# Monotonicity in distributivity with binominal *each*

Jess H.-K. Law

Rutgers, The State University of New Jersey

## Take-home message

- Distributivity establishes **dependency** with **internal mereological structure** (van den Berg 1996, Brasoveanu 2008, Champollion 2017, a.o.)
- Binominal *each* joins forces with a **measure function** to track this mereological structure

## Puzzles of binominal *each*

The **distributivity** (1) and **variation** (2) inferences of binominal *each* has motivated dynamic accounts (Champollion 2015, Kuhn 2017, see also Henderson 2014).

(1) *Scenario: the boys made two kites together.*

\# The boys made two kites each.

(2) *Scenario: the boys watched the same two films in a film study class.*

a. Every boy watched two films.

b. #The boys watched two films each.

However, two puzzles remain open:

- **Counting Quantifier Constraint** (Sutton 1993)

(3) The boys saw $\left\{\begin{array}{c}\text{2}\\ \text{at least 2}\\ \text{more than 2}\\ {}^{*}\emptyset\\ \text{*some/*most/*every}\\ \text{*the}\end{array}\right\}$ films each.

- **Extensive Measurement Constraint** (Zhang 2013)

(4) The angles are 60 degrees each.

(5) *The coffees are 60 degrees (Fahrenheit) each.

## A single root: measure function

- Counting quantifiers have a measure function component not shared by other quantifiers (Hackl 2000, Kennedy 2015), as evidenced by their compatibility with unit functions like *pounds.*

(6) $\left\{\begin{array}{c}\text{2}\\ \text{at least 2}\\ \text{more than 2}\\ \text{*some/*most/*every}\\ \text{*the}\end{array}\right\}$ pound(s) (of chicken)

- So do quantity expressions (Schwarzschild 2006, Rett 2014, Solt 2015), which can also host binominal *each.*

(7) The boys saw $\left\{\begin{array}{c}\text{a few}\\ \text{many}\\ \text{a lot of}\end{array}\right\}$ films each.

## Proposal in a nutshell

**Monotonicity relative to distributivity (d-monotonicity)**

1. Use dynamic semantics to construct and store distributivity-induced dependency in an info-state $H$ (a set of variable assignments, van den Berg 1996, Nouwen 2003, Brasoveanu 2008, Henderson 2014, a.o.)

| $H$ | $x$ | $y$ |
|---|---|---|
| $h_1$ | boy1 | film1⊕film2 |
| $h_2$ | boy2 | film1⊕film2 |
| $h_3$ | boy3 | film3⊕film4 |

$H\,x = \{\text{boy1}, \text{boy2}, \text{boy3}\}$ *the boys*

$H\,y = \{\text{film1⊕film2}, \text{film3⊕film4}\}$ *the films*

$h_1, h_2, h_3$ *the dependency between x and y*

$H|_{x\in\{\text{boy1}\}}\,y = \{\text{film1⊕film2}\}$

2. Find a measure function $\mu_{\mathbf{dim}}$ in the host, i.e., the NP preceding binominal *each*
3. Check that $\mu_{\mathbf{dim}}$ and $H$ together satisfy:

(8) NON-DECREASING MAPPING

$$\forall A, A' \subseteq H\,x.\ A \subseteq A' \to \mu_{\mathbf{dim}} \bigoplus(H|_{x\in A}\,y) \leq \mu_{\mathbf{dim}} \bigoplus(H|_{x\in A'}\,y)$$

(9) NON-CONSTANT MAPPING

$$\exists B, B' \subseteq H\,x.\ \mu_{\mathbf{dim}} \bigoplus(H|_{x\in B}\,y) \neq \mu_{\mathbf{dim}} \bigoplus(H|_{x\in B'}\,y)$$

## Evaluating d-monotonicity

**Dynamic distributivity ($\delta_x$)**

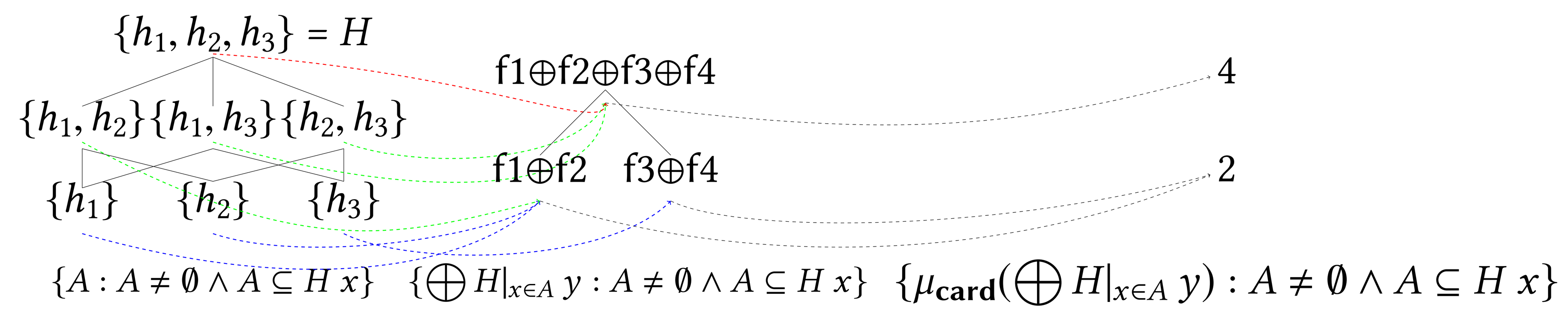
$\{\emptyset\} \overset{\mathbf{max}^x(\mathbf{boy}\ x)}{\Longrightarrow}$

| $G$ | $x$ |
|---|---|
| $g_1$ | boy1 |
| $g_2$ | boy2 |
| $g_3$ | boy3 |

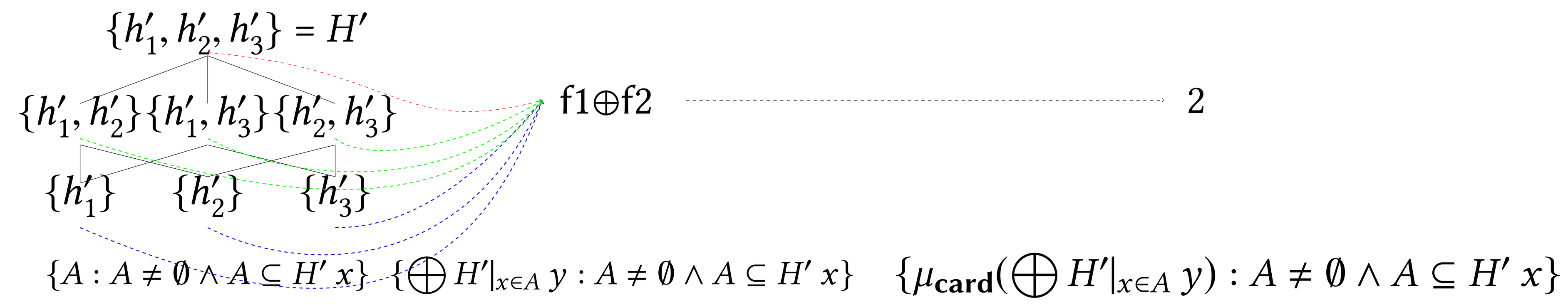
$\overset{\delta_x\left(\exists y(\mathbf{films}\ y \wedge \mu_{\mathbf{card}} y = 2 \wedge \mathbf{saw}\ y\ x)\right)}{\Longrightarrow}$

| $H$ | $x$ | $y$ |
|---|---|---|
| $h_1$ | boy1 | film1 ⊕ film2 |
| $h_2$ | boy2 | film1 ⊕ film2 |
| $h_3$ | boy3 | film3 ⊕ film4 |

**Evaluating d-monotonicity against $H$: ✓**



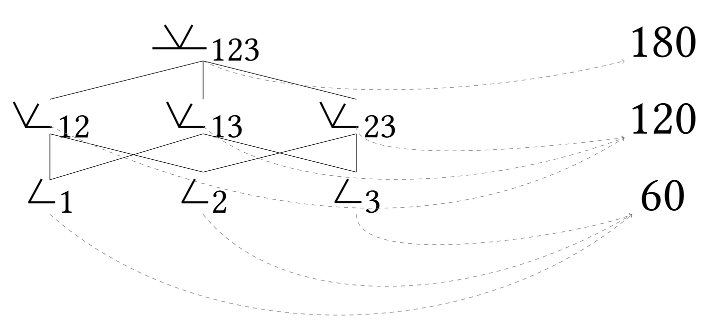

**Consider an alternative $H'$ without variation**: (9) is violated




## Extensive Measurement Constraint

**Extensive measurement**

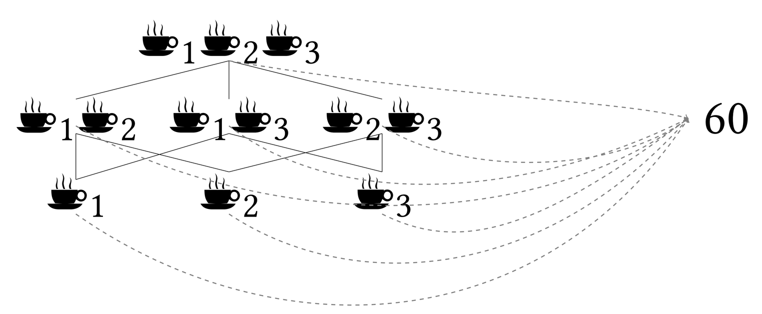
(angle degree)




✓

**Non-extensive measurement**

(temperature)




(9) is violated

Extensive Measurement Constraint still holds when a measure phrase has a modified numeral, thanks to (8).

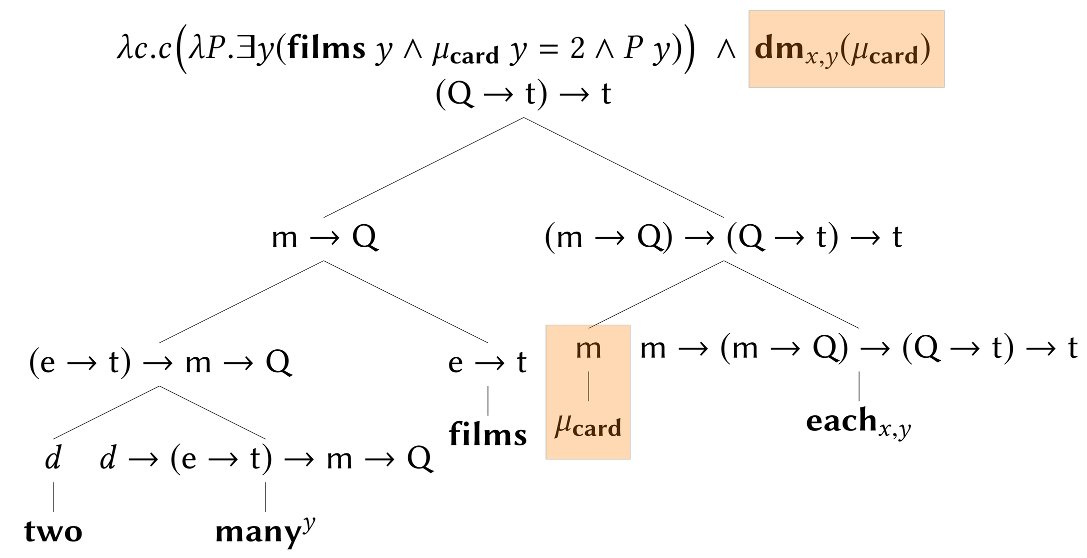
(10) a. The angles are more than 60 degrees each.

b. *The coffees are more than 60 degrees each.

## Composing d-monotonicity

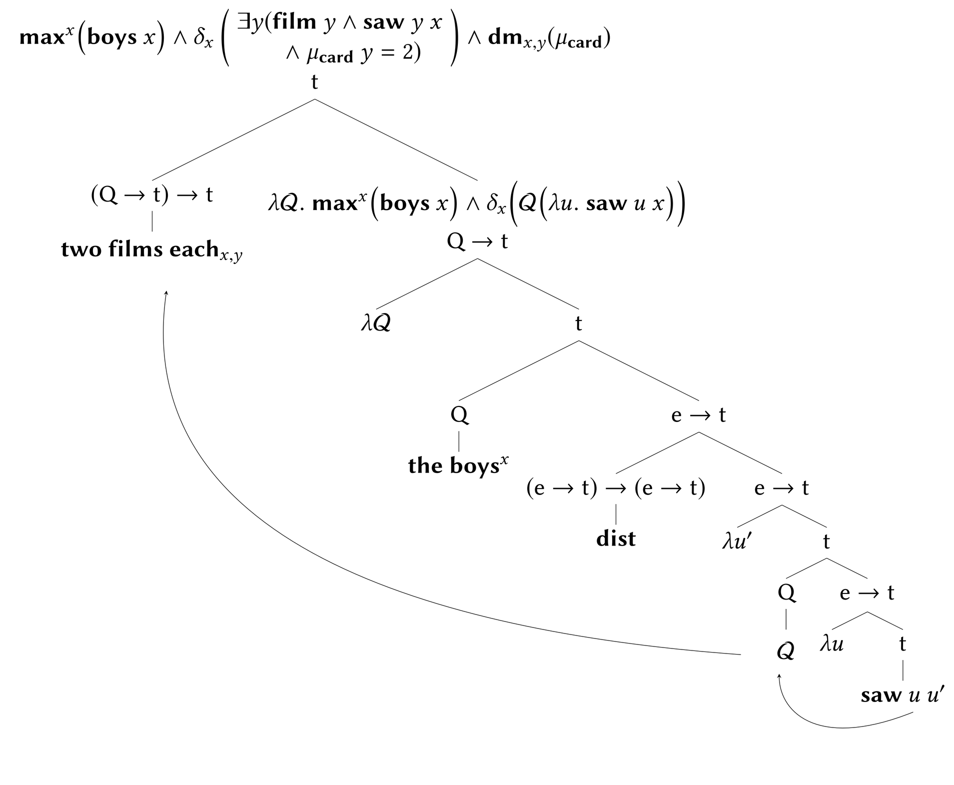
Binominal *each*

- attaches to the measure function component of a host
- turns the host into a higher order dynamic GQ capable of taking split scope (Charlow to appear)




| Basic types | | Derived types | |
|---|---|---|---|
| $e$ | entities | e :: $s \to e$ | individual-drefs |
| $s$ | assignments | t :: $(s \to t) \to (s \to t) \to t$ | propositions |
| $d$ | degrees | m :: e → $d$ | measure functions |
| $t$ | truth values | Q :: e → t → t | quantifiers |

- The basic meaning of the host is reconstructed inside the scope of a distributivity operator (to the $Q$ position).
- D-monotonicity is introduced outside the scope of the distributivity operator.
- A pair of indices are used to retrieve the values stored in the dependency anaphorically (see Dotlačil 2012, Safir & Stowell 1988 for similar claims).

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