# Counting Configurational Entities

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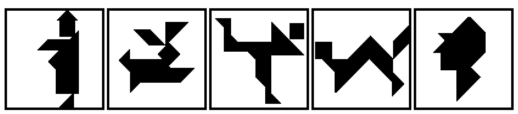
## 1. A taste of configurations

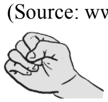
(1) [The puzzle of the two matrioshkas.]
*How many different matrioshka dolls* can one make with two different sets of five matrioshkas with different colors? You can make *20 different dolls*. (Source: Own life).

(2) You have 3 shirts and 4 pairs of pants. *How many different outfits* can you make? [...] You get *twelve outfits*. Not counting if a dude makes an outfit without a shirt, or a crazy person without pants.
(Source: answers.yahoo.com/question/index?qid=20080723031442AAYcny3. The text continues: *Now let's say you throw in three different pairs of socks...then you'd have 3 shirts times 4 pairs of pants times 3 pairs of socks for 36. It can get crazy the more options you throw in there*).

(3) 
[Description of tangram set.] With just seven simple pieces, you can make *dozens of amazing shapes*.
(source: www.amazon.com/Think-Fun-4985-Tangram/dp/B000BXHP04)

(4) [Description of fischertechnik crane construction kit:]
100 Bauteile ermöglichen den Bau *dreier unterschiedlicher, einfacher Kräne*.
'With 100 construction parts one can build *three different, simple cranes*.'
(Source: spielwaren.1index.de/Fischertechnik@Cranes@Fischertechnik @Basic.19673.WOB00000001.137)


(5) [Description of Scrabble Word Builder:] We typed in the letters C, D, P, N, Y, E, A, and U and the Word Builder provided *dozens and dozens of words* that could be created with those letters.
(Source: www.education-world.com/a_lesson/dailylp/dailylp/dailylp099.shtml)

(6) 
*How many fists* can you make in one second?
Bill says he can make *seven fists* in one second.

Notice: These sentences do not imply that there are 20 different single dolls, twelve outfits, three cranes etc. at one and the same time.

## 2. The problem with configurational entities

We concentrate on the following example:

(7) It is possible to make *four outfits* with these two shirts and two pairs of pants.

<u>Illustration of representation framework</u>

Let

- $i$, $i'$ be variables over indices (time intervals or possible worlds, type s)
- $u$, $u'$ be variables over entities (type e)
- $i' \angle i$ stand for: time index $i'$ immediately precedes time index $i$
- $s_1$, $s_2$ be two shirts, $p_1$, $p_2$ two pairs of pants (type e)
- $\sqcup$ stand for the sum operation, $\sqsubseteq$ the part relation.
- $s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2$ the sum of the two shirts and pairs of pants (type e)

Examples of word and constituent meanings:

(8) a. $[\![$*outfit*$]\!]$ = $\lambda i \lambda u[$u consists of parts arranged in i forming an outfit in i$]$
a property, type set

b. $[\![$*four outfits*$]\!]$ = $\lambda i \lambda P[\#(\lambda u[[\![outfit]\!](i)(u) \wedge P(i)(u)]) \geq 4]$
a quantifier, type s(set)t

c. $[\![$*make*$]\!]$ = $\lambda i \lambda u \lambda u' \exists i'[i' \angle i \wedge u'$ arranges the parts of u in $i']$
a relation, type seet

d. $[\![$*this*$]\!]$ = $s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2$, sum of two shirts and two pairs of pants
a referring expression, type e

e. $[\![$*with this*$]\!]$ = $\lambda i \lambda R \lambda u \lambda u'[R(i)(u)(u') \wedge u \sqsubseteq s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2]$
a relational modifier, type s(seet)eet

f. $[\![$*make with this*$]\!]$ = $\lambda i \lambda u \lambda u' \exists i'[i' \angle i \wedge u'$ arranges the parts of u in $i'$
$\wedge u \sqsubseteq s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2]$
a relation type, seet

g. $[\![$*to make with this*$]\!]$ = $\lambda i \lambda u \exists u' \exists i'[i' \angle i \wedge u'$ arranges the parts of u in $i'$
$\wedge u \sqsubseteq s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2]$
a property type, set; a simplified representation of arbitrarily controlled infinitive

h. $[\![[$*an outfit*$]$ $[$*to make with this*$]]\!](i_0)$
$= \lambda i[[\![an\ outfit]\!](i)([\![to\ make\ with\ this]\!](i)](i_0)$
$= \exists u[[\![outfit]\!](i_0)(u) \wedge [\![to\ make\ with\ this]\!](i_0)(u)]$
$= \exists u[$u consists of parts arranged in $i_0$ to form an outfit in $i_0 \wedge$
$\exists u' \exists i'[i' \angle i_0 \wedge u'$ arranges the parts of u in $i' \wedge u \sqsubseteq s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2]]$

"There is a u whose parts form an outfit in $i_0$, and there is a time interval i' immediately preceding $i_0$ during which someone arranges the parts of u, and u is a part of the sum individual consisting of the two shirts $s_1$, $s_2$ and the two pairs of pants $p_1$, $p_2$."

Assume that there are four possible sum individuals that would qualify as outfits when properly arranged, $s_1 \sqcup p_1$, $s_1 \sqcup p_2$, $s_2 \sqcup p_1$, and $s_2 \sqcup p_2$. But at each index i, only two of these can be arranged to an outfit simultaneously, namely $s_1 \sqcup p_1$ and $s_2 \sqcup p_2$, and $s_1 \sqcup p_2$ and $s_2 \sqcup p_1$.

First solution attempt: Wide-scope modal.

Modeling of modal via accessibility relation R, where R(i) is the set of indices at which the construction rules of i are followed.

(9) $[\![\textit{it is possible}]\!] = \lambda i' \lambda p \exists i \in R(i')[p(i)]$

Wide-scope modal:

(10) $[\![[\textit{it is possible}]\ [[\textit{four outfits}]\ [\textit{to make with this}]]]\!](i_0)$

$= \lambda i[[\![\textit{it is possible}]\!](i)(\lambda i'[[\![\textit{four outfits}]\!](i')([\![\textit{to make with this}]\!](i'))])](i_0)$

$= \exists i \in R(i_0)[\#(\lambda u[[\![\textit{outfit}]\!](i)(u) \wedge u \sqsubseteq s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2 \wedge [\![\textit{to make with this}]\!](i)(u)]) \geq 4]$

Incorrect, as there is no accessible world i in which four outfits exist simultaneously.

Second solution attempt: Narrow-scope modal:

(11) $[\![[\textit{four outfits}]\ \lambda t[\textit{it is possible}\ [\textit{to make}\ t\ \textit{with this}]]]\!](i_0)$

$= \lambda i[[\![\textit{four outfits}]\!](i)(\lambda u[[\![\textit{it is possible}]\!](i)(\lambda i'[[\![\textit{to make with this}]\!](i')(u)]))](i_0)$

$= \#(\lambda u[[\![\textit{outfit}]\!](i_0)(u) \wedge \exists i \in R(i_0)[[\![\textit{to make}]\!](i)(u) \wedge u \sqsubseteq s_1 \sqcup s_2 \sqcup p_1 \sqcup p_2]) = 4$

Incorrect, as there are no four outfits that exist in the world of interpretation, $i_0$.

## 3. The individual concept analysis

### 3.1 Diagnosis of the problem and outline of a solution

The problem is rooted in the treatment of outfits as individuals of type e. There cannot be four outfit entities at the same time.

Solution: Nouns like *outfit* do not apply to individuals, but to (partial) individual concepts (functions from indices to individuals), type se.

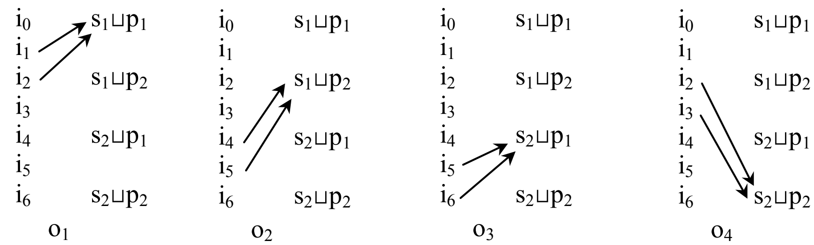
Example:

- Assume two shirts $s_1$, $s_2$ and two pairs of pants $p_1$, $p_2$.
- Use notation λv. Restriction[v] [Value [v]], cf. Heim & Kratzer (1998).
- We can define four outfits $o_1$, $o_2$, $o_3$, $o_4$:

(12) $o_1 = \lambda i$. $s_1$ and $p_1$ are arranged as an outfit in i. $[s_1 \sqcup p_1]$
$o_2 = \lambda i$. $s_1$ and $p_2$ are arranged as an outfit in i. $[s_1 \sqcup p_2]$
$o_3 = \lambda i$. $s_2$ and $p_1$ are arranged as an outfit in i. $[s_2 \sqcup p_1]$
$o_4 = \lambda i$. $s_2$ and $p_2$ are arranged as an outfit in i. $[s_2 \sqcup p_2]$

- As one piece of clothing cannot be part of two outfits at a given index, the outfit concepts have non-overlapping domains: only the outfits $o_1$ and $o_4$ and the outfits $o_2$ and $o_3$ can co-exist, as they consist of non-overlapping parts.

For a concrete example, assume seven indices $i_0 \ldots i_6$




### 3.2 A short & incomplete history of individual concepts

Leibniz (1686), *Discourse de métaphysique,* §8

Posits the notion of an "individual substance", which affords "a conception so complete that the concept shall be sufficient for the understanding of it and for the deduction of all the predicates of which the substance is or may become the subject".

For example, the individual substance of Alexander the Great is not a simple entity, but the person with all his properties and achievements.

This suggests modeling individual concepts as sets of properties (like quantifiers!)

Two individual substances (individual concepts) are **compossible** iff they do not have contradictory properties (e.g., being both the tallest man in a particular world and time).

In this sense, outfits $o_1$ and $o_3$ are compossible, and outfits $o_2$ and $o_3$ are compossible, but $o_1$ and $o_2$ are incompossible, as are $o_3$ and $o_4$.

Frege (1892), "Über Sinn und Bedeutung"

Names like *the Morning star* and *The Evening star* can have the same meaning ("Bedeutung", the planet Venus), but different senses ("Sinn").

Hence, *The Morning star is the Evening star* can be an informative utterance.

Carnap (1947), *Meaning and necessity*

Individual concepts as functions from indices to individuals: The individual concept contains the information that helps to identify an entity in a particular possible world.

Two distinct individual concepts, like *Scott* and *the author of "Waverly"* may pick out the same individual in a particular possible world.

Montague (1973), "On the proper treatment of quantification in ordinary English"

Incorporates Carnap's treatment of individual concepts in intensional logic. Verbal predicates are properties of individual concepts. This allows for a solution of Partee's temperature puzzle:

(13) *The temperature is ninety.*
*The temperature is rising.*
=/=> *Ninety is rising.*

(14) ⟦*The temperature is ninety.*⟧($i_0$) ⟦*is*⟧ as extensional predicate
iff ⟦*temperature*⟧($i_0$) = ⟦*ninety*⟧($i_0$)
iff ⟦*the temperature*⟧($i_0$) = $90^0$ F.

(15) ⟦*The temperature is rising*⟧($i_0$) ⟦*rising*⟧ as intensional predicate
iff ⟦*rising*⟧($i_0$)(⟦*the temperature*⟧)
iff $\exists i', i''$ [$i' \angle i_0 \angle i \wedge$ ⟦*temperature*⟧($i'$) < ⟦*temperature*⟧($i_0$) < ⟦*temperature*⟧(i)]

Dowty, Wall, Peters (1981), *An Introduction to Montague Grammar*

Role names like *Miss America* as individual concepts:

(16) ⟦*Miss America*⟧($i_0$) = the person that holds the title of Miss America at $i_0$.

But the textbook simplifies Montague Grammar for expository reasons by assuming that properties apply to individuals, not to individual concepts.

Gupta (1980), *The logic of common nouns. An investigation of quantified modal logic*

Common nouns apply to individual concepts, not just to individuals. Common nouns come with distinct criteria of identity that single out different individual concepts:

(17) ⟦*person*⟧(i) applies to individual concepts x such that for all indices i′, i″ for which x is defined, x(i′) is **the same person** as x(i″).

(18) ⟦*passenger*⟧(i) applies to individual concepts x such that for all indices i′, i″ for which x is defined, x(i′) is the same passenger as x(i″), that is, **the same person during the whole duration of a trip**.

The following two sentences need not have the same truth conditions, if persons take multiple trips.

(19) a. National Airlines served *two million passengers* in 1975.

b. National Airlines served *two million persons* in 1975.

But Krifka (1990) pointed out that identity criteria of common nouns are not sufficient, and that instead the event variable related to the verbal predicate can provide a counting criterion:

(20) *4000 ships* passed through the lock last year.

Heim (1979), *Concealed questions*

(21) John knows *the temperature* as: 'John knows what the temperature is.'

Reading of *know*: To know' an individual concept at $i_0$ is to know the value of it at $i_0$.

Grosu & Krifka (2008), "Equational intensional "reconstruction" relatives

(22) *The gifted mathematician Bill claims to be* should have solved this problem easily.

Apparent scope of *claims to be* over *gifted mathematician*.

Suggested treatment: The DP refers to an individual concept that is, for all indices at which it is defined, a gifted mathematician, and for all indices compatible with Bill's claim, identical to Bill.

Predictions: Only definite article can be used; main clause must have a modal element.

No syntactic reconstruction necessary to achieve this reading.

Phase nouns

(23) In einem Jahr mit *dreizehn Monden.* (Movie by R. W. Fassbinder)
"In a year with thirteen (full) moons."

Suggestion: *moon* (in this sense) applies to individual concepts x such that x maps all indices from the first appearance of the moon to the last appearance of the moon in one cycle to Luna.

Other examples: Bodily configurations, e.g. *fist, lap, plough* (in yoga)...

We may consider to treat these nouns as applying to events. But they do not satisfy the selectional restriction of *happen*:

(24) a. **This fist* happened at 2:54:04 p.m.

b. *The explosion* happened at 2:54:04 p.m.

Material constitution; configurational entities

Plutarch the Elder describes the ship of Theseus displayed for many centuries in Athens, where every plank had been replaced over the centuries.

Suggestion: *The ship of Theseus* is an individual concept x that maps every index i to the collection of planks that form, at i, what people consider the ship of Theseus.

## 3.3 A concept analysis of outfits and their ilk

Common nouns as properties of individual concepts

(25) ⟦*outfit*⟧($i_0$)
= {$\lambda$i. the parts of u are arranged in i to qualify as outfit in $i_0$ . [u] | u$\in D_e$}

Hence ⟦*outfit*⟧ is of type s(se)t, a property of individual concepts.

It might be that at $i_0$, the individual concepts in ⟦*outfit*⟧($i_0$) are not defined for $i_0$, as their parts are not arranged in $i_0$ in the proper way. Yet ⟦*outfit*⟧($i_0$) is not empty.

Example of extension of *outfit*:

For the concrete example mentioned above:

(26) ⟦*outfit*⟧($i_0$) = {$o_1$, $o_2$, $o_3$, $o_4$}

Example of intension of *outfit*:

The property ⟦*outfit*⟧ might assign different sets of individual concepts to different indices. E.g., $i_1$ might be an index at which the combination $s_2 \sqcup p_1$ does not count as an outfit because the color of $s_2$ and $p_1$ do not match according to esthetic criteria of $i_1$, we have:

(27) ⟦*outfit*⟧ = [ $i_0 \rightarrow \{o_1, o_2, o_3, o_4\}$,
$i_1 \rightarrow \{o_1, o_2, o_4\}$, ($o_3$ does not satisfy outfit criteria of $i_1$)
$i_2 \rightarrow \{o_1, o_2, o_3, o_4\}$,
$i_3 \rightarrow \{o_1, o_3, o_4\}$, ($o_2$, $o_3$ do not satisfy outfit criteria of $i_3$)
$i_4 \rightarrow \{o_2, o_3, o_4\}$, ($o_1$ does not satisfy outfit criteria of $i_4$)
$i_5 \rightarrow \{o_1\}$ (only $o_1$ satisfies outfit criteria of $i_5$)
$i_6 \rightarrow \varnothing$] (no configuration satisfies criteria of $i_6$)

Extensional and intensional verbal predicates

Verbal predicates apply to individual concepts, but often reduce to individuals:

(28) ⟦*be in the laundry machine*⟧
= λiλx[x(i) is in the laundry machine at i]

Intensional verbal predicates like *make* are not reducible in this way:

(29) ⟦*to make*⟧
= λiλx∃x′∃i′. i′ ∠ i ∧ ¬i′∈DOM(x) [i∈DOM(x) ∧ x′ acts on x(i) during i′]
= λiλx[someone realizes x at i] (in short)

To make an outfit x at interval i is to act on the parts of the outfit x at i during an interval i′ immediately before i with the result that at i′, o is not defined, but at i, o is defined.

Derivation of example: Extensional interpretation of *outfit*

We can interpret *four outfits* extensionally, i.e. what counts as outfit is determined at the index of evaluation, $i_0$.

(30) ⟦[*four outfits*] λt[*it is possible* [*to make* t *with this*]]⟧($i_0$)
= λi[⟦*four outfits*⟧(i)(λx[⟦*it is possible*⟧(i)(λi′[⟦*to make with this*⟧(i′)(x)]))]]($i_0$)
= ⟦*four outfits*⟧($i_0$)(λx[⟦*it is possible*⟧($i_0$)(λi′[⟦*to make with this*⟧(i′)(x)]))
= #(λx[⟦*outfit*⟧($i_0$)(x) ∧ ⟦*it is possible*⟧($i_0$)(λi′[⟦*to make with this*⟧(i′)(x)]) ≥ 4
= #(λx[x∈⟦*outfit*⟧($i_0$)(x) ∧ ∃i′∈R($i_0$)[⟦*to make*⟧(i′)(x) ∧ x∈ $\{o_1,o_2,o_3,o_4\}$]) ≥ 4
= #(λx[x∈ $\{o_1, o_2, o_3, o_4\}$∧ ∃i′∈R($i_0$)[someone realizes x at i′]) ≥ 4

Assuming that R($i_0$) = $\{i_0, i_1, i_2, i_3, i_4, i_5, i_6\}$, this gives us the right interpretation.

Another reading: Intensional interpretation of *outfit*

We set up our example in such a way that wherever $o_3$ is defined (i.e., at $i_5$ and $i_6$) it does not qualify as an outfit there.

(31)

| index | existing i. concepts | qualify as outfits | existing outfits |
|---|---|---|---|
| $i_0$ | — | $o_1, o_2, o_3, o_4$ | — |
| $i_1$ | $o_1$ | $o_1, o_2, o_4$ | $o_1$ |
| $i_2$ | $o_1, o_4$ | $o_1, o_2, o_3, o_4$ | $o_1, o_4$ |
| $i_3$ | $o_4$ | $o_1, o_3, o_4$ | $o_4$ |
| $i_4$ | $o_2$ | $o_2, o_3, o_4$ | $o_2$ |
| $i_5$ | $o_2, o_3$ | $o_1$ | — |
| $i_6$ | $o_3$ | — | — |

In this model, there is a reading in which the sentence is false.

An unattractive possibility: *outfit* is interpreted inside the scope of modal, *four* is interpreted outside:

(32) ⟦*four*⟧($i_0$)(⟦*it is possible*⟧($i_0$)(λi′[⟦*outfit*⟧(i′)(x) ∧ ⟦*to make with this*⟧(i′)(x)]))
= #(λx[⟦*it is possible*⟧($i_0$)(λi′[⟦*outfit*⟧(i′)(x) ∧ ⟦*to make with this*⟧(i′)(x)]) ≥ 4
= #(λx[∃i′∈R($i_0$)[⟦*outfit*⟧(i′)(x) ∧ ⟦*to make*⟧(i′)(x) ∧ x∈ $\{o_1,o_2,o_3,o_4\}$]) ≥ 4

Problem: Compositional derivation, as *four outfits* form a syntactic constituent.

Solution: An alternative interpretation of *outfit* that guarantees that the individual concepts are outfits for all indices at which they are defined (cf. Grosu & Krifka 2008).

(33) ⟦*outfit′*⟧
= λi′{λi. the parts of u are arranged in i to qualify as outfit in **i** . [u] | u∈ $D_e$}

This is a constant intension, as it is not dependent on the index of interpretation, i′.

In the model proposed above:

(34) ⟦*outfit′*⟧ = [ $i_0 \rightarrow \{[i_1 \rightarrow s_1 \sqcup p_1, i_2 \rightarrow s_1 \sqcup p_1], [i_2 \rightarrow s_2 \sqcup p_2, i_3 \rightarrow s_2 \sqcup p_2], [i_4 \rightarrow s_1 \sqcup p_2]\}$,
...
$i_6 \rightarrow \{[i_1 \rightarrow s_1 \sqcup p_1, i_2 \rightarrow s_1 \sqcup p_1], [i_2 \rightarrow s_2 \sqcup p_2, i_3 \rightarrow s_2 \sqcup p_2], [i_4 \rightarrow s_1 \sqcup p_2]\}$]

Where
$[i_1 \rightarrow s_1 \sqcup p_1, i_2 \rightarrow s_1 \sqcup p_1]$ is $o_1$
$[i_2 \rightarrow s_2 \sqcup p_2, i_3 \rightarrow s_2 \sqcup p_2]$ is $o_4$ } restricted to the indices where they qualify as outfit.
$[i_4 \rightarrow s_1 \sqcup p_2]$ is $o_2$

Notice: Under this interpretation, there are only three outfit concepts, hence (30) would be false if ⟦*outfit*⟧ is replaced by ⟦*outfit′*⟧.

## 4. Collective, distributive, cumulative interpretations and temporal operators.

### 4.1 Sums of individual concepts

The proposal works for distributive interpretations, but not for collective ones:

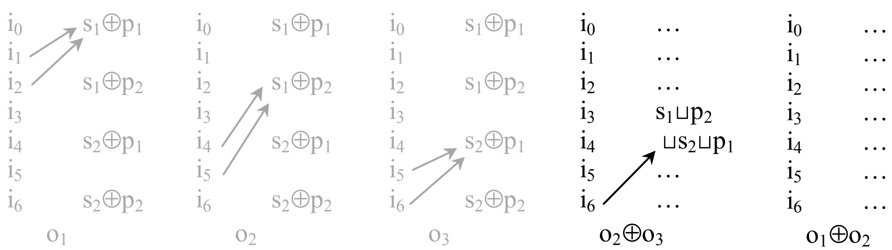
(35) *Two of the outfits* are rather similar to each other.

Collective interpretations require sum entities, here: sum individual concepts. How can they be defined? First attempt:

(36) $x \sqcup y = \lambda i[x(i) \sqcup y(i)]$

Not what we want. For example, $o_1 \sqcup o_2$ is not defined at all, it is the empty concept:

(37)




Second attempt: A new irreducible join operation ⊕ (commutative, associative, idempotent):

(38) $[\![$*the four outfits*$]\!] = o_1 \oplus o_2 \oplus o_3 \oplus o_4$, type se

But: this sum of individual concepts is not an individual concept by itself; it does not map indices to individuals.

The introduction of join operations has been motivated by the idea that regular and sum individuals have the same semantic types (Link 1983). Not useful here: sum individual concepts are not individual concepts. Hence sum operation can be treated by set formation:

(39) $[\![$*the four outfits*$]\!] = \{o_1, o_2, o_3, o_4\}$, type (se)t

### 4.2 Collective interpretations

Analysis of example, with adjectival analysis of number words;
X: Variable over sets of individual concepts.

(40) a. $[\![\textit{two}]\!] = \lambda i \lambda P \lambda X[\#(X) = 2 \wedge X \subseteq P(i)]$

b. $[\![[_{NP}\ \textit{two outfits}]]\!] = \lambda i\ [[\![\textit{two}]\!](i)[\![\textit{outfit}]\!](i)] = \lambda i \lambda X[\#(X) = 2 \wedge X \subseteq [\![\textit{outfit}]\!](i)]$

c. $[\![[_{DP}\ [\textit{two outfits}]]]\!] = \lambda i \lambda \underline{P} \exists X[[\![[_{NP}\ \textit{two outfits}]]\!](i)(X) \wedge \underline{P}(i)(X)]$

d. $[\![[_{DP}\ [\textit{two outfits}]]\ [\textit{are similar}]]\!](i_0)$

$= [\![[_{DP}\ [\textit{two outfits}]]]\!](i_0)([\![\textit{are similar}]\!](i_0))$

$= \lambda \underline{P} \exists X[[\![[_{NP}\ \textit{two outfits}]]\!](i_0)(X) \wedge \underline{P}(i_0)(X)]$
$(\lambda X \forall x,y \in X[x \text{ is similar to } y \text{ at } i_0])$

$= \exists X[\#(X) = 2 \wedge X \subseteq [\![\textit{outfit}]\!](i_0) \wedge \forall x,y \in X[x \text{ is similar to } y \text{ at } i_0]]$

Where similarity of two individual concepts x and y at $i_0$ means that according to the similarity standards of $i_0$, the realizations of x and the realizations of y are deemed similar.

This does not require that x and y are realized at common indices. Relations across times and possible worlds are possible:

(41) The lips and chins of the Spanish Hapsburg kings Carlos II. (1661–1700) and Alfonso XIII. (1886-1941) were similar to each other.

(42) If a European war had broken out in 1908, it would have been less devastating than World War I actually was.

### 4.3 Distributive interpretations

Type-lifting of predicates to accommodate sets of individual concepts as arguments:

(43) $^*P = \lambda i \lambda X \forall x \in X[P(i)(x)]$ (cumulative closure of predicate):

(44) $^*[\![\lambda t[\textit{it is possible } [\textit{to make } t]]]\!] = \lambda i \lambda X \forall x \in X \exists i' \in R(i)[\text{someone realizes } x \text{ at } i']$:

(45) $[\![[[_{DP}\textit{four outfits}]\ \lambda t[\textit{it is possible } [\textit{to make } t]]]\!](i_0)$

$= [\![[_{DP}\textit{four outfits}]]\!](i_0)(^*[\![\lambda t[\textit{it is possible } [\textit{to make } t]]]\!](i_0))$

$= \lambda \underline{P} \exists X[\#(X) = 4 \wedge X \subseteq [\![\textit{outfit}]\!](i_0) \wedge \underline{P}(i_0)(X)]$
$(\lambda X \forall x \in X \exists i' \in R(i_0)[\text{someone realizes } x \text{ at } i'])$

$= \exists X[\#(X) = 4 \wedge X \subseteq [\![\textit{outfit}]\!](i_0) \wedge \forall x \in X \exists i' \in R(i_0)[\text{someone realizes } x \text{ at } i']]$

### 4.4 Configurational entities and temporal operators

(46) John has made *three outfits* with these shirts and pairs of pants.

Perfect entails: there was a time prior to time of utterance at which the root property holds.

(47) $[\![\textit{PERFECT}]\!] = \lambda i \lambda p \exists i' < i[p(i')\ (\wedge \text{ afterstate of } p(i') \text{ still holds at } i)]$

Derivation of example:

(48) $[\![[_{DP}\ \textit{three outfits}]\ [\textit{have been made}]]\!](i_0)$

$= [\![[_{DP}\ \textit{three outfits}]]\!](i_0)(^*[\![\textit{PERFECT } [\textit{be made}]]\!](i_0))$

$= \lambda \underline{P} \exists X[\#(X) = 3 \wedge X \subseteq [\![\textit{outfit}]\!](i_0) \wedge \underline{P}(i_0)(X)]$
$(\lambda X \forall x \in X \exists i' < i_0[\text{someone realizes } x \text{ at } i'])$

$= \exists X[\#(X) = 3 \wedge X \subseteq [\![\textit{outfit}]\!](i_0) \wedge \forall x \in X \exists i' < i_0[\text{someone realizes } x \text{ at } i']]$

Notice: Examples with past tense are not quite felicitous:

(49) a. John has made *dozens of shapes* with this tangram set.

b. ?John made *dozens of shapes* with this tangram set.

Reason: Past tense typically refers to a contextually given time (or time interval), hence the temporal operator has wide scope.

## 4.5 Cumulative Interpretations

Description of a construction set for a vehicle in a kindergarten. There are only four wheels, so only one vehicle can be built at a time.

(50) *Dozens of children* have built *hundreds of vehicles* with this set over the years.

Cumulative interpretations with Sternefeld (1998), operator ** (here with simplified definition):

(51) $**Q = \lambda i\lambda X\lambda Y[\forall x\in X\exists y\in Y[Q(i)(x)(y)] \wedge \forall y\in Y\exists x\in X[Q(i)(x)(y)]]$

Derivation of example (where *dozens*: >> 24, *hundreds*: >> 200):

(52) $[\![$[*dozens of children*] [[*have built*] [*hundreds of vehicles*]]$]\!](i_0)$

$= [\![\textit{dozens of children}]\!](i_0)([\![\textit{hundreds of vehicles}]\!](i_0)(**[\![\textit{have built}]\!](i_0)))$

$= \lambda P\exists X[\#(X) >> 24 \wedge X\subseteq [\![\textit{child}]\!](i_0) \wedge \underline{P}(i_0)(X)]$
$(\lambda\underline{R}\lambda X\exists Y[\#(Y) >> 200 \wedge Y\subseteq[\![\textit{vehicle}]\!](i_0) \wedge \underline{R}(i_0)(Y)(X)]$
$(**[\![\textit{PERFECT}]\!](i_0)([\![\textit{build}]\!])(Y)(X)))$

$= \exists X\exists Y[\#(X) >> 24 \wedge X\subseteq [\![\textit{child}]\!](i_0) \wedge \#(Y) >> 200 \wedge Y\subseteq[\![\textit{vehicle}]\!](i_0)$
$\wedge \forall x\in X\exists y\in Y\ \exists i'<i_0[\text{x realizes y at } i'] \wedge$
$\forall y\in Y\exists x\in X\ \exists i'<i_0[\text{x realizes y at } i']]$

Remarks:

- As $[\![\textit{child}]\!](i_0)$ applies to individual concepts, the entities in it need not be children at the index $i_0$. If we assume an interpretation of *child* similar to *outfit'*, we can infer that the children were children at the time at which they built the vehicles, because the individual concepts that $[\![\textit{child'}]\!]$ refer to have the property of being a child at all indices at which they are defined.
- A different definition of ** is required if we want to capture cases in which two or more children collaborate in the construction of a vehicle.

# 5. The Property Analysis, and Identity Criteria for Individual Concepts

## 5.1 The property analysis of Condoravdi e.a. (2001).

Condoravdi e.a. discuss the following example:

(53) The mayor prevented three strikes.

Assumption: *prevent* applies to properties, type set, like *seek*, cf. Zimmermann (1993).

More specifically: To prevent a property at an index i requires

- that the property is not instantiated at i,
- that the normal courses of things from i would have led to an index i′, i < i′, such that the property would have been instantiated at i′,
- and that one acts at i in such a way that there is no index i″ in the actual continuation of i such that the property is instantiated at i″.

Nonspecific reading (where e is a variable over events):

(54) $[\![\textit{The mayor prevented a strike}]\!](i_0)$
$= \exists i<i_0\ [[\![\textit{prevent}]\!](i)([\![\textit{strike}]\!])([\![\textit{the mayor}]\!])]$
$= \exists i<i_0\ [[\![\textit{prevent}]\!](i)(\lambda i'\lambda e[\text{e is a strike in } i'])(\mathbf{m})]$

Specific reading:

(55) $\exists P \subseteq_{sc} [\![\textit{strike}]\!]\ \exists i<i_0\ [\![\textit{prevent}]\!](i)(P)(\mathbf{m})$, where $\subseteq_{sc}$: subconcept relation

Specific reading of *three strikes*:

(56) $[\![\textit{the mayor prevented three strikes}]\!](i_0)$

$= \#(\lambda P[P \subseteq_{sc} [\![\textit{strikes}]\!] \wedge \exists i<i_0\ [\![\textit{prevent}]\!](i)(P)(\mathbf{m})]) \geq 3$

Problems:

- The subconcept relation $\subseteq_{sp}$ is not clearly defined. It cannot be just any sub-property of $\lambda i\lambda u$[u is a strike in i]; it must be subproperties that single out the same strike and how it developed in different possible worlds.
- Properties (type set) can apply to more than one entity at one index, but in the intended reading, for each possible world (history) there is maximally one strike.

## 5.2 An individual concept analysis

The restriction to single entities is built in the notion of individual concepts. This is an argument in terms of individual concepts, instead of properties.

(57) $[\![\textit{The mayor prevented three strikes}]\!](i_0)$

$= \#(\lambda x[[\![\textit{strike}]\!](i_0)(x) \wedge \exists i'<i_0[\mathbf{m} \text{ prevents x at } i']) \geq 3$, or alternatively:

$= \exists X[\#(X) = 3 \wedge X\subseteq[\![\textit{strike}]\!](i_0) \wedge \forall x\in X\exists i'<i_0[\mathbf{m} \text{ prevents x at } i']]$

Here $[\![\textit{strike}]\!](i_0)$ refers to the set of individual concepts that count as strikes, with respect to the criteria of $i_0$:

(58) $[\![strike]\!](i_0)$
$= \{\lambda i\ .\ e$ is a protest that counts as strike, according to $i_0\ .\ [e] \mid e \in D_{Events}\}$

Advantage of the individual concept analysis: The very notion of an individual concept ensures that at a particular index, there can be only one entity the concept refers to.

## 5.3 Identity criteria for individual concepts

But there are issues of identity of individual concepts relating to the indices. Example:

- if $[i_1 \rightarrow e_1, i_2 \rightarrow e_2]$ is a strike (realized in $i_1$ by event $e_1$, and in $i_2$ by event $e_2$),
- and if $[i_3 \rightarrow e_3, i_4 \rightarrow e_4]$ is a (different) strike,
- why don't we say that $[i_1 \rightarrow e_1, i_2 \rightarrow e_2, i_3 \rightarrow e_3, i_4 \rightarrow e_4]$ is a strike, that is, that $[i_1 \rightarrow e_1, i_2 \rightarrow e_2]$ and $[i_3 \rightarrow e_3, i_4 \rightarrow e_4]$ are actually the same strike?
- and why don't we say that $[i_1 \rightarrow e_1]$ is a strike different from $[i_2 \rightarrow e_2]$?

This depends on lexical semantics and cannot be derived abstract principles that formal semantics can offer. Formal semantics only provides the general format of the objects of lexical semantics. E.g., formal semantics does not state what is the difference between $[\![red]\!]$ and $[\![orange]\!]$.

In our example, there are complex issues involved, e.g. when an announced strike is declared illegal, and the workers announce another strike with similar goals and methods to circumvene the court ruling.

<u>Temporal contiguity and temporal quantization.</u>

Example: Gupta's passenger.

(59) $-i_1-i_2-i_3-i_4-i_5-i_6-i_7-i_8-i_9-i_{10}-i_{11}-i_{12}-i_{13}-i_{14}-i_{15}$———→ time indices
——[————]———[—————]——————→ flight times of John

$[i_2,i_3,i_4,i_5 \rightarrow \mathbf{j}], [i_9, i_{10}, i_{11}, i_{12} \rightarrow \mathbf{j}] \in [\![passenger]\!]$

$[i_6,i_7 \rightarrow \mathbf{j}], [i_5,i_7 \rightarrow \mathbf{j}], [i_3,i_4], [i_3, i_{10}], [i_2,i_3,i_4,i_5, i_9, i_{10}, i_{11}, i_{12} \rightarrow \mathbf{j}] \notin [\![passenger]\!]$

General property of quantization:

(60) If x is a natural individual concept, hence falls under a common noun $\alpha$, then for all y with $x \subset y$: y does not fall under the common noun $\alpha$.

Notice: Quantization is a necessary condition for counting.

<u>Same and different</u>

(61) With this tangram set, John has made *many different shapes.*

(62) With this tangram set, John has made *the same shape over and over again.*

Example: Tangram figures built from a tangram set **t**

(63) $-i_1-i_2-i_3-i_4-i_5-i_6-i_7-i_8-i_9-i_{10}-i_{11}-i_{12}-i_{13}-i_{14}-i_{15}$———→ time indices
——[——]——————[——]————————[———]———→ ice skater
——————[——]———————————————————→ rabbit
————————————————[———]——————————→ cat

$[i_2, i_3, i_8, i_9, i_{14}, i_{15} \rightarrow \mathbf{t}], [i_5, i_6 \rightarrow \mathbf{t}], [i_{11}, i_{12} \rightarrow \mathbf{t}] \in [\![$*tangram shape* (*made with* **t**)$]\!]$, these concepts count as different shapes, as their building plans are different, not just their indices.

$[i_2,i_3 \rightarrow \mathbf{t}], [i_8,i_9 \rightarrow \mathbf{t}], [i_{14},i_{15} \rightarrow \mathbf{t}]$ count as the same tangram shape, as they just differ in their time indices.

Without *different*, counting may include maximally temporal contiguous individual concepts:

(64) John has built many cranes with this construction set, but (nearly) always the same one.

Geach (1967): Identity is relative to a sort that is related to the common noun.

The identity criteria of *Tangram shape* determine that two Tangram shapes are the same iff they have the same building plan; otherwise they are different. Hence two different realizations of the same building plan (with the same Tangram set or with different Tangram sets) do not count as different. By contraposition, two different Tangram shapes have different building plans.

## 5.4 An argument for properties? The token/type distinction.

Possible type reading with:

(65) With tangram sets, one can build *dozens of different shapes*.

Here we refer to different types, not tokens. The sentence would be false if each tangram set could by arranged only to one shape (e.g., the ice-skater).

Possible way to render tokens and types:

- Types are properties that may apply to more than one individual at an index.
- Tokens are properties (!) that apply to maximally one individual per index.

Hypothetical example:

(66) Type: $[i_0 \rightarrow \{u_1, u_2\}, i_1 \rightarrow \{u_1\}, i_2 \rightarrow \{u_2\}, i_3 \rightarrow \varnothing]$
Tokens: $[i_0 \rightarrow \{u_1\}, i_1 \rightarrow \{u_1\}, i_2 \rightarrow \varnothing, i_3 \rightarrow \varnothing]$
$[i_0 \rightarrow \{u_2\}, i_1 \rightarrow \varnothing, i_2 \rightarrow \{u_2\}, i_3 \rightarrow \varnothing]$

Example for types and tokens:

(67) $[\![$*the ice-skater*$]\!](i_0)$
$= \lambda i\ \{u \mid u$ is a tangram set in $i_0 \wedge$ the parts of u are put together in i such that they form a shape that looks like an ice-skater, according to $i_0\}$

(68) ⟦*the ice-skater made of the tangram set* ***t***⟧($i_0$)
= λi {u | u = **t** ∧ **t** is a tangram set in $i_0$ ∧ the parts of u are put together in i such that they form a shape that looks like an ice-skater, according to $i_0$}

Example for predicates of types and tokens:

(69) a. ⟦*tangram figure (types)*⟧($i_0$)
= {λi {u | u is a tangram set in $i_0$ ∧ the parts of u are put together in i such that they form a shape that looks like α } | α is a tangram shape in $i_0$}

b. ⟦*tangram figure (tokens)*⟧($i_0$)
= {λi {u | u = v ∧ the parts of u are put together in i such that they form a shape that looks like α }
| v is a tangram set in $i_0$ and α is a tangram shape in $i_0$}

Example of sentence:

(70) ⟦[$_{DP}$ *dozens of t. figures (types)*] λt[*it is possible* [*to make* t]]⟧($i_0$)
= ⟦[$_{DP}$ *dozens of t. figures (types)*]⟧($i_0$)(*⟦λt[*it is possible* [*to make* t]]⟧($i_0$))
= λP∃X[#(X) >> 24 ∧ X⊆⟦*tangram figure*⟧($i_0$) ∧ P($i_0$)(X)]
(λX∀x∈X∃i′∈R($i_0$)[someone realizes an x at i′])
= ∃X[#(X) >> 24 ∧ X⊆⟦*tangram figure*⟧($i_0$) ∧
∀x∈X∃i′∈R($i_0$)[someone realizes an x at i′]]

## 6. Summary

Individual concepts for configurational entities

The goal of this talk was to give a model for the strange ways one counts "configurational" entities in modal and temporal contexts. It seems that we count these entities across possible worlds or times. Individual concepts appear to be the right semantic notion to capture this behavior.

As an aside, I mentioned another possibility, the use of properties. This might lead to an interesting way to deal with the type/token-distinction.

But what precisely ARE configurational entities?

One question I did not go into: What are configurational entities precisely? As many objects consist of parts that can be changed without changing the essence of the object, the class of configurational entities might be much larger than the examples here suggest. Cf. discussion in Unger (1972), Van Inwagen (1990), Merricks (2001), which claim that objects like statues do not exist – only atoms "arranged statuewise". It appears that individual concepts have not been used as a tool for modeling material constitution in ontology, and that they might be fruitfully applied.

Are living organisms, including humans, configurational entities? Think of their metabolism!

Debtor's paradox

According to a paradox ascribed to Epicharmus, the "Prince of Comedy", about 500 B.C., cf. Wassermann (2009), a debt collector wants to get back a loan. The person that received the money argues that in the meantime he ingested so much food and wine, and also excreted so much that he is not the same person anymore. No way would he pay back!

Obviously, we apply criteria of identity for persons that are not reducible to the matter they consist of. This was pointed out by McCawley (1981, p. 391), referring to the felicity of the following example:

(71) *If John had gone on the diet that I had recommended, he'd be at least 20 pounds lighter than he is.*

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