

Dealing with Fuzzy Categories by Coercion

Categories and Grammar – Criteria and Limitations
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Manfred Krifka
krifka@rz.hu-berlin.de



Zentrum für Allgemeine Sprachwissenschaft,
Berlin

Humboldt-Universität zu Berlin



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Beans, Lentils, Oats, and Rice



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Mass / Count as nominal subcategories

Distributional characteristics:

- ▶ No number distinction, typically singular:
*bean / beans vs. rice / *rices* (singulare tantum) **oat vs. oats* (plurale tantum)
- ▶ Combination with numerals: *one bean, three beans / *one rice, *three rice(s)*
- ▶ Combination with quantifiers: *every bean, all beans / *every rice, all rice*
- ▶ Specific determiners: *many, few beans / much, little rice*
- ▶ Indefinite and definite determiners: *a bean, the bean / *a rice, the rice*
- ▶ Full DP: **Bean / Rice was spilled all over the floor.*
Similar to plural nouns: *Beans were spilled all over the floor.*

Clear evidence for two subcategories of nouns:

- ▶ Mass nouns vs. Count nouns (Cf. Jespersen 1924, *The Philosophy of Grammar*).
- ▶ Gerstenhofer 2007: From a randomly selected set of 600 nouns,
 - ▷ 35% are mass in Russian, 29% in German,
 - ▷ Inanimates: 50% are mass in Russian, about 30% are mass in German,
 - ▷ Abstract: 60% are mass in Russian, about 50% are mass in German;
 - ▷ In Russian, 50% of mass nouns are feminine;
 - ▷ in German, 40% of mass nouns are neuter.

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Mass / Count as nominal subcategories

Some typological aspects (see Doejes 2012)

- ▶ In classifier languages distinction measure / count construction, e.g. Mandarin:
liǎng bàng (de) ròu *liǎng pī (*de) luózi* *sān wūzi *(de) rén*
two pound LNK meat two CL LNK mule three room LNK people
'two pounds of meat' 'two mules' 'three roomful of people'
- ▶ Interacts with nominal classification,
e.g. *ma*-class (Cl. 6), *u*-class (Cl. 11) in Bantu
(Swahili *maji* 'water', *mafuta* 'oil'; *uji* 'porridge', *udongo* 'soil')
- ▶ Plural agreement with number words not essential for mass/count distinction:
e.g. Turkish: *çocuk* 'child', *çocuklar* 'children', *yedi çocuk* 'seven children'
- ▶ Possible lack of distinction, e.g. Nez Perce (Deal 2013)

a. k'uyc heesu
nine eel
nine eels

b. k'uyc heecu
nine wood
nine pieces of wood

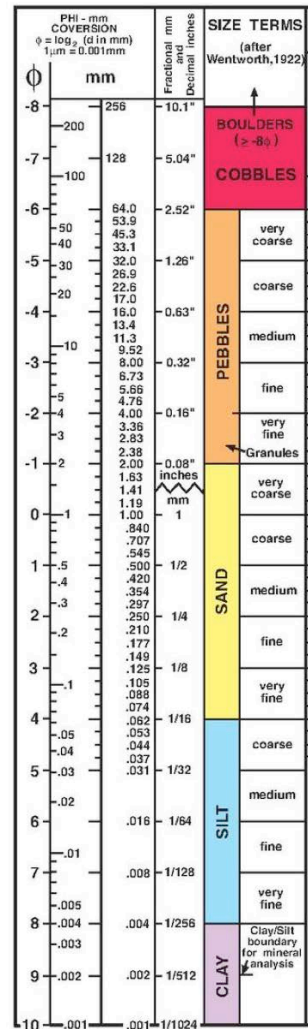
a. yi-yos-yi-yos kapoo
PL-blue coat
blue coats

b. yi-yos-yi-yos mayx
PL-blue sand
quantities of blue sand

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Mass / Count and cognition

Krumbein Φ scale, Wentworth scale



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Cognitive characteristics:

- ▶ Substances are mass: *gold, dust, dirt, porridge*
- ▶ Fluids are mass: *water, milk, glass (!)*
- ▶ Small objects tend to be mass: *silt, sand, gravel – stone(s), rock(s), boulders*
- ▶ Entities low on the animacy scale tend to lack number distinction (Smith-Stark 1974; e.g. Manchu, 'horse' only animal term with SG/PL)

▶ But: *police, military*, e.g.
There was a lot of police everywhere

- ▶ Shape reference: count, e.g. *ring, edge, corner*

Arguably rooted in pre-linguistic categorization:

- ▶ Spelke 1985, other, for infants: Cars / drops bumping into each other, resulting in a bigger car (!) / drop
- ▶ Cognitive differentiation of substances / animals present with primates (e.g. Rhesus monkeys, Hauser 1996)
- ▶ Bootstrap for linguistic count / mass distinction

Mass / Count: Cognition is not everything

But cognitive characteristics are not sufficient:

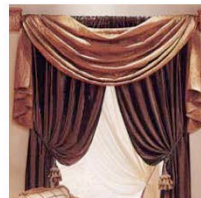
- ▶ Differences between languages:
 - ▷ English *leave, leaves*, German *Laub* (next to *Blatt, Blätter*)
 - ▷ Middle English *peasen* to Modern English *pea, peas*
- ▶ Differences within a language:



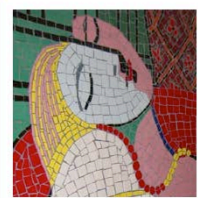
gold / nuggets



change / coins



drapery / curtains



The face consists of white tiles / tiling.

- ▶ Two types of mass nouns (Barner & Snedeker 2005):

Mass / Count distinction motivated by ontological / cognitive considerations, but not fully determined by it – cf. Gender.

count nouns	mass nouns	
	object mass nouns	substantive mass nouns
<p>(Who has more shoes?)</p>	<p>(Who has more silverware?)</p>	<p>(Who has more toothpaste?)</p>
	number-based judgement	
		quantity-based judgement

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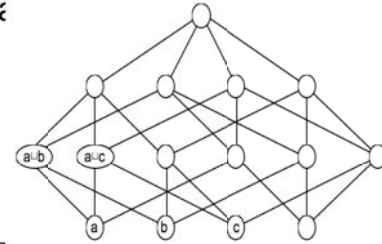
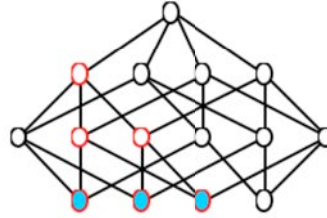
Mass / Count as a semantic distinction

Voluminous literature on mass/count in semantics, philosophy,

- ▶ e.g. F.J. Pelletier, Chierchia; Champollion & Krifka t.2

Basic assumption:

- ▶ Sum individuals
- ▶ Part relation
- ▶ Mass and plural denotation closed under sum operation (cumulative), e.g. *rice*, *beans*
- ▶ Singular denotation, e.g. *bean*: atomic.
- ▶ Mass noun denotation: nonatomic? But rice has “atoms”, too!



Mass / Count as a semantic distinction

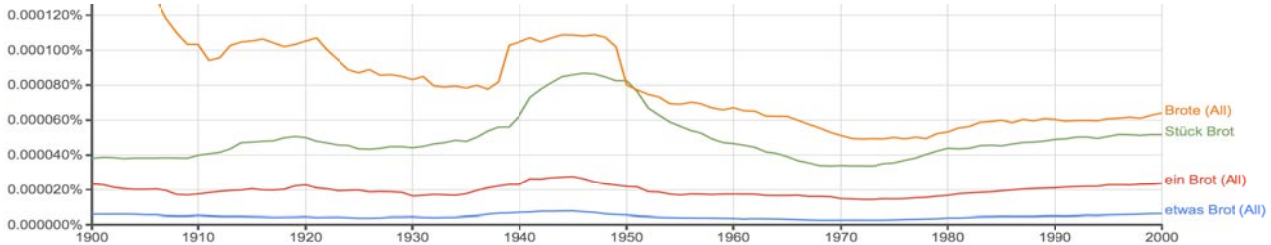
Krifka (1989 ff.):

- ▶ Mass nouns are predicates: $\llbracket rice \rrbracket = \lambda x[RICE(x)]$
- ▶ Measure expressions as restrictores:
 - $\llbracket kilo(s) \rrbracket = \lambda P \lambda n \lambda x [P(x) \wedge KG(x)=n]$ agreement plural
 - $\llbracket kilo(s) of rice \rrbracket = \lambda n \lambda x [RICE(x) \wedge KG(x)=n]$
 - $\llbracket three kilos of rice \rrbracket = \lambda x [RICE(x) \wedge KG(x)=3]$
- ▶ Classifiers refer to type-specific natural units (NU):
 - $\llbracket grain(s) \rrbracket = \lambda P \lambda n \lambda x [P(x) \wedge NU(P)(x)=n]$ agreement plural
 - $\llbracket grain(s) of rice \rrbracket = \lambda n \lambda x [RICE(x) \wedge NU(RICE)(x)=n]$
 - $\llbracket three grains of rice \rrbracket = \lambda x [RICE(x) \wedge NU(RICE)(x)=3]$
- ▶ Count nouns have built-in classifiers:
 - $\llbracket bean \rrbracket = \lambda x [BEAN(x)]$, not a lexical entry
 - $\llbracket bean(s) \rrbracket = \lambda n \lambda x [BEAN(x) \wedge NU(BEAN)(x)=n]$ agreement plural
 - $\llbracket three beans \rrbracket = \lambda x [BEAN(x) \wedge NU(BEAN)(x)=3]$
- ▶ Bare plurals with count nouns:
 - $\llbracket bean-s \rrbracket = \llbracket PL \rrbracket(\llbracket bean \rrbracket) = \lambda x \exists n [BEAN(x) \wedge NU(x)=n]$ semantic plural
- ▶ NE requires internally connected “figures” that can be traced, move independently
 - ▶ E.g. solid detached objects, organisms,
 - ▶ but also entities with social, functional structure: *legion*, *cohort*
- ▶ Built-in NE is conventionalized, more likely if existence of an NU is particularly evident, or NU reference is frequent

Mass / Count category changes

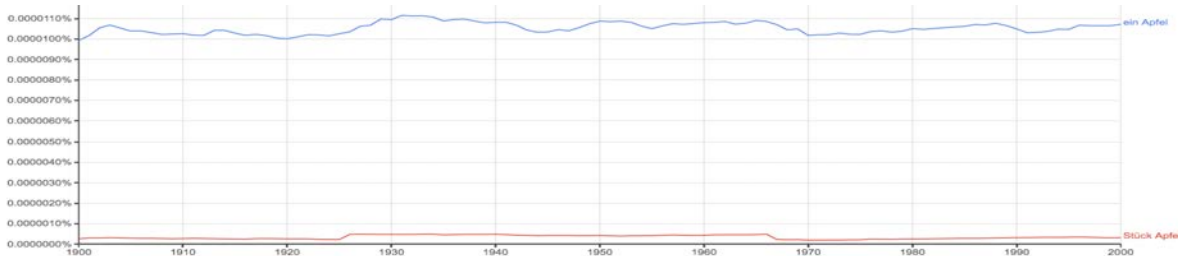
Truly ambiguous nouns:

- ▶ German *Brot* 'bread'
 - ▷ *Brote, ein Brot*: typical count noun use
 - ▷ *etwas Brot, Stück Brot*: typical Mass noun use
 - ▷ cf. English *cake, stone*
 - ▷ distribution in Google n-gram, 1900-2000



Non-ambiguous noun: German *Apfel* 'apple'

- ▶ *Stück Apfel, ein Apfel, Äpfel, no etwas Apfel*

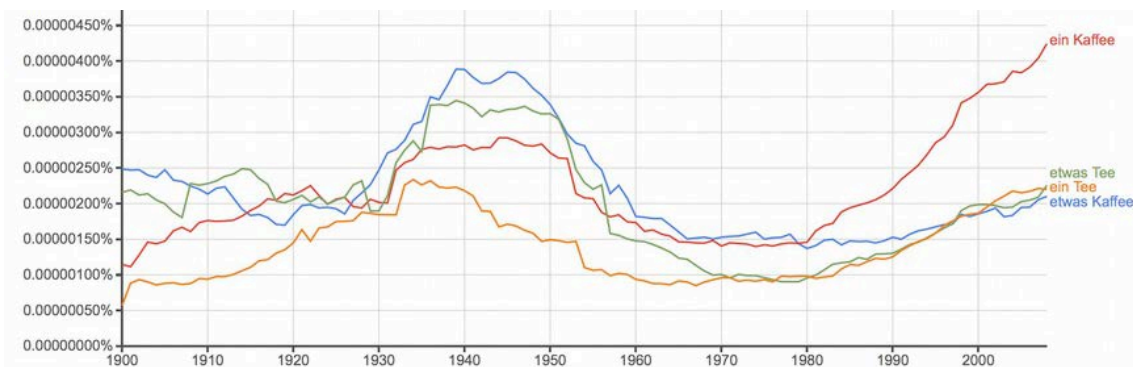


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Category changes: Mass to count, Containers

Reference to portions of liquids:

- ▶ *etwas Kaffee* vs. *ein Kaffee, Kaffees*; *etwas Tee* vs. *ein Tee, Tees*



How does “packaging” work?

- ▷ By container, container is countable, substances are self-connected
notice: service portions are self-connected
- ▷ Change from $coffee_{MN}$ to $coffee_{CN}$ $\lambda n \lambda x \exists y [[coffee_{MN}] (x) \wedge CONTAINER(y)=n \wedge FILL(x,y)]$
- ▷ More specifically: container for coffee appropriate in the reference situation
- ▶ Packaging also relevant in *He put the coffee on the table*.
- ▶ Reverse process, from container to content: *He drank a bottle (of beer)*.

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Category changes: Mass to count, Subkinds

Reference to subkinds (taxonomic readings, cf. Krifka e.a. 1995)

- ▷ *Viele Tees aus ökologisch fairem Anbau!*
- ▷ *top three teas for weight control*
- ▷ *Morgenstund hat Gold im Mund. Was für ein Gold haben die Alten damit gemeint?*

Reference to subkinds in exclamatives (cf. Gorishneva 2014):

- ▶ *Das ist das "Sommerleuchten", Was für ein tolles Gold, liebe Ellen!*
- ▶ *Oh, was für ein wunderbarer Kaffee, danke!*
- ▶ Implies a ranking of subkinds, expression of astonishment about the subkind.

How does reference to subkinds work?

- ▶ The specimens of a subkind share a distinctive property, hence are connected within the superkind
- ▶ This allows to form a counting operator SK with similar properties as NE
- ▶ which in turn allows for the formation of a count noun: $coffee_{MN}$ to $coffee(s)_{SK}$, with $\llbracket coffee(s)_{SK} \rrbracket = \lambda n \lambda x [\llbracket coffee_{MN} \rrbracket (x) \wedge SK(\llbracket coffee_{MN} \rrbracket)(x)=n]$

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Category change: Count to mass, Grinding

The “universal grinder” (D. Lewis, F.J. Pelletier)

- ▷ *I went to the site of the traffic accident, and there was dog lying all over the road.* (From the Wikipedia entry on the Universal Grinder)
- ▷ *How much chicken should we eat?*
- ▷ *This table is made of oak.*
- ▷ *Zuviel Ei im Mürbeteig – was tun?*
- ▶ How the universal grinder works:
 - ▷ The objects and the stuff they consist of may have different properties: *This ring was made in Prague, but I bought the gold it consists of in Brazil.*
 - ▷ Link (1983 assumes) a function STUFF: concrete object $x \rightarrow$ stuff x consist of.
 - ▷ As belonging to the object is the only identifying criterion for the stuff, the stuff itself arguably has no other NE to rely on.
 - ▷ Hence: mass use related to the universal grinder
- ▶ Grinding is a rather complex procedure:
 - ▷ **much chicken*: requires cumulative predicate $\lambda x[\dots]$, but $\llbracket chicken_{CN} \rrbracket = \lambda n \lambda x[\dots]$
 - ▷ cumulative predicate: $\lambda x[\exists x'[\exists n[\llbracket chicken_{CN} \rrbracket (x')(n) \wedge x \sqsubseteq STUFF(x')]]$
- ▶ Not just: Recovery from CN denotation (cf. Rothstein 2010)
 - ▷ $\llbracket chicken_{CN} \rrbracket = \lambda n \lambda x[CHICKEN(x) \wedge NU(CHICKEN)(x)=n]$ (plural denotation)
 - ▷ Mandarin does not have this reading (cf. Cheng e.a. 2008), as bare noun can have a regular denotation (referring to one or more chickens)

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Category change: Count to Mass, Product

From producer to product

- ▷ *John read 700 pages of Tolstoy over the weekend.*
- ▷ *John hat 700 Seiten Tolstoy übers Wochenende gelesen.*
- ▷ *Klassik-Marathon: 100 Stunden Beethoven*
- ▷ *Das ist Beethoven!*
- ▷ *Die Welt ist voller Degussa.*
- ▷ *Mary has two original Klees in her living room.*
- ▶ How it works
 - ▷ Derivation of a mass noun from a **name**
 - ▷ $\lambda x[\text{PRODUCT}(\text{Tolstoy})(x)]$
 - ▷ Application of a measure phrase:
 $\llbracket \text{pages of Tolstoy} \rrbracket = \lambda n \lambda x[\text{PRODUCT}(\text{Tolstoy})(x) \wedge \text{PAGE}(x)=n]$
 - ▷ Application of NU operator if there is a natural unit, with fine arts:
 $\llbracket \text{Klee}(s) \rrbracket = \lambda n \lambda x[\text{PRODUCT}(\text{Klee})(x) \wedge \text{NU}(\text{PRODUCT}(\text{Klee}))(x)=n]$

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Category change: Count to mass, Root

Internal structure, natural unit does not matter:

- ▷ *A lot of house for the money.*
- ▷ *Viel Schlafsack für wenig Geld.*
- ▷ *Und das ZDF ist heute ein Routinebetrieb zur Erstellung von Programm*
- ▷ *Noch mehr U-Bahn ab 28. Mai*

How it works (cf. Rothstein 2010):

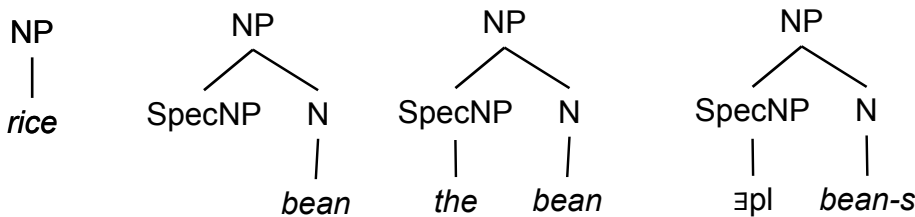
- ▶ Distinction between roots and lexical entries
- ▶ Mass nouns:
 - ▷ Root: $\llbracket \sqrt{\text{water}} \rrbracket = \lambda x[\text{WATER}(x)]$, a cumulative predicate
 - ▷ The root is the lexical entry: $\llbracket \llbracket_N \text{water} \rrbracket \rrbracket = \llbracket \sqrt{\text{water}} \rrbracket$
- ▶ Count nouns:
 - ▷ Root: $\sqrt{\text{house}} = \lambda x[\text{HOUSE}(x)]$, a cumulative predicate
 - ▷ Lexical entry derived from root by count operator:
 $\llbracket \llbracket_N \text{house} \rrbracket \rrbracket = \text{COUNT}(\llbracket \sqrt{\text{house}} \rrbracket) = \lambda n \lambda x[\llbracket \sqrt{\text{house}} \rrbracket(x) \wedge \text{NU}(\llbracket \sqrt{\text{house}} \rrbracket)=n]$
 - ▷ This is a lexical property that has to be learned (but there are recurrent features)
- ▶ Special uses: back to the root
 - ▷ *a lot of house* requires resorting to $\sqrt{\text{house}}$, meaning $\lambda x[\text{HOUSE}(x)]$
 - ▷ hence not derived from the lexical entry meaning, but from its root

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Count / Mass as a syntactic distinction

The fundamental representation of sortal nouns:

- ▶ Kind individuals
 - ▷ *rice*: r (oryza)
 - ▷ *beans*: b (fava)
- ▶ Mass / Count distinction already with reference to kinds
 - ▷ *(*The) Rice was first cultivated in Asia.*
 - ▷ **(The) bean was first cultivated in Africa.*
Beans were first cultivated in Africa.
- ▶ No apparent semantic distinction, yet there is a syntactic distinction:



- ▶ Distinct derivation of non-kind-referring uses:
 - ▷ *rice*: $\lambda x[R(r)(x)]$ where R: Carlson's realization relation
 - ▷ *bean*: $\lambda n \lambda x[R(b)(x) \wedge NU(b)(x)=n]$

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Coercion

What is coercion?

- ▶ Compositional interpretation of meanings: $\llbracket [\alpha \beta] \rrbracket = \llbracket \alpha \rrbracket (\llbracket \beta \rrbracket)$
- ▶ Sometimes there is a type mismatch or a sortal mismatch: $*\llbracket \alpha \rrbracket (\llbracket \beta \rrbracket)$
- ▶ There are coercion operators C_1, C_2, \dots, C_n that can be applied to fix things,
 - ▷ for example: $\llbracket \alpha \rrbracket (C_i(\llbracket \beta \rrbracket))$ is o.k.
 - ▷ Coercions appear to affect the argument of the predicate, not the predicate.
- ▶ Extended compositionality (cf. Pustejovsky 2011):
 - ▷ The meaning of a complex expression can be computed from its immediate parts, their mode of syntactic combination, and possibly the application of one of a fixed set of coercion operators.

Standard examples for coercion:

- ▶ Pustejovsky 1995: Qualia structure of nouns, e.g. the telic or agentive role,
 - ▷ *John began a cigarette. / a movie. / a novel.* (consuming)
 - ▷ *The author began a new novel.* (producing)
- ▶ Moens & Steedman 1987, aspectual coercion
 - ▷ *The light flashed for an hour.* (iterative)
 - ▷ *John was reaching the top.* (preparatory phase)
 - ▷ *Suddenly it was dark.* (change)

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Coercion and categories

How coercion helps the notion of categories:

- ▶ We assume a strict category distinction:
 - ▷ mass nouns, e.g. *gold, water, rice*
 - ▷ count nouns, e.g. *bean, ring, boy*
 - ▷ in rare cases, ambiguous nouns, e.g. *bread, cake*
- ▶ Coercion operators can map expressions from one category to another, the semantic effect on the argument satisfies the requirement of the functor.
- ▶ In contrast to typical cases of ambiguity, coercion is a rare phenomenon for any given argument; if frequent, it would lead to ambiguity in the lexicon (as e.g. with *bread*).

Hence with coercion as maps between linguistic categories: they become less fuzzy.

- ▶ We do not have to say that *apple* is 15% mass, 85% count
- ▶ Or that *apple* is ambiguous
- ▶ Rather: *apple* is a count noun that can be coerced to various mass nouns
 - ▷ *Put some apple on the salad.* (Quine): Grinder
 - ▷ *Two apples, namely Granny Smith, and Pink Lady, were most popular.* Subkind
 - ▷ *That's a lot of apple!* (Looking at heap of apples): Root
- ▶ *apple* is polysemous (where polysemy is generally a matter of coercion). 17 / 23

The crisp nature of syntactic categories

If syntactic categories were fuzzy, we would expect

- ▶ Non-prototypical items have only some of the formal properties associated with the syntactic category
- ▶ E.g., a penguin as a non-prototypical bird:
 - ▷ does not fly
 - ▷ has a different posture
 - ▷ has different types of feathers
- ▶ Hypothetical examples:
 - ▷ Non-prototypical count nouns allows for indefinite article: *an apple*, but not for number word or quantifier: **every apple*
 - ▷ Non-prototypical mass nouns allows for indefinite article: *a beer* but not for number word: **one beer, two beers*
- ▶ Apparently, this does not hold
 - ▷ E.g. Bavarian: All mass nouns allow for indefinite article, e.g. *a B'schteck, a Schnaps*
- ▶ But possible cases: defective plurals,
 - ▷ e.g. *sheep, three sheep, *sheeps, *three sheeps*

The limits of coercion

Metonymy (cf. Nunberg 1979)

- ▷ *The ham sandwich wants to pay his bill.*
ordered meal → person, more general: possessum → possessed, cf. bahuvrihi noun
- ▷ *I am parked at parking lot 3.*
person → vehicle
But: *The valet parked ?me / my car in parking lot 3.*
- ▶ Appears to be more restricted to particular situations.

Denominal verb derivations

- ▷ *They housed the refugees (in tents).*
- ▷ *They watered the flowers (with cold tea).*
- ▶ Denominal verb derivation is a more restricted process.
 - ▷ **The tented the refugees.*
 - ▷ **They teaed the flowers.*
- ▶ Notice that a coercion analysis would require a change of the functor, not the argument.

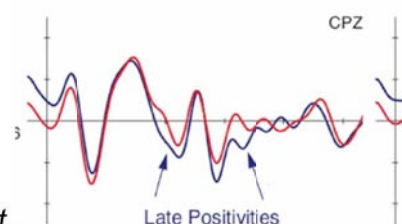
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The brain signature of coercion

Coercion is visible in speech processing: Schumacher 2013, ERPs

▶ Container for Contained

- ▷ *Er hat den Becher hastig getrunken.*
Er hat den Becher wie seinen Augapfel gehütet.
- ▷ Result: Late positivities, reflect discourse updating, similar in eye tracking studies of reading.



▶ Contained for Container:

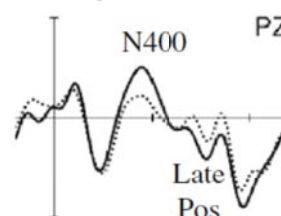
- ▷ *Er hat den Zaubertrank an seinem Gürtel festgeschnallt.*
Er hat den Zaubertrank vor dem Eintreffen der Römer gebraut.
- ▷ Result: No difference.

▶ Explanation:

- ▷ Container for contained: Accesses the qualia structure of container nouns.
- ▷ Contained for container: Reference to liquid object invokes container easily (perhaps especially with *Trank* 'drink').

Schumacher 2014: *ham sandwich* metonymies

- ▷ *Thomas / The doctor asked Claudia who had called that early. Claudia responds that the hepatitis / the therapist had called that early.*
- ▷ N400 after *Thomas...*, not *The doctor...*
- ▷ Hence; distinct brain reactions.



We need more studies for different coercion types!

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A new case of coercion?

Embedded clauses with main clause features: V2, particles

- ▶ *Hans glaubt, Maria wird wohl zu spät kommen.*

Analysis as embedded illocutionary acts (Krifka 2014)

- ▶ *Hans glaubt* [_{ActP} *Maria wird wohl zu spät kommen*]
- ▶ *Hans glaubt* [_{CP} *dass Maria wohl zu spät gekommen ist*]

Problem: Particles occur also in prototypical embedded clauses:

- ▶ *Hans glaubt, dass Maria wohl zu spät kommen wird.*
- ▶ *Hans wollte wissen, ob Maria denn zu spät gekommen ist.*

Solution: Coercion of CP to ActP, triggered by particle

- ▶ *Hans glaubt*, C_{ActP} ([_{CP} *dass Maria wohl zu spät kommen wird*])
- ▶ *Hans wollte wissen*, C_{ActP} ([_{CP} *ob Maria denn zu spät gekommen ist*])

Derivation of ActP from proposition in general (Krifka 2014):

- ▶ [_{ActP} *Maria ASSERT-ist* [_{TP} *t_{Maria} zu spät gekommen t_{ist}*]]

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References (selected)

- ▶ Gerstenhofer, Katerina. 2007. Zur Kategorie des Numerus im Vergleich: Massen- und Zählnomina im Deutschen und im Russischen. Magisterarbeit, HU Berlin
- ▶ Gorishneva, Elena. 2014. The Variety of Functions of the Numeral and Indefinite Marker „One“ in Bulgarian and Russian.
- ▶ Cheng, Lisa L.-S., Jenny Doetjes & Rint Sybesma. 2008. How universal is the universal grinder? *Linguistics in the Netherlands* 50-62.
- ▶ Rothstein, Susan. 2010. Counting and the mass-count distinction. *Journal of Semantics* 27: 343-397
- ▶ Pustejovsky, James. 2011. Coercion in a general theory of argument selection. *Linguistics* 49: 1401-1431.
- ▶ Schumacher, Petra B. 2014. Content and context in incremental processing: “the ham sandwich” revisited. *Philosophical Studies* 168: 151-165.
- ▶ Doetjes J.S. (2012), Count/mass distinctions across languages. In: Maienborn C., Heusinger K. von, Portner P. (Eds.) *Semantics: an international handbook of natural language meaning, part III*. Berlin: De Gruyter. 2559-2580.

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