Counting Configurations

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Abstract

The sentence *With these three shirts and four pairs of pants, one can make twelve different outfits* does not entail that one can dress twelve persons. The article proposes an analysis of "configurational" entities like outfits as individual concepts. It investigates the interaction of noun phrases based on such nouns with temporal and modal operators and in collective and cumulative interpretations. It also discusses a generalization from tokens to types, as in *with the seven pieces of a tangram set, one can lay dozens of figures*, suggesting an analysis of outfits and tangram figures in terms of properties.

1 What are Configurations?

"Configurations" is a term that I will use for what the italicized terms in sentences like the following refer to:

(1) a. 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.[1]

b. [Description of a tangram set.] With just seven simple pieces, you can make *dozens of amazing shapes*.[2]

c. [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*.'[3]

[1] 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.*

[2] www.amazon.com/Think-Fun-4985-Tangram/dp/B000BXHP04

d. [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.[4]

Our main concern here is in the fact that even though the sentences in (1) talk about twelve outfits, dozens of tangram shapes, three cranes, and dozens and dozens of words, they do not imply that at any one possible world or point in time, dozens of shapes, twelve outfits, three cranes exist, or dozens of words constructed with a set of eight scrabble pieces coexist. For example, we can combine three shirts and four pairs of pants only to three outfits at a time. Nevertheless, the sentences in (1) are true. The number words appear to count things that exist across the different possible worlds or times referred to be the modal and temporal operators of the sentences. This might not appear so remarkable for examples (1.b,c,d) if *tangram figure*, *crane*, or *word* refer to types (or kinds), which presumably have a more abstract way of existence anyway. However, (1.a) does not lend itself to a type reading; the shirts and pants that are mixed and matched may well be unique.

Our main goal is to develop a semantic representation for configurational entity expressions that captures their semantic behavior in numeral constructions. I will start with sentences like (1.a), and look at singular, cumulative and collective interpretations. Then I will generalize the solution to account for the type-related readings that are more likely for (1.a).

2 The Problem with Configurations

The natural readings of the examples in (1) cannot be rendered if nouns like *outfit* refer to regular individuals, type e. Consider the following simplified example:

(2) It is possible to make four outfits with these two shirts and two pants.

We assume an interpretation format with explicit quantification over indices that stand for worlds or times (including time intervals), and with entities that can be combined to form sum entities. I use i, i′ etc. as variables over indices (type s), and u, u′ etc. as variables over entities (type e). The count noun *outfit* applies to single outfits that consist of combining pieces of clothing in culturally acceptable ways, cf. (3).

(3) ⟦*outfit*⟧ = λiλu[u consists of parts arranged in i so that they form an outfit in i]

The number word *four* can be represented in various ways. Let us assume the standard Generalized Quantifier analysis (where P is a variable over properties, type set).

[3] spielwaren.1index.de/Fischertechnik@Cranes@Fischertechnik@Basic.19673.WOB00000001.137

[4] www.education-world.com/a_lesson/dailylp/dailylp/dailylp099.shtml

(4) $[\![\textit{four outfits}]\!] = \lambda i \lambda P[\#(\lambda u[[\![\textit{outfit}]\!](i)(u) \wedge P(i)(u)]) \geq 4]$

The verb *make* means 'arrange the parts of u in a particular way'. It is true at an index i iff the agent arranges the parts of u at an index i′ that immediately precedes i, for which I will write $i' \angle\, i$ (cf. von Stechow 2001 for verbs of creation).

(5) $[\![\textit{make}]\!] = \lambda i \lambda u \lambda u' \exists i'[i' \angle\, i \wedge u'$ arranges the parts of u in $i']$

The PP headed by *with* is analyzed as an internal adverbial modifier. Let us assume that *this* refers to a sum individual consisting of two shirts s_1, s_2 and two pairs of pants p_1, p_2, where $\oplus$ denotes the sum operation, and $\sqsubseteq$ the part relation.

(6) $[\![\textit{make with this}]\!]$
$= \lambda i \lambda u \lambda u' \exists i'[i' \angle\, i \wedge u \sqsubseteq s_1 \oplus s_2 \oplus p_1 \oplus p_2 \wedge u'$ arranges the parts of u in $i']$

Combining the meaning of an indefinite object *an outfit*, a subject DP *John*, and tense information (with < as the temporal precedence relation), and applying the resulting proposition to an index of evaluation i_0, we get the following interpretation:

(7) $[\![\textit{John made an outfit with this}]\!](i_0)$
$= \exists i{<}i_0\, \exists u \exists i'[i' \angle\, i \wedge u \sqsubseteq s_1 \oplus s_2 \oplus p_1 \oplus p_2$
$\wedge$ John arranges the parts of u in i′
$\wedge$ u consists of parts arranged in i so that they form an outfit in i]

This says that there is a time i before i_0 that immediately follows a time i′ during which John arranges parts of the two shirts and two pairs of pants, and that they form an outfit at the culminating time, i.[5] According to the intended understanding of *outfit*, there are four possible sum individuals that would qualify as outfits when properly arranged, namely $s_1 \oplus p_1$, $s_1 \oplus p_2$, $s_2 \oplus p_1$, and $s_2 \oplus p_2$. But at each index i, only two of these can be arranged to an outfit simultaneously, namely $s_1 \oplus p_1$ and $s_2 \oplus p_2$, and $s_1 \oplus p_2$ and $s_2 \oplus p_1$.

Let us now look at our example, (2). The non-governed infinitival form existentially quantifies over the subject position:

(8) $[\![\textit{to make with this}]\!]$
$= \lambda i \lambda u \exists u' \exists i'[i' \angle\, i \wedge u \sqsubseteq s_1 \oplus s_2 \oplus p_1 \oplus p_2 \wedge u'$ arranges the parts of u in $i']$

For the modal *possible* we assume the standard analysis as existential quantifier over indices that are elements of a set of indices R(i), the indices that are accessible from i. In our case, accessibility means that the parts of the shirts and pairs of pants are combined such that they qualify as outfits relative to the standards of i.

[5] This does not capture a possible intentional component that John wanted to create an outfit, which is irrelevant for our purposes.

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

We are now in a position to test whether we can generate the correct interpretation of (1.a), the reading that does not require that at any particular index, four outfits exist.

First, the modal might have wide scope with respect to the DP, resulting in the following interpretation at an index i_0.

(10) $[\![[\textit{it is possible}]\ [[\textit{four outfits}]\ [\textit{to make with this}]]]\!](i_0)$
$= \lambda i[[\![\textit{it is possible}]\!](i)(\lambda i'[[\![\textit{four outfits}]\!](i')([\![\textit{to make with this}]\!](i'))])](i_0)$
$= \exists i{\in}R(i_0)[\#(\lambda u[[\![\textit{outfit}]\!](i)(u) \wedge u \sqsubseteq s_1{\oplus}s_2{\oplus}p_1{\oplus}p_2 \wedge [\![\textit{to make}]\!](i)(u)]) \geq 4]$

This states that from i_0 there is an index i′ accessible from i_0 such that the cardinality of outfits made with the two shirts and two pairs of pants at i′ is at least four. Clearly, this is not the intended reading: it requires that four outfits are made at the same index.

Second, the DP might have wide scope with respect to the modal. This results in the following interpretation:

(11) $[\![[\textit{four outfits}]\ \lambda t[\textit{it is possible}\ [\textit{to make}\ t\ \textit{with this}]]]\!](i_0)$
$= \lambda i[[\![\textit{four outfits}]\!](i)(\lambda u[[\![\textit{it is possible}]\!](i)(\lambda i'[[\![\textit{to make with this}]\!](i')(u)]))]\!](i_0)$
$= \#(\lambda u[[\![\textit{outfit}]\!](i_0)(u) \wedge \exists i{\in}R(i_0)[[\![\textit{to make}]\!](i)(u) \wedge u \sqsubseteq s_1{\oplus}s_2{\oplus}p_1{\oplus}p_2]) = 4$

This result is even worse because it states that there are four outfits made with the two shirts and two pairs of pants at the index of interpretation i_0 itself.

3 An Individual Concept Analysis

What went wrong? The fault, I would like to argue, is with the analysis of outfits as simple entities, type e, as suggested by (3). There cannot be four outfit **entities** at the same time. The solution I would like to propose is that outfits and their ilk are rather **individual concepts**, that is, possibly partial functions from indices to entities, type se. Individual concepts were used by Gupta (1980) to model the meaning of sentences like *National Airlines served two million passengers in 1975.* Gupta pointed out that this does not entail that National Airlines served two million persons, as one and the same person can perform the role of a passenger multiple times. Gupta's solution – which analyzes passengers as individual concepts defined only for the time of a person's flight – is problematic for passenger sentences, as we have the same interpretation for sentences like *National Airlines served two million persons in 1975* (cf. Krifka 1990). But individual concets appear to be well-suited for configurations.

To illustrate the individual concept analysis, take the four outfits one can make with the two shirts s_1, s_2 and the two pairs of pants p_1, p_2. I make use of the notation introduced in Heim & Kratzer (1998) according to which an expression of the form λv.Restriction[v]. [Value[v]] denotes the (possibly partial) function from entities of the type of v that is only defined for arguments for which Restriction[v] holds; if defined, the function gives as value whatever is specified in Value[v].

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

For example, o_1 is an individual concept that is only defined for indices i if s_1 and p_1 are arranged as an outfit in i; if defined, o_1 maps to the sum individual consisting of s_1 and p_1. As one piece of clothing cannot be part of two outfits at a given index, the outfit concepts o_1, o_2 and o_3 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.

The individual concept analysis should not be restricted to configurations, of course. Take a regular entity, like Wolfgang Amadeus Mozart; he can be represented as individual concept that maps all indices i at which Mozart exists to Mozart – in our world, these are all indices from January 27, 1756 to December 5, 1791. In contrast to configurations, this is a convex set of indices: If i and i′ are indices of the same possible world that are in this set, and if i″ is an index of the same possible world that is temporally in between i and i′, then i″ is in this set as well. – Second, take role concepts like *the tallest man*, or *the Pope*. In contrast to configurations, they may refer to different entities for different indices. – Third, take individual concepts like the denotation of *the gifted mathematician that John claims to be* (cf. Grosu & Krifka 2008). Like configurations, they denote individual concepts referring to the same entity, but are restricted to those indices that are compatible with John's claims.

Gupta analyzed common nouns as properties of individual concepts, type s(se)t, and we will follow him here. The common noun *outfit* applies to individual concepts like o_1 in (12), and not to simple entities. I first give the extension of this common noun meaning at an index i_0 in the set notation; it is of type (se)t.

(13) $[\![\textit{outfit}]\!](i_0)$
$= \{\lambda i.$ the parts of u are arranged in i to qualify as outfit in i_0 . $[u] \mid u \in D_e\}$

This is the set of all functions from indices i to entities u in the universe D_e whose parts are arranged in such a way in i that they qualify as an outfit at the index of interpretation, i_0. This accounts for the fact that there might be indices at which we do not consider the arrangement of a striped shirt and a checkered pairs of pants a suitable outfit. We get the intension of this set by lambda-abstraction over i_0, as usual.

Notice that it might be that at a given index i_0, all the individual concepts in $[\![\textit{outfit}]\!](i_0)$ are such that they are not defined for i_0, because their parts are not arranged in i_0 in the proper way. Nevertheless, $[\![\textit{outfit}]\!](i_0)$ is not empty in this case. To give a concrete example, assume a set of seven indices $i_0,...i_6$, and assume that the four outfits mentioned in (12) are as follows:

(14) $o_1 = [i_1 \rightarrow s_1 \oplus p_1, i_2 \rightarrow s_1 \oplus p_1]$ $o_3 = [i_5 \rightarrow s_2 \oplus p_1, i_6 \rightarrow s_2 \oplus p_1]$
$o_2 = [i_4 \rightarrow s_1 \oplus p_2, i_5 \rightarrow s_1 \oplus p_2]$ $o_4 = [i_2 \rightarrow s_2 \oplus p_2, i_3 \rightarrow s_2 \oplus p_2]$

Notice that o_1 and o_4 both exist for i_2, and o_2 and o_3 both exist for i_5, but that o_1 and o_4 as well as o_2 and o_3 do not co-exist. At i_0 no outfit exists at all. But the noun *outfit* denotes for all indices, including i_0, the set of all these individual concepts, if what qualifies as outfit is the same for all indices:

(15) $[\![\textit{outfit}]\!] = \lambda i \in \{i_0, \ldots i_6\} [\{o_1, o_2, o_3, o_4\}]$

It simplifies the grammatical description if we assume that common nouns and verbal predicates in general are properties of individual concepts, following the methodological principle of Montague grammar of generalizing types to the most complex case. With extensional predicates like *be on the table*, they can be reduced to entities (in the following, I use x, x′ etc. as variables over individual concepts).

(16) $[\![\textit{be in the laundry machine}]\!] = \lambda i \lambda x[x(i) \text{ is in the laundry machine at } i]$

That is, the property is ascribed to x(i), the value of the individual concept x at the index i. Non-extensional predicates like *rise* or *change* are not reducible in this way (cf. Montague 1973). Verbs of creation like *make* state that an agent causes an individual concept to be realized at an index. For example, if John makes outfit o_1 at an index i then John caused during an interval preceding i that at i, o_1 is defined. This presupposes that during the making of i, o_1 was not defined (one cannot be making something that exists already) and entails that the agent acted upon the parts that o_1 refers to, $s_1 \oplus h_1$, in the time before i. The essential parts of this is captured in the following interpretation.

(17) $[\![\textit{to make}]\!]$
$= \lambda i \lambda x \exists x' \exists i'.\ i' \angle i \wedge \neg i' \in DOM(x)\ [i \in DOM(x) \wedge x' \text{ acts on } x(i) \text{ in } i']$
$= \lambda i \lambda x[\text{someone realizes } x \text{ at } i]$ (in short)

The DP *four outfits* will get the following interpretation, with P is a variable for properties of individual concepts, type s(se)t.

(18) $[\![[_{DP}\textit{four outfits}]]\!] = \lambda i\ \lambda P\ [\#(\lambda x[[\![\textit{outfit}]\!](i)(x) \wedge P(i)(x)]) \geq 4]$

We now can give an appropriate interpretation to our example. It states that there are four outfit concepts such that there are accessible indices at which these outfits are made. Notice that the predication is understood as distributive: For each of these individual concepts, there is an accessible index at which it can be made.

(19) $[\![[\textit{four outfits}]\ \lambda t[\textit{it is possible}\ [\textit{to make}\ t\ \textit{with this}]]]\!](i_0)$
$= \lambda i[[\![\textit{four outfits}]\!](i)(\lambda x[[\![\textit{it is possible}]\!](i)(\lambda i'[[\![\textit{to make with this}]\!](i')(x)]))]\!](i_0)$
$= [\![\textit{four outfits}]\!](i_0)(\lambda x[[\![\textit{it is possible}]\!](i_0)(\lambda i'[[\![\textit{to make with this}]\!](i')(x)])$
$= \#(\lambda x[[\![\textit{outfit}]\!](i_0)(x) \wedge [\![\textit{it is possible}]\!](i_0)(\lambda i'[[\![\textit{to make with this}]\!](i')(x)]) \geq 4$
$= \#(\lambda x[x\in[\![\textit{outfit}]\!](i_0)(x) \wedge \exists i'\in R(i_0)[[\![\textit{to make}]\!](i')(x) \wedge x\in\{o_1,o_2,o_3,o_4\}]) \geq 4$
$= \#(\lambda x[x\in\{o_1, o_2, o_3, o_4\}\wedge \exists i'\in R(i_0)[\text{someone realizes x at i}']) \geq 4$

This is true iff for each of the four individual concepts there is an index i' accessible from i_0 such that x is realized by someone at i'. Notice that this does not entail that there is an index at which all four individual concepts are realized. In particular, (19) is compatible with a situation in which only two outfits can be realized at a time.

4 Sum Formation for Individual Concepts

4.1 Collective Interpretations

Our proposed treatment of sentences with reference to configurations allows only for a distributive interpretation, as distributivity is built in into the very nature of DPs like *four outfits.* However, we also find collective readings:

(20) Two outfits are rather similar to each other.

Equivalent readings of sentences with noun phrases that refer to regular individuals have been analyzed with the help of the notion of sum individuals (cf. e.g. Link 1983), and we can employ this idea in the present case as well.

One natural way in which the notion of sum formation can be extended to individual concepts is to lift the join operation $\oplus$ for entities to a join operation for individual concepts, as follows:

(21) $x\oplus y = \lambda i[x(i) \oplus y(i)]$

The join of two individual concepts, $x\oplus y$, is an individual concept that maps every index i to the join of the individuals x(i) and y(i). But notice that this join is only defined in case x(i) and y(i) are defined. This may be useful for certain kinds of complex individual concepts, but not for the one we are after. In our example, the four outfits o_1,... o_4 do not all exist at the same index, hence $o_1\oplus o_2\oplus o_3\oplus o_4$ will not be defined for any index. Hence we need a different join operation of individual concepts. One option is to use set formation; the join of the four outfits then is $\{o_1, o_2, o_3, o_4\}$. This is not an individual concept in its own right: It is not a function from indices to entities, but a set of such functions. Let us consider the construction of DPs with number words, like *two outfits*, in this framework.

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

This is a property of sets of individual concepts, type s((se)t)t. From it we can derive an indefinite DP which is interpreted as an existential quantifier that combines with a verbal predicate $\underline{P}$, a property of sets of individual concepts.

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

The predicate *are similar* is a property of sets of individual concepts; it is true of such a set iff its elements are pairwise similar to each other.

(24) $[\![[_{DP}\ [two\ outfits]]\ [are\ similar]]\!](i_0)$
$= [\![[_{DP}\ [two\ outfits]]]\!](i_0)([\![are\ similar]\!](i_0))$
$= \lambda\underline{P}\exists X[[\![[_{NP}\ two\ outfits]]\!](i)(X) \wedge \underline{P}(i)(X)](\lambda X\forall x,y\in X[\text{x is similar to y at } i_0])$
$= \exists X[\#(X) = 2 \wedge X\subseteq[\![outfit]\!](i) \wedge \forall x,y\in X[\text{x is similar to y at } i_0]]$

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. Notice again that this does not entail that x and y have realizations at i_0; *be similar* must be understood as an intensional predicate. We find this type of comparison with other cases of individual concepts, as in *two popes were similar to each other*, which may be true even if the two popes were not contemporaries.

The interpretation of expressions like *two outfits* proposed here is also possible for the non-collective examples we started out with, provided that we assume that verbal predicates, when applied to sets of individual concepts, distribute over their elements. This can be implemented by a type lifting of verbal predicates to accommodate sets of individual concepts as arguments. The type lifting is indicated with *, a symbol that is sometimes used for the cumulative closure of a predicate, as we have cumulativity here as well, insofar as $*\underline{P}(i)(X) \wedge *\underline{P}(i)(Y)$ entails $*\underline{P}(i)(X\cup Y)$.

(25) $*P = \lambda i\lambda X\forall x\in X[P(i)(x)]$

(26) $*[\![\lambda t[it\ is\ possible\ [to\ make\ t]]]\!] = \lambda i\lambda X\forall x\in X\exists i'\in R(i)[\text{s.o. realizes x at } i']$

The derivation of the reading of our original sentence is straightforward:

(27) $[\![[[_{DP} four\ outfits]\ \lambda t[it\ is\ possible\ [to\ make\ t]]]\!](i_0)$
$=[\![[_{DP} four\ outfits]]\!](i_0)(*[\![\lambda t[it\ is\ possible\ [to\ make\ t]]]\!](i_0))$
$= \lambda\underline{P}\exists X[\#(X) = 4 \wedge X\subseteq[\![outfit]\!](i_0) \wedge \underline{P}(i_0)(X)]$
$(\lambda X\forall x\in X\exists i'\in R(i_0)[\text{someone realizes x at } i'])$
$= \exists X[\#(X) = 4 \wedge X\subseteq[\![outfit]\!](i_0) \wedge \forall x\in X\exists i'\in R(i_0)[\text{someone realizes x at } i']]$

Notice that we do not assume a distributive operator here; distributivity is rather a consequence of type lifting expressed by the * operator.

4.2 Configurations and Temporal Operators

Examples like (28) involve a temporal operator, the perfect. Just as with modal operators, the sentence does not entail that the three outfits existed at the same time.

(28) John has made three outfits with these shirts and pants.

The proper representation of perfect tense is beyond the scope of this paper. What is important is that perfect clauses like *John has arrived* entail that there was a time prior to the time of utterance at which John arrives. Then we can give the interpretation (29), where the part in parentheses will be neglected, for the perfect. This enables derivations like in (30), which allows for each element x of the four outfit concepts X that they were made at different times i′.

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

(30) $[\![[_{DP}\ \mathit{three\ outfits}]\ [\mathit{have\ been\ made}]]\!](i_0)$
$= [\![[_{DP}\ \mathit{three\ outfits}]]\!](i_0)(*[\![\mathit{PERFECT}\ [\mathit{be\ made}]]\!](i_0))$
$= \lambda \underline{P} \exists X[\#(X) = 3 \wedge X \subseteq [\![\mathit{outfit}]\!](i_0) \wedge \underline{P}(i_0)(X)]$
$(\lambda X \forall x \in X \exists i' < i_0[\text{someone realizes x at } i'])$
$= \exists X[\#(X) = 3 \wedge X \subseteq [\![\mathit{outfit}]\!](i_0) \wedge \forall x \in X \exists i' < i_0[\text{someone realizes x at } i']]$

Notice that a simple past tense as in *John made three outfits* tends to have the reading for which the three outfits coexist. This is because past tense typically refers to a particular time given by the context. When we say that the three outfit concepts x of the set X were made at that particular time, then they must coexist at that time (or at the end of that time).

4.3 Cumulative Interpretations

Sets of individual concepts can also accommodate cumulative interpretations. Imagine that a kindergarten owns a construction set with which all kinds of vehicles can be constructed, but only one at a time (there are only four wheels).

(31) Dozens of children have built hundreds of vehicles with this construction set.

Such interpretations have been explained as a consequence of the cumulativity of verbal predicates (cf. Krifka 1989, Sternefeld 1998). That is, transitive predicates like *build* are interpreted such that if u builds v and u′ builds v′, then u⊕u′ builds v⊕v′. This interpretation is triggered by Sternefeld's operator **, here adapted as in (32). Let Q be a variable for relations between sets of individual concepts, type s(se)(se)t.

(32) $**Q = \lambda i\lambda X\lambda Y[\forall x{\in}X\exists y{\in}Y[R(i)(x)(y)] \wedge \forall y{\in}Y\exists x{\in}X[Q(i)(x)(y)]]$

This operator enables derivations as in (33), where ">> 24" and ">> 200" state that a number is in the range of dozens and hundreds, respectively.

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

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

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

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

Here, X is a set of individual concepts that have the property of being children with respect to i_0. This set X contains dozens of elements. Similarly, Y is a set of individual concepts that are vehicle concepts with respect to i_0; the way things are set up, no two vehicle concepts exist at the same temporal index. Y contains hundreds of elements. For every element x of X there is an element y of Y and a time before t_0 such that x builds y at that time, and for every element y of Y there is an element x of X such that y was built by x at that time. Notice that this does not require that at any one time there exists more than one vehicle. It does require, though, that the builders of the vehicle are children at the time of the building, as the condition "x realizes y at i′" entails that the realization x(i′) did the building at i′, and if x is only defined for persons during their childhood years, then x must be a child during the time of the building of y. Notice, also, that this interpretation allows that children cooperate in the building of one vehicle, as the individual concept x may well refer to two or more children; cf. (21).

5 The Property Analysis, and Identity Criteria for Concepts

Condoravdi, Crouch & van den Berg (2001) have analyzed examples like (34) in a way that looks similar to what we have proposed for configurations.

(34) The mayor prevented three strikes.

Prevent is analyzed as an intensional predicate, like *seek*, which Condoravdi e.a. interpret, following Zimmermann (1993), as having a property argument:

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

This captures the reading in which no reference to a specific strike is intended. But there is also a specific reading: There was a threat for a strike, and the mayor prevented that strike from happening. The normal solution for specific reading, giving the noun phrase wide scope (cf. (36)), does not work. It entails the existence of a strike u – but this is exactly what the next conjunct says was prevented.

(36) $\exists i{<}i_0\ \exists u[[\![$*strike*$]\!](i)(u) \wedge [\![$*prevent*$]\!](i)(\lambda i'\lambda v[u{=}v])(\mathbf{m})]$

Condoravdi et. al. propose a solution for the specific interpretation using "sub-concepts" (that is, subproperties). No strict definition is given, but we certainly should assume that a superconcept applies to all indices and individuals a subconcept applies to. The specific reading can be given as follows, where $\subseteq_{sc}$ is the subset relation.

(37) $\exists P \subseteq_{sc} [\![$*strike*$]\!]\exists i{<}i_0\ [\![$*prevent*$]\!](i)(X)(\mathbf{m})$

For the interpretation of *three strikes*, Condoravdi et al. (2001) discuss various options, settling on a generalized quantifier analysis:

(38) $[\![$*the mayor prevented three strikes*$]\!](i_0)$
$= \#(\lambda P[P \subseteq_{sc} [\![$*strikes*$]\!]] \wedge \exists i{<}i_0\ [\![$*prevent*$]\!](i)(P)(\mathbf{m})]) = 3$

But for this to work, the notion of subconcept must be properly restricted. One entity may fall under different subconcepts of *strike*, e.g. it might be a strike of the railroad workers and at the same time (as railroad workers are public workers) a strike of the public workers. Obviously, the subconcepts that we count should not be such that one is included in the other. Hence Condoravdi e.a. propose to restrict counting to minimal subconcepts, that is, to "maximally specific instantiated concepts".

Using individual concepts instead of properties, we get minimality for free, as individual concepts can apply to maximally one individual. Hence it seems natural to apply the individual concepts analysis to examples of the type of Condoravdi e.a. (2001). The natural reading of (34) is that what the mayor prevented was that three specific strike threats led to a full-blown strike. In each world at which these strikes would have been realized, there would have been exactly one realization.

(39) $[\![$*The mayor prevented three strikes*$]\!](i_0)$
$= \exists X[\#(X) = 3 \wedge X \subseteq [\![$*strike*$]\!](i_0) \wedge \forall x{\in}X\exists i'{<}i_0[\mathbf{m} \text{ prevented x at } i']]$

This says that X consists of three individual concepts that are strikes, and that the mayor prevented them (possibly at three different times). To prevent an individual concept at an index i′ means to act in such a way that the individual concept is not realized in the possible future continuations of the index i′. That is, without the intervention, the individual concept x would have been realized at a normal continuation of i′.

But there is still an issue of minimality to be considered: While individual concepts necessarily refer to one entity, they may be defined for a greater of smaller set of indices. For example, if $[i_1 \rightarrow e_1, i_2 \rightarrow e_2]$ is a strike (which is realized in i_1 by the event e_1, and in i_2 by the event e_2), and if $[i_3 \rightarrow e_3, i_4 \rightarrow e_4]$ is a strike, what prevents us from saying that $[i_1 \rightarrow e_1, i_2 \rightarrow e_2, i_3 \rightarrow e_3, i_4 \rightarrow e_4]$ is a strike? Alternatively, what prevents us from saying that $[i_1 \rightarrow e_1]$ is a strike? Put differently, what would make us say that $[i_1 \rightarrow e_1]$ is the same strike as $[i_2 \rightarrow e_2]$, but that $[i_1 \rightarrow e_1, i_2 \rightarrow e_2]$ and $[i_3 \rightarrow e_3, i_4 \rightarrow e_4]$ are different strikes?

Like identity criteria in general, this depends on lexical semantics and cannot be determined by abstract principles. In the case at hand, 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. Formal semantics can only provide the general format of the objects of lexical semantics.

With sentences referring to configurations, the adjective *different* occurs quite naturally, cf. the examples in (1). This points to the greater relevance of identity criteria in such sentences. There are two competing strategies: First, we might count as one outfit, tangram figure or crane the maximally temporally convex individual concept that is a particular outfit, tangram figure, or crane. There is no contradiction in (40):

(40) John has made many figures with this tangram set, but he nearly always makes the same one – the ice-skater.

Different excludes such readings, hence indicates that a criterion of identity is used beyond temporal convexity. A similar effect was noticed by Barker (1999), who observed that the reading of *National Airlines served two million persons* that is similar to (11) vanishes if the object is replaced by *two million different persons*.

6 Tokens and Types

The preceding section argued that there are advantages of the individual concept analysis of strikes (and outfits) over the property analysis. However, the property analysis has its advantages when we consider the availability of type readings, in addition to the token readings of *outfit* and *strike* considered so far.

The type reading is quite natural for examples (1.b,c,d), We can distinguish between the type of tangram sets, or the type of a particular tangram shape like the ice skater, and the tokens that realize this type. The crucial difference is that tokens exist only once at a particular world and time, whereas types can be realized multiple times. But notice that, even under the type interpretation, it is still true to say: *With a tangram set, one make dozens of figures, but only one at a time.*

There are different ways to model the type/token distinction. Types can be treated as kinds and tokens as exemplars that are related to kinds via a realization relation (cf. Carlson 1978). Or they may refer to the sum individuals of all tokens (cf. Chierchia 1998 for definite generics). But there is one way that hasn't been explored so far, according to which types and tokens are properties, where types may apply to multiple entities at an index, whereas tokens may apply to maximally one entity. In this light, it is worthwhile to reconsider the property analysis of Condoravdi e.a. (2001). The type of a particular tangram figure, say the ice-skater, is realized by many tokens – all the tangram pieces that are in the configuration of the shape called the ice-skater.

(41) ⟦*the ice-skater*⟧(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 an ice-skater, according to i_0}

If we concentrate on a single tangram set **t**, then we can model tangram shape tokens in a similar way – as properties that map indices to singleton sets, or to the empty set.

(42) ⟦*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}

This token belongs to the type of (41), as the following holds:

(43) ∀i∀i′∀u[⟦*the ice-skater made of* ***t***⟧(i)(i′)(u) → ⟦*the ice-skater*⟧(i)(i′)(u)]

The predicate *tangram figure* applies to such properties, regardless whether they tokens or types; hence it is of type s(set)t. We can define the set of tangram figure types and the set of tangram figure tokens as follows:

(44) ⟦*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}
⟦*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}

A noun like *tangram figures* can be seen as ambiguous between the type reading and the token reading, or alternatively as vague – then it would refer to the union of the two readings indicated in (44). The use of *different* selects the type reading, or restricts the vague reading to it.

With this analysis of common nouns, we can treat sentences like *it is possible to make dozens of different tangram figures* with reference to tangram figure types rather than tokens. Following an analysis along the lines of (22) and (23) we have the following meaning of the DP; here $\underline{X}$ is a variable of type (set)t, and $\underline{P}$ is a variable of type s(set)t.

(45) $[\![[_{\text{DP}}\ \textit{dozens of}\ [\textit{tangram figures (types)}]]]\!]$
$= \lambda i \lambda \underline{P} \exists \underline{X}[\#(\underline{X}) >> 24 \wedge \underline{X} \subseteq [\![\textit{tangram figure (types)}]\!](i) \wedge \underline{P}(i)(\underline{X})]$

The meaning of verbal predicates has to be adjusted to the property analysis. For example, to *make* a particular tangram figure (type) means to cause that an entity u that was not in the extension of this tangram figure to become part of it. The definition of *to make* in (17) has to be replaced by the following, where $\underline{x}$ now stands for properties.

(46) $[\![\textit{to make}]\!]$
$= \lambda i \lambda x \exists \underline{x}' \exists i' \exists u.\ i' \angle\ i \wedge \neg\ \underline{x}(i')(u)\ [\underline{x}(i)(u) \wedge \underline{x}' \text{ acts on u in } i']$
$= \lambda i \lambda \underline{x}[\text{someone realizes an } \underline{x} \text{ at } i]$ (for short)

We now can analyze our example as follows:

(47) $[\![[_{\text{DP}}\ \textit{dozens of t. figures (types)}]\ \lambda t[\textit{it is possible}\ [\textit{to make}\ t]]]\!](i_0)$
$= [\![[_{\text{DP}}\ \textit{dozens of t. figures (types)}]]\!](i_0)({}^*[\![\lambda t[\textit{it is possible}\ [\textit{to make}\ t]]]\!](i_0))$
$= \lambda \underline{P} \exists X[\#(X) >> 24 \wedge \underline{X} \subseteq [\![\textit{tangram figure}]\!](i_0) \wedge \underline{P}(i_0)(\underline{X})]$
$(\lambda \underline{X} \forall \underline{x} \in \underline{X} \exists i' \in R(i_0)[\text{someone realizes an } \underline{x} \text{ at } i'])$
$= \exists \underline{X}[\#(X) >> 24 \wedge \underline{X} \subseteq [\![\textit{tangram figure}]\!](i_0) \wedge$
$\forall \underline{x} \in \underline{X} \exists i' \in R(i_0)[\text{someone realizes an } \underline{x} \text{ at } i'])$

This says that there is a set $\underline{X}$ containing dozens of properties that are all different tangram figure types, and that for each property $\underline{x}$ of this set there is an accessible index i′ at which $\underline{x}$ is realized. This in turn means that some agent acts on a sum individual u (the elements of a tangram set) such that it falls under the property $\underline{x}$. This renders the intended interpretation correctly. In particular, it does not imply that at any accessible index dozens of tangram figure types are realized simultaneously.

7 Conclusion

In this paper I have outlined two different ways how to deal with what I called "configurational" entities denoted by such terms as *outfit* or *tangram figure*. First, they can be analyzed as partial individual concepts that are realized at some indices but not at others. This predicts their behavior in modal and temporal clauses, and the analysis can explain the behavior of such sentences in distributive, collective and cumulative interpretations. The individual concept analysis is well-suited for the token readings of these terms. For the type readings I suggested an alternative representation, as properties that could be generalized to token readings as well.

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