per vs. *-nként*

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Evidence for a ratio marker analysis

Proposal

Distributivity vs. division

English *per* is a ratio marker rather than a distributivity marker.

Evidence:

- ▶ sub-unit uses
- ▶ non-uniform contexts
- ▶ dimension noun and gradable numerators
- ▶ degree-term uses

Lexical entries for *per*

Three ratio-marker senses of *per*:

- ▶ quotient function

$$per \rightsquigarrow \lambda d \lambda q . \frac{q}{d}$$

- ▶ quotient operator

$$per \rightsquigarrow \lambda d . \lambda q . \lambda G_{\langle d, \tau t \rangle} . \lambda \alpha_{\tau} . \frac{\max(\lambda d' . G(d')(\alpha))}{\mu_{\dim(d)}(\alpha)} = \frac{q}{d}$$

- ▶ dimension quotient function

$$per \rightsquigarrow \lambda g_{\langle e, d \rangle} \lambda f_{\langle e, d \rangle} \lambda x . \frac{f(x)}{g(x)}$$

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Translating between *per* and *-nként*

-nként can be translated as *per*:

- (28) *Kutyá-nként* 5000 Ft adó-t kell fizetni
dog-DIST 5000 HUF tax-ACC must pay.INF
'One must pay 5000 HUF per dog.'
(Dékány & Hegedűs, 2021, 109)

Most common strategies found among translations of *per* in EuroParl:

- ▶ 'distributive' *-nként(i)*
- ▶ iterative (e.g. *év-ente*, *nap-onta*)
- ▶ sublative + verb *-ra/-re jut*

Non-decisive examples

- (29) ... hogy hajón-ként egy tudós-t alkalmazunk
... that boat-DIST one scientist-ACC employ.IPL
'... that we would employ one scientist per vessel'
or '... that we would employ one scientist on each vessel'
- (30) ki-kér-t-em képviselőcsoport-onként egy
out-ask-PAST-1SG.DEF political.group-DIST one
képviseelő véleményé-t
representative opinion.POSS-ACC
'I asked the opinion of one representative per political group.'

Self-licensing

-nként needs no licensor:

- (31) **Péntek-enként** / **Het-enként** úszni járok.
Friday-DIST / month-DIST swim.INF go.ISG
'I go swimming on Fridays'.
(Dékány & Hegedűs, 2021)

unlike *per*:

- (32) *I go swimming **per Friday** / **per week**.

These are temporal. Relics from an earlier stage? It was originally found in temporal adverbs (Simonyi, 1888).

Balazs Suranyi (p.c.): Could these uses involve an implicit 'once'?

Incomplete productivity

Dékány & Hegedűs (2021) point out that the introduction of a numeral improves *?naponként* ‘daily’:

- (33) a. ??János *nap-onként* úszni jár.
János day-DIST swim.INF go.3SG
‘János goes swimming daily.’
- b. János *két-nap-onként* / *más-nap-onként* úszni jár.
János two-day-DIST / other-day-DIST swim.INF go.3SG
‘Janos goes swimming every second / other day.’

This contrast may just be due to blocking by *naponta* ‘daily’, with the iterative suffix *-(V)nta*.

Incomplete productivity (Dékány & Hegedűs, 2021)

| | |
|-----------------------|---|
| <i>percenként</i> | ‘once per second’ |
| <i>óránként</i> | ‘once per hour’ |
| <i>reggelenként</i> | ‘every morning’ |
| <i>éjjel-enként</i> | ‘every night’ |
| <i>esténként</i> | ‘every evening’ |
| <i>*del-enként</i> | intended: ‘every day at noon’ (cf. <i>*every noon</i>) |
| <i>tavaszonként</i> | ‘every spring’ |
| <i>nyaranként</i> | ‘every summer’ |
| <i>*őszönként</i> | intended: ‘every autumn’ |
| <i>?telenként</i> | ‘every winter’ |
| <i>*januárionként</i> | ‘every January’ |
| <i>*marciusonként</i> | ‘every March’ |

More self-licensing

- (34) Mari **szín-enként** rendezte el a ruhákat.
Mari color-DIST arranged the clothes.ACC
'Mary arranged the clothes by color.'
(Balazs Suranyi, p.c.)
- (35) a. *Mary arranged the clothes **per color**.
b. ... **by color**.
c. ??... **color by color**.
- (36) a. I shall now give a short resume of our findings **per country**.
(EuroParl)
b. ... **by country**.
c. ... **country by country**.

More 'by' examples from Europarl

- (37) I think it would be useful if we were to give report figures *per category* and *per sector* on how the budget is implemented.
- (38) The complete table with a breakdown of all applications *per prior right and country of applicant* can be found on the registry's website .
- (39) It now provides additional information *per sector of revenue and expenditure* in each chapter, which should make the report more useful in assessing the particular situation in each field.

In all of these, *per* can be replaced with *by*, keeping the meaning.

Yet more self-licensing

- (40) A nagymama **negyed-enként** vette be a nagy tablettát
the grandma quarter-DIST took the big pill.ACC
'Grandma took the big pill quarter by quarter'

Similar examples can be constructed with

| | |
|--------------------|--|
| <i>felenként</i> | half by half (not: * <i>per half</i>) |
| <i>adagonként</i> | portion by portion |
| <i>darabonként</i> | piece by piece |
| <i>hármanként</i> | three by three |
| <i>lépésenként</i> | step by step |
| <i>téglánként</i> | brick by brick |

(Balazs Suranyi, p.c.)

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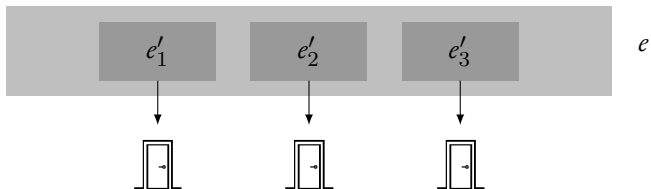
Old Hungarian *-nkéd*

- (41) És reggel az fráterek *ajtó-nkéd* kenyeret kolulának.
and morning the friars door-DIST bread begged
'And in the morning, the friars went begging for bread from door
to door.'

Bende-Farkas & Halm (2024): Old Hungarian *-nkéd* is a pluractional marker à la Beck & von Stechow 2007.

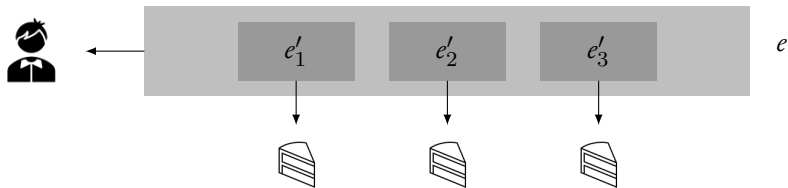
- ▶ The eventuality is partitioned into subeventualities
- ▶ Some parameter of the eventuality (theme, location or time) is partitioned in terms of the N-denotation
- ▶ There is a 1:1 relation between the two partitions.

Pluractional marker analysis



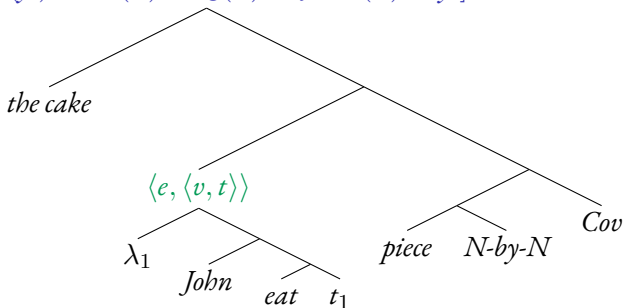
Pluractional marker analysis

(42) John ate the cake piece by piece



Beck and von Stechow's analysis

$$\lambda e . \partial(\text{part}(\mathbf{Cov}, e \oplus y)) \wedge \\ \langle e, \text{thecake} \rangle \in **[\lambda y' \lambda e' . \mathbf{Cov}(y') \wedge \mathbf{Cov}(e') \wedge \\ \text{piece}(y') \wedge \text{eat}(e') \wedge \text{ag}(e') = j \wedge \text{th}(e') = y']$$

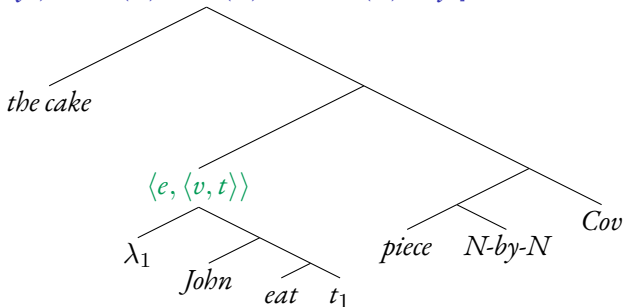


Cov is a free variable (hence bold) introduced by *Cov*.

Beck and von Stechow's analysis

$$\lambda e . \partial(\text{part}(\mathbf{Cov}, e \oplus y)) \wedge$$

$$\langle e, \text{thecake} \rangle \in **[\lambda y' \lambda e' . \mathbf{Cov}(y') \wedge \mathbf{Cov}(e') \wedge$$

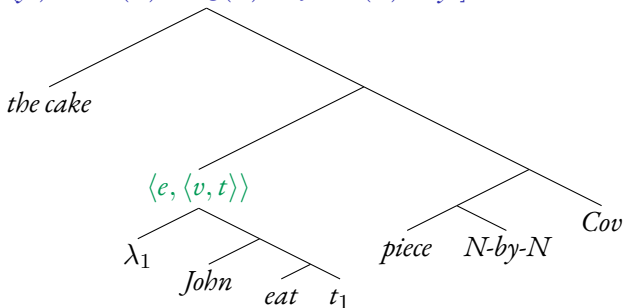
$$\text{piece}(y') \wedge \text{eat}(e') \wedge \text{ag}(e') = j \wedge \text{th}(e') = y']$$


Cov is a free variable (hence bold) introduced by *Cov*.

$\text{part}(\mathbf{Cov}, e \oplus y) = \text{'Cov is a partition over the sum of } e \text{ and } y\text{'}$

Beck and von Stechow's analysis

$$\lambda e . \partial(\text{part}(\mathbf{Cov}, e \oplus y)) \wedge \\ \langle e, \text{thecake} \rangle \in **[\lambda y' \lambda e' . \mathbf{Cov}(y') \wedge \mathbf{Cov}(e') \wedge \\ \text{piece}(y') \wedge \text{eat}(e') \wedge \text{ag}(e') = j \wedge \text{th}(e') = y']$$

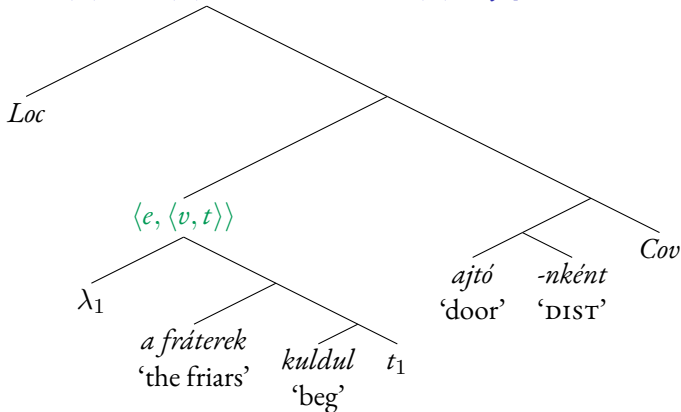


Cov is a free variable (hence bold) introduced by *Cov*.

$\text{part}(\mathbf{Cov}, e \oplus y) = \text{'Cov is a partition over the sum of } e \text{ and } y\text{'}$

∂ = the partial operator (for presupposition)

Application of Beck & von Stechow to friar example

$$\lambda e. \partial(\text{part}(\mathbf{Cov}, e \oplus y')) \wedge$$
$$\langle e, \mathbf{Loc} \rangle \in **[\lambda y' \lambda e'. \mathbf{Cov}(y') \wedge \mathbf{Cov}(e') \wedge$$
$$\text{door}(y') \wedge \text{beg}(e') \wedge \text{ag}(e') = \text{the-friars} \wedge \text{loc}(e') = y']$$


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Not always theme, location or time

- (43) Belgium 32 euró centet ad vasútjainak
Belgium 30 Euro cent.ACC gives railways.DAT
utas-kilométer-enként.
passenger-kilometer-DIST
'Belgium gives 32 euro cents per passenger/kilometre to its
railways.'
- (44) Egy gáztüzelésű erőmű 300-400 kilogramm CO₂-t bocsát ki
megawatt-óránként
'One gas-fired power station emits between 300 and 400
kilograms of CO₂ per megawatt-hour'

Hard to swallow the idea that silent passenger/km or megawatt-hour arguments are syntactically projected and undergo QR.

Quantity word numerators

- (45) ... kilowatt-onként több szén-dioxidot termel, mint a földgáz
... kw-DIST more CO₂ produces than the gas
'... [coal] produces more CO₂ per kilowatt than gas'

Does not describe a sum of kilowatt-sized events that are all events of coal producing more carbon dioxide than gas.

Compares the CO₂ per kilowatt that coal produces with the CO₂ per kilowatt that gas produces.

More quantity word numerators

- (46) Ezzel szemben, a Lordok Háza 1,77 fontba, az Alsóház pedig 5,79 fontba kerül évente, ami sokkal több polgáronként.
'By contrast, the House of Lords costs GBP 1.77 and the House of Commons GBP 5.79 per year, far more per citizen.'
- (47) Ugyanakkor az ellenkező irányban eltűnik ez a különbség és az utasnak utanként, 15 euróval többet számítanak fel.
'However, in the other direction, this difference disappears and the passenger is treated to EUR 15 extra in charges per journey.'

Sub-unit cases

Csirmaz & Szabolcsi (2012) mention *-nként* under ‘rate expressions’ and give the following example:

- (48) Az a vonat **óra-nként** **400 kilométer-rel** halad
that the train hour-DIST 400 km-INST advances
‘That train is travelling at 400 km/hour’

The event is not necessarily composed of hour-long subevents.

Non-uniform scenarios

- (49) a nitrát-irányelv 1,7 szamosállat-egységről rendelkezik
the nitrate-directive 1.7 livestock-units provides for
hektáronként.
hectare-DIST
'The Nitrates Directive provides for 1.7 livestock units per
hectare.'

There are no subevents involving 1.7 livestock units.

Non-uniform scenarios

- (49) a nitrát-irányelv 1,7 szamosállat-egységről rendelkezik
the nitrate-directive 1.7 livestock-units provides.for
hektáronként.
hectare-DIST
'The Nitrates Directive provides for 1.7 livestock units per
hectare.'

There are no subevents involving 1.7 livestock units.

Also, it is not the providing for that is measured in hectares.

Term uses

- (50) az olajárak [hordó-nként 9 dollár-ra] essenek
the oil.prices [barrel-DIST 9 dollar-to] would.fall
'The oil prices would fall to 9 dollars a barrel.'
- (51) ez [ut-anként 150 euró] pluszköltséget jelentene
this [trip-DIST 150 Euro] additional.cost would.mean
'this would mean an additional cost of 150 euros per trip'
- (52) [Állampolgár-onként két euro] nem lesz elég ahhoz,
[citizen-dist two euro] not will.be enough which.to
hogy letöröljük a könnyeket
that cancel the tears
'Two euros per citizen will not be enough to wipe away the tears.'

Term uses with comparatives

Differential argument:

- (53) kilométer-enként két perc-cel gyors-abb tempó-t ment.
kilometer-dist 2 minute-with fast-er tempo-acc go.3sg
'it went two minutes faster per kilometer'
not: '... two minutes faster (for/in) each kilometer'

Standard of comparison:

- (54) hogy állam-onként kettő-nél nem lehet kevesebb
that state-DIST two-CASE not could.be less
'that there couldn't be less than two per state'

Gradable predicates

- (55) Ez a rendszer **kilométer-enként drágább**, mint ...
this the system kilometer-DIST expensive-CMPR than ...
'This system is more expensive per kilometer than ...'
- (56) **Fej-enként olcsóbb** is, és környezetbarát-abb.
head-DIST cheap-CMPR also, and environmentally.friendly-CMPR
'It's cheaper per person, and more environmentally friendly.'
- (57) A túlárzott köztévés szerződések, az M₄-es kartellezés Európa **kilométerenként legdrágább** autópálya-építésénél és a földmulyi mind-mind olyan sztori.
'The overpriced public television contracts, the M₄ cartel in Europe's most expensive highway construction per kilometer and the earthworm are all stories.'

Dimension nouns

- (58) a kilométer-enként kivetett díj csak növeked-het-ne
the km-DIST levied fee only increase-could-would
'The fee levied per km would only potentially increase.'
- (59) 2007 óta a hordónkénti ár 63%-kal növekedett
2007 since the barrel-DIST price 63%-by increased
'The price per barrel has increased by 63% since 2007'
- (60) a mérföldenként megtakarított üzemanyag mennyisége ... óriási
the mile-DIST saved fuel quantity ... huge
lehet.
can.be
'the amount of fuel saved per mile ... can be huge'

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-nként has unambiguously ratio marker uses:

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- ▶ uses with gradable predicates
- ▶ uses with dimension nouns

But its distribution is also broader than *per*:

- ▶ *hetenként* ‘weekly’
- ▶ *péntekenként* ‘every Friday’
- ▶ *színenként* ‘by color’

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Main idea

For self-licensing cases, posit a silent multiplicative *egyszer* ‘once’.

- (6I) Mari legalább egyszer het-enkent látogatja a nagymamát
Mary at.least once week-DIST visits the grandma.POSS.ACC
‘Mary visits her grandma at least once weekly.’

Taking inspiration from Wagiel (2023) for the analysis of multiplicatives.

Background assumptions (I)

- ▶ Our ontology consists of a set of basic dimensions \mathcal{B} such as L ‘distance and T ‘time’
- ▶ From these the full set of dimensions \mathcal{D} can be derived through multiplication, e.g. $\mathsf{L} \cdot \mathsf{T}$
- ▶ Every quantity/degree d in D_d has a dimension $\mathbf{dim}(d)$ in \mathcal{D} .
- ▶ So-called ‘dimensionless quantities’ have dimension \mathbf{I} , the identity element in the set of dimensions, which forms a group.
- ▶ Each dimension D has a multiplicative inverse D^{-1} such that $D \cdot D^{-1} = \mathbf{I}$
- ▶ Division is multiplication by an inverse, e.g. $\frac{\mathsf{L}}{\mathsf{T}} = \mathsf{L} \cdot \mathsf{T}^{-1}$
- ▶ Each dimension D in \mathcal{D} is associated with a unit quantity in D_d called $\mathbf{unit}(D)$.

(Raposo, 2019; Coppock, 2021, 2022)

Background assumptions (II)

- ▶ For each basic dimension D there is a ‘calibration object’ o such that $\mu_D(o) = \text{unit}(D)$.
- ▶ Thus for any individual or event o , $\mu_D(o)$ denotes the ‘canonical measure’ of object o (event or individual) along dimension D .

Background assumptions (III)

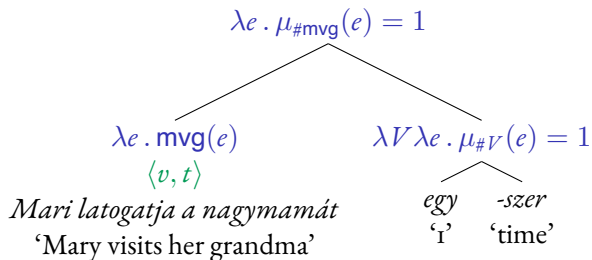
- ▶ For every intensionally distinct property of events or individuals P , there is a ‘cardinality dimension’ $\#P$.
- ▶ For a given event description V , $\mu_{\#V}(e) = n$ means that e contains as a (proper or improper) subpart exactly n instances of V .

Plain *egyszer* example

Lexical entry for the multiplicative:

$$-szer \rightsquigarrow \lambda n \lambda V_{\langle v, t \rangle} \lambda e . \mu_{\#V}(e) = n$$

Derivation tree:

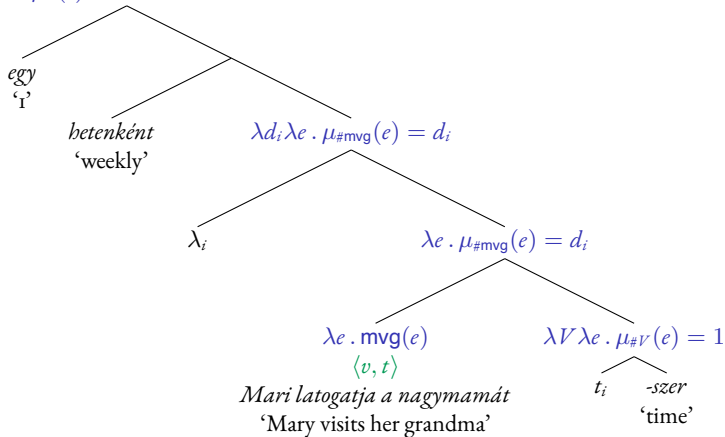


Example with *egyszer* and *-nként*

Assume quotient operator sense for *-nként*:

$$-nként \rightsquigarrow \lambda d . \lambda q . \lambda G_{\langle d, \tau t \rangle} . \lambda \alpha_{\tau} . \frac{\max(\lambda d' . G(d')(\alpha))}{\mu_{\dim(d)}(\alpha)} = \frac{q}{d}$$

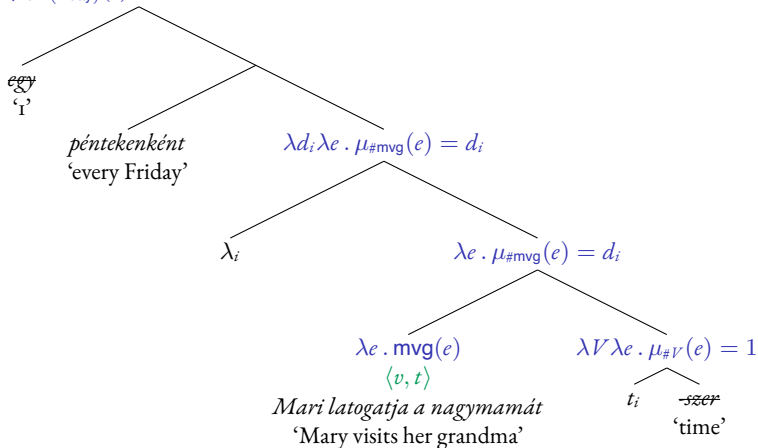
$$\lambda e . \frac{\mu_{\#mvg}(e)}{\mu_{\tau}(e)} = \frac{1 \cdot \text{unit}(\#mvg)}{\text{week}}$$



Example with *péntekenként*

Assume that *péntek* ‘Friday’ can be zero-derived to an expression of type d .

$$\lambda e . \frac{\mu_{\#mvg}(e)}{\mu_{\dim(\text{friday})}(e)} = \frac{1 \cdot \text{unit}(\#mvg)}{\text{friday}}$$



Towards distributivity

A way to enforce evenness of the numerator-quantity across units of the denominator without enforcing it too strictly:

- ▶ Add a granularity parameter ϵ , and put a requirement on subparts of the measured entity of size ϵ or greater
- ▶ The requirement is that those parts be within δ of the numerator.

Perfect distributivity is when both:

- ▶ $\epsilon = \text{unit}(D)$, where $D = \text{dim}(d)$ and d is the denominator
- ▶ $\delta = 0$

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For the first two uses, I have suggested appealing to a silent multiplicative.

Thank you!

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