

Word Classes in Formal Semantics¹

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Formal semantics of natural language grew out of works that assume a strong relationship between syntactic categories and semantic types (Lewis, 1970; Montague, 1973). In its strictest formulation, this assumption entails that any two words of the same category must have the same type of meaning. Thus, by learning the morpho-syntactic category of a word, you learn some of its important semantic aspects. This idea is theoretically appealing but it comes with a heavy toll. Descriptively, a too restrictive matching between syntactic categories and semantic types is untenable even for the most well-studied European languages. Many word classes systematically correspond to more than one semantic type, or contribute to sentence meaning in ways that are not easy to describe in a type-theoretical fashion. Much of the progress in formal semantics since the 1970s has been achieved by articulating a richer palette of semantic objects suitable for describing meanings of major word classes in Germanic and Romance languages. This has been accompanied by a principled relaxation of the matching between categories and types. Starting from the mid-1990s, much research in formal semantics has been devoted to less well-studied languages (Von Stechow and Matthewson, 2008), with a more recent keen interest in the cross-linguistic analysis of categories in formal semantics (Franez and Koontz-Garboden, 2017).

To review this state of the art, section 1 starts out with the traditional semantic types of entities, truth-values, and their semantic composites. These types encode semantic notions like *referential*, *predicative* and *quantificational*, which specify extrinsic aspects of word meanings: their contribution to sentence meaning in terms of functions and their arguments. However, word classes are also characterized using their intrinsic semantics, which plays a central role in phrase-internal modification. This is the topic of section 2, which discusses modifiers and their interaction with intrinsic arguments of verbs (states and events), gradable adjectives (degrees) and locative prepositions (spatial objects). Sections 3, 4 and 5 address some major issues in the semantics of nouns in relation to their semantic characterization: as restrictors of quantifiers and individuator of entities, and as referring to kinds, mass substances and ‘adjectival’ qualities.

1 Extrinsic types of words and their function-argument relationships

All languages have ways of referring to entities and propositions, whose types are denoted using the labels ‘*e*’ and ‘*t*’, respectively. Entities are concrete or abstract objects that are typically referred to by proper names and definite noun phrases. Propositions are the full thoughts expressed by declarative sentences. The notation ‘*t*’ of their type reflects their analysis as having *truth-values* relative to given situations (Frege, 1892).

In principle, any mathematical function that operates on entities and propositions is a legitimate candidate for being the meaning of linguistic expressions. Accordingly, types of different word classes are described using the basic types *e* and *t* and their combinations. One-place predicates are viewed as functions from entities to propositions, or *one-place predicates*,

¹Acknowledgements to follow.

whose type is denoted $\langle e, t \rangle$. Such meanings are assigned to intransitive verbs (V), common nouns (N) and adjectives (A). Transitive verbs, as well as most prepositions and relational nouns (*brother of*) and adjectives (*fond of*), are viewed functions from *pairs* of entities to truth-values. The type of these *two-place predicates* is denoted $\langle e \bullet e, t \rangle$. Functional categories like articles, demonstratives, conjunctions, determiners, and comparatives, are assigned more complex types, which are nonetheless mathematically straightforward. Let us exemplify this point using the English definite article. In the noun phrase *the flutist*, the article combines with a noun of type $\langle e, t \rangle$ to yield an entity. Accordingly, English articles and demonstratives receive the following type:

$\langle \langle e, t \rangle, e \rangle$: functions from one-place predicates to entities

Types like $\langle e, t \rangle$, $\langle e \bullet e, t \rangle$ and $\langle \langle e, t \rangle, e \rangle$ are referred to here as *extrinsic*. They describe semantic interactions between expressions in terms of function-argument relations. Some conventional assignments of extrinsic types to categories are summarized in Table 1.

Category		Extrinsic type	Intrinsic argument	Notes
PN	proper name	e	-	
N	noun	$\langle e, t \rangle$	-	
V	verb (in.)	$\langle e, t \rangle$	E event	the E argument is also for stative verbs
	(tr.)	$\langle e \bullet e, t \rangle$	E event	
A	adjective	$\langle e, t \rangle$	d degree	the d argument is only for gradable As
P	preposition	$\langle e \bullet e, t \rangle$	r region	the r argument is only for locative Ps
ADV	adverb	$\langle e, t \rangle$	d degree	manner and degree ADVs are derived from As
ART	article	$\langle \langle e, t \rangle, e \rangle$	-	functions from 1-place nouns to entities
DET	determiner	$\langle \langle e, t \rangle, \langle \langle e, t \rangle, t \rangle \rangle$	-	functions from 1-place nouns to quantifiers
CON	conjunction	$\langle \tau \bullet \tau, \tau \rangle$	-	for any type τ of a conjoinable category

Table 1: Categories – extrinsic types and intrinsic arguments

A central mode of meaning composition is *Function Application* (FA). The rule describes situations where an expression of an extrinsic functional type combines with its argument. For instance, when the functional meaning of the intransitive verb *runs* combines with the entity for the name *Ben*, the result is the propositional meaning of the sentence *Ben runs*, of type t . We describe this function application as follows:

$$\langle e, t \rangle + e \xrightarrow{\text{FA}} t$$

The same idea is generalized for all function-argument constructions. Thus, the noun phrase *the flutist* involves the following type transition, from the typed meanings of the article and the noun to the entity denotation of the noun phrase:

$$\langle \langle e, t \rangle, e \rangle + \langle e, t \rangle \xrightarrow{\text{FA}} e$$

Further, a two-place predicate like the transitive verb *see* combines with an entity argument to form a one-place predicate like the verb phrase *see Ben*. This is described using the following rule:

$$\langle e \bullet e, t \rangle + e \xrightarrow{\text{FA}} \langle e, t \rangle$$

The three cases of function application above are illustrated in Figure 1a. The semantic

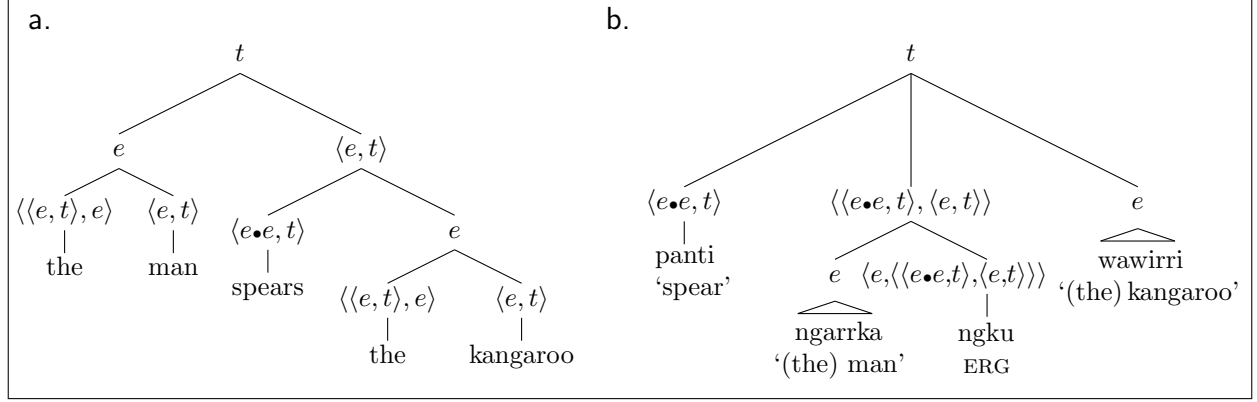


Figure 1: **English vs. Warlpiri.** The identification of arguments in English is achieved using a configurational analysis; in Warlpiri that identification is achieved by case marking with Keenan’s typing and Hale’s non-configurational analysis.

analysis of transitive verbs assumes that their first argument is the patient or theme, which in English is expressed as the object argument. For example, the two-place predicate corresponding to the transitive verb *spear* is described as follows:

spear = the 2-place predicate holding of the pairs $\langle x, y \rangle$ where x is the patient and y is the agent (“ y spears x ”)

In an English sentence like *the man is spearing the kangaroo*, we obtain the following one-place predicate as the meaning of the verb phrase:

spear the kangaroo = the 1-place predicate holding of the entities y such that $\langle \text{the_kangaroo}, y \rangle$ is a pair in the 2-place predicate *spear*

This analysis relies on the traditional structure of Figure 1a, which is suitable for SVO languages like English. However, this kind of configurational analysis is a not part and parcel of the formal semantic approach. To consider a language where configurational analyses are less consensual, let us look at the following Warlpiri example from (Hale, 1983):

- (1) panti-rni ka ngarrka-ngku wawirri (WARLPIRI)
 spear-NONPAST AUX man-ERG kangaroo
 “The man is spearing the kangaroo”

Word order in Warlpiri is famous for being much more permissive than in English. Hale (1983) and others propose to deal with that using a ‘non-configurational’ flat analysis, where a transitive verb, subject and object (essentially) form a trinary sentential structure. Keenan (1989) analyzes such structures by (essentially) assigning the Warlpiri case marker *ngku* the following type:

$\langle e, \langle \langle e \bullet e, t \rangle, \langle e, t \rangle \rangle \rangle$

This type of the case marker makes sure that the noun phrase *ngarrka-ngku* (‘the man’-ERG) gets the type $\langle \langle e \bullet e, t \rangle, \langle e, t \rangle \rangle$: a function from two-place predicates to one-place predicates. By assigning Keenan’s ‘nominative’ meaning to the marker *ngku*, we get the following analysis

of the noun phrase:

ngarrka-ngku = the function mapping any 2-place predicate P to the 1-place predicate holding of the entities x such that $\langle x, the_man \rangle$ is in P

Keenan’s approach allows identifying the nominative argument semantically in a flat structure like Hale’s, which uninterpreted case does not. Unlike the analysis for the English verb phrase in Figure 1a, where the accusative argument composes directly with the transitive verb, in Figure 1b the case marker mediates between the verb and its nominative argument. This does not happen due to a syntactic configuration, but due to the assumed meaning of the case marker.² Ignoring the auxiliary and the tense suffix, we analyze sentence (1) as in Figure 1b, using Hale’s “non-configurational” rules. This analysis is contrasted to the standard analysis of the parallel English sentence in Figure 1a. Unlike English, the Warlpiri example does not require assumptions about configurationality, and not even common categories. The key to the semantic analysis of Warlpiri in Figure 1b is the extrinsic types assumed for the words and morphemes, and the following processes of function application:

$$\langle \langle e \bullet e, t \rangle, \langle e, t \rangle \rangle + \langle e \bullet e, t \rangle \xrightarrow{FA} \langle e, t \rangle \quad \langle e, t \rangle + e \xrightarrow{FA} t$$

The introduction of silent definite articles in Figure 1b makes sure that the nouns *ngarrka* ‘man’ and *wawirri* ‘kangaroo’ are interpreted as entities. This treatment is not special to the semantic analysis of Warlpiri, and is used for many other languages with bare nominal arguments (see section 5.1).

As exemplified above, the assignment of extrinsic types to categories as in Table 1 is suitable for configurational and non-configurational analyses of different languages, and does not depend on a specific syntactic theory. Rather, it applies type theory to generalize insights which are common in the typological literature (Croft, 1991; Hengeveld, 1992), and is applicable to natural languages that have rich case systems. For further details on case in formal semantics, see the review in (De Hoop and Zwarts, 2008).

2 Intrinsic meanings of different word classes – intersective modification

The extrinsic types that were introduced above account for function-argument relations, which are relevant for all word classes in all phrases and expressions. However, extrinsic types do not cover more specialized aspects of meaning that characterize specific word classes. These more intrinsic aspects of meaning are easy to observe when we look at modification constructions with different categories. Modification of nouns by adjectives often has a conjunctive meaning, for example:

- (2) x is a *quiet man* = x is a man and x is quiet

We refer to this kind of modification as *intersective* (IM), which is another way of combining types on top of function application.³ Cases of intersective modification with $\langle e, t \rangle$ predicates

²Warlpiri case has further functions. Croft (2001, p.186) mentions that the ergative case can establish a connection between a noun and an attributive adjective at a distance. This does not rule out Keenan’s analysis, but it requires a more careful formulation than what is given here.

³This analysis is not immediately applicable to adjectives like *skillful*, whose predicative meaning may shift depending on the nominal they modify. For instance, *a skillful driver* is skillful at driving, not necessarily at

To analyze these modification constructions we retain the intersective analysis of modifiers, but introduce a distinction between nouns and other categories. As we have seen, modifiers of nouns target their extrinsic entity argument (2). This is assumed to happen since entities are intrinsic elements of nominal meanings, in addition to being part of their extrinsic meaning as predicates. By contrast, with other word classes, other arguments are more intimately related to the semantics of modification than the extrinsic entity arguments. For example, to treat the modification in sentences (3a-c), we first observe the following intuitive paraphrases:

x sang quietly = *x sang in some **event** *y*, and *y* is quiet*
x is extremely quiet = *x is quiet to some **degree** *y*, and *y* is extreme*
x is 10m above L.P. = *x is at the end of some **region** *y* pointing upwards from La Pedrera, and *y* is 10 meters long*

This kind of treatment was pioneered in (Davidson, 1967) for adverbial modification, and was extended for degree adjectives in (Cresswell, 1976) and locative prepositions in (Zwarts, 1997).⁴ These analyses crucially employ the semantic notions *event*, *degree* and *region*. Modifiers of Vs, As and Ps are assumed to target arguments that pertain to these specialized semantic aspects of the modified category. These *intrinsic arguments* of Vs, As and Ps are distinguished from their *e*-type arguments that are described by the extrinsic types in Table 1.⁵

Table 1 above summarizes our main assumptions about the intrinsic arguments of different categories. Modification of manner adverbs (ADV) is analyzed as similar to the modification of degree adjectives. Many adverbs are derived from degree adjectives, and we assume that they inherit their intrinsic degree argument. This is in view of examples like the following:

Sue ran *extremely fast* = Sue ran in some event *z*, and *z* was fast to some **degree** *y*, and *y* was extreme

Thus, the analysis of adverbs modified by degree modifiers is similar to the intersective analysis of the parallel constructions with adjectives.

With some notable exceptions (see below), intrinsic arguments are not accessible to function application. By default, events, degrees and regions do not appear as subjects or objects predicated in the sentence. Conversely, the extrinsic arguments of Vs, As, Ps and ADVs are not a natural target for modification. This is one way in which the category N is distinguished from other categories: it is the only lexical category that systematically supports intersective modification of its extrinsic argument. This leads us to a general principle about

⁴Davidson’s proposal was revised in (Parsons, 1990) and (Kratzer, 1996); for a review see (Maienborn, 2011). On degree modification see the book-length overview (Morzycki, 2016). On vectors in spatial semantics see (Zwarts, 2020).

⁵The terms “intrinsic” and “extrinsic” are semantic, and should be distinguished from the syntactic terms *internal/external argument*.

categories in formal semantics:

Principle 1 – intersective modification:

Intersective modification targets the extrinsic argument of Ns, but the intrinsic argument of Vs, As and Ps.

One exception to this principle is *noun incorporation*. Mithun (1984, p.863) defines this phenomenon as an “N stem [that] is incorporated to narrow the scope of the V”, where “the compound stem can be accompanied by a more specific external NP which identifies the argument”. For instance, consider the following Chamorro example from (Chung and Ladusaw, 2003, p.109):

- (4) si Carmen gäi-ga’ i ga’lagu (CHAMORRO)
 UNM⁶ Carmen AGR.have-pet the dog
 “Carmen has the dog as pet”

Chung and Ladusaw analyze the incorporated noun *ga’* (‘pet’) as a modifier that targets the object argument of the verb *gäi* (‘have’). The modified verb applies to the extrinsic argument *i ga’lagu* (‘the dog’). This analysis is informally stated below:

$x \text{ gäi-ga’ } y = x \text{ has-pet } y = x \text{ has } y \text{ and } y \text{ is a pet}$

The noun ‘pet’ in this analysis modifies an extrinsic argument (*y*) of the verb, in contrast to Principle 1. Cross-linguistically, however, such cases of N incorporation involve special morphological processes, and do not have the default status of common manner adverbials that target the intrinsic event argument.

Another exceptional semantic process concerns sentences like *Laura laughed a loud laugh* (Mittwoch, 1998). In such cases, the ‘cognate’ indefinite syntactically acts like a complement of the verb. Semantically, however, it modifies the event argument, and similarly to adjuncts it licenses further adverbial modification. Thus, it does not ‘saturate’ an argument position of the verb like ordinary, ‘extrinsic’, objects do. This modificational behavior is illustrated in the following Hebrew example:

- (5) ha-matos naxat nexitat xerum be-sade natuS (HEBREW)
 the-aircraft landed landing emergency in-field deserted
 “the aircraft made an emergency landing in a deserted field” = “there is an emergency landing event *x* with the aircraft as agent, and *x* occurred in a deserted field”

This behavior is perfectly in line with Principle 1, but it highlights the semantic nature of this principle: the intrinsic event argument in (5) is semantically modified (rather than applied to), although its modifier is syntactically realized with an accusative marker as if it were an object ‘argument’ of the intransitive verb.

Summing up, Figure 3 showcases the formal analysis of the English categories we have discussed so far. In this analysis, function application (FA) is univocally with respect to extrinsic arguments, whereas intersective modification (IM) targets intrinsic or extrinsic arguments according to Principle 1. Thus, with the noun *bird* in Figure 3, IM targets the extrinsic entity (*e*) argument, while with other categories IM targets the extrinsic argument:

⁶UNM = unmarked morphological case

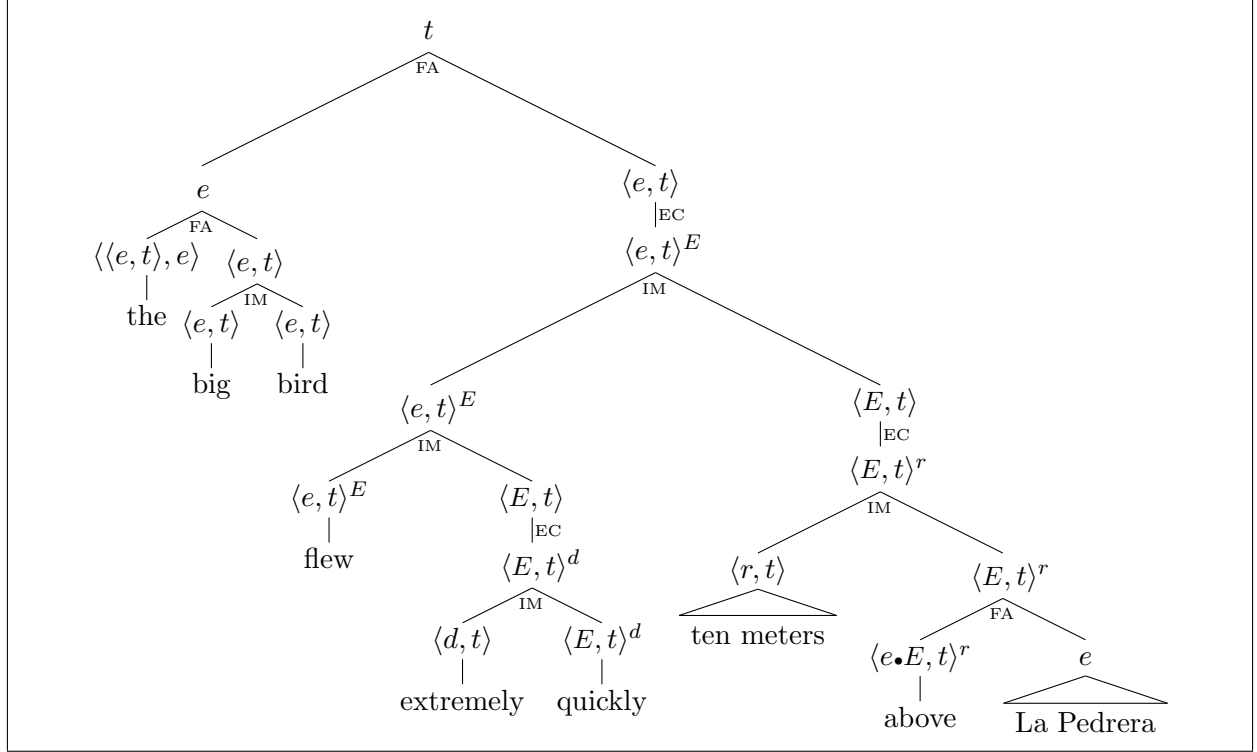


Figure 3: Intersective modification and extrinsic/intrinsic arguments

event (E) with Vs, degree (d) with As and ADVs, and region (r) with Ps. For example, the $\langle E, t \rangle$ meaning of *extremely quickly* modifies the intrinsic event argument of the verb *flew* without affecting the verb’s extrinsic argument (e). The analysis is similar with the degree modifier *extremely* within the adverbial phrase, and the region modifier *ten meters* in the prepositional phrase. At the phrase level, the intrinsic $E/d/r$ argument is “erased” using an Existential Closure (EC) operator (“there is an event/degree/region such that...”). Thus, while the verb *flew* has the meaning of a relation between entities and events (type $\langle e, t \rangle^E$), the verb phrase headed by *flew* ends up having the standard meaning of one-place predicate over entities (type $\langle e, t \rangle$).

3 Nouns as restrictors

Principle 1 above is a formal semantic criterion that distinguishes nouns from other lexical categories in terms of their combination with intersective modifiers. Typological studies often propose other ideas that distinguish nouns from other categories in terms of their intrinsic functions (Croft 1991, p.63, Hengeveld 1992, ch.4). As we will see in section 4, such intuitive criteria are not easy to state in terms of formal semantic theories. Before entering this controversial territory, we introduce a related but more consensual formal semantic characteristic of nouns: their ability to act as restrictors of quantificational domains.

Let us consider the following semantic identities:

- (6) *a.* every cat ate = *b.* every cat is a cat that ate
 (7) *a.* some cats ate = *b.* some cats are cats that ate
 (8) *a.* most cats ate = *b.* most cats are cats that ate

The *b* sentences in (6)-(8) contain a semantic redundancy: although these sentences are acceptable, they are trivially equivalent to their more concise *a* correlates. These equivalence highlight that in order to assess whether the *a* sentences are true, it is sufficient to consider the cats and check how many of them ate. Non-feline entities are irrelevant for the truth or falsity of these sentences. This is what makes the repetition of the noun *cat* in (6b)-(8b) semantically redundant. Intuitively, we say that in (6a)-(8a), the noun *restricts* the set of entities that the verb *ate* is talking about, or, in more technical terms, that quantification in (6a)-(8a) is *N-conservative*.

Semantic observations as in (6)-(8) have led formal semanticists to the following generalization about quantification in natural language (Barwise and Cooper, 1981; Glanzberg, 2006):

Principle 2 – N-conservativity:

Across languages, all quantificational constructions that involve nouns are N-conservative.

N-conservativity is a robust generalization about quantification in natural language, which distinguishes the nominal domain from the verbal domain. Verbs do not as a rule specify which entities the nouns they combine with are talking about. We can observe that by considering the following sentences:

- (9) every cat that ate ate
 (10) some cats that ate ate
 (11) most cats that ate ate

Sentences (9) and (11) are not equivalent to sentences (6a) and (8a). While (6a) and (8a) are semantically contingent, sentences (9) and (11) are logically tautological: it hard to see how these sentences might ever fail to be true. Accordingly, they are communicatively dubious. Note however that sentence (10) is non-tautological and contributes the same information as (7a) (although, here again, putting it as in (10) is surely stylistically cumbersome). We see that among the three sentences (6a)-(8a), only in (7a) does the verb restrict the set of cats that the noun is talking about. Thus, while we may assume that Principle 2 on N-conservativity is generally valid, there is no parallel principle of V-conservativity.

Case study: noun-verb flexibility in Hebrew

The fact that Principles 1 and 2 hold for nouns but not for other categories gives a semantic twist to the search for definitional criteria of lexical categories. As semantic criteria, these principles are applicable to cases where there are no clear morpho-syntactic differences between nouns and verbs. For many such cases across languages, see (Rijkhoff and van Lier, 2013). According to Principles 1 and 2, such languages may still give us a semantic indication of categorical differences by: (i) modifying entities in their nominal-like elements but other semantic objects in other word classes; (ii) restricting their quantificational processes on nominal-like items or constituents, but not on verb-like elements. We illustrate these general points using profession nouns/verbs in Modern Hebrew.

Hebrew has a large class of participle forms, which function both as the present tense of verbs and as nominal modifiers (Doron, 2013). Additionally, many Hebrew participles are also nouns, as illustrated by the following profession terms:

(12) V/N participles in Hebrew (singular masculine forms):

- (i) *oved* ‘work/worker’, *yo’ec* ‘advise/adviser’, *xoker* ‘research/researcher’
- (ii) *metaxnet* ‘program/programmer’, *me’amen* ‘coach’, *mefaked* ‘command/commander’
- (iii) *mamei* ‘invent/inventor’, *malxin* ‘compose/composer’, *mafik* ‘produce/producer’

The examples in (12) illustrate profession terms in three morphological templates. These items are not overtly specified as nouns or verbs. Unlike the other verbal tenses in Hebrew, participles are not inflected for person. Thus, the inflections of present tense verbs in Hebrew are the same as nominal inflections. This entails that when the words in (12) are used as bare nominals, they can form sentences without any formal difference between N and V. For instance, in the sentence *metaxnet metaxnet* (‘a programmer programs’) the noun and verb are phonologically identical. Any assignment of categories to the words in such sentences must rely on indirect considerations like the semantic principles 1 and 2 above.

Let us first illustrate this using Principle 1, in relation to the participle *oved* (‘work/worker’) and the adjective/adverb *naki* (‘clean/ly’). When the verb ‘work’ appears in its past tense it is inflected for person and has no nominal reading. Accordingly, *naki* is disambiguated as an adverb (‘cleanly’):

- (13) tal avad naki (HEBREW)
Tal worked-3.MASC.SG cleanly
Unambiguous: “Tal worked cleanly”

Sentence (13) refers to Tal’s manner of work, and does not imply anything about his being a cleanly person. By contrast, to put sentence (13) in the present tense, we have to use the verb in its participle form, which leads to the following ambiguity:⁷

- (14) tal oved naki
Tal works/worker clean/ly
Ambiguous: “Tal worked cleanly” or “Tal is a worker and is clean”

Sentence (14) is ambiguous between a present tense version of (13), and another reading that refers to Tal’s clean habits. Principle 1 directly expects this variation. In sentence (13), with a non-ambiguous verb in the past tense, the word *naki* must be used as an adverb ‘cleanly’, hence Principle 1 expects event-orientated modification, with reference to Tal’s manner of work. By contrast, the participle in (14) leads to a V/N ambiguity. Under the V-reading, the adverbial modification works as in (13), and Principle 1 similarly expects reference to Tal’s manner of work. Under the N-reading, Principle 1 correctly expects the reference to Tal as being a ‘clean entity’.

Let us move on now to the conservativity Principle 2 and its effects on categorical identification in quantificational processes. Hebrew has bare nominals both in the singular and

⁷ A related kind of ambiguity appears in English, with some adjectives and *-er* nouns that are fully specified categorically, as in *Olga is a beautiful dancer*. For discussion and analysis of such cases, see (Larson, 1998; Winter and Zwarts, 2012; Alexeyenko, 2015; Maienborn, 2021).

in the plural. The quantificational processes in such sentences are morphologically silent, and similarly to English bare plurals (Krifka et al., 1995), they support generic readings as well as existential readings. For instance, in the following examples the bare singular *kelev* (‘dog’) leads to two different interpretations:

- (15) a. kelev nove’ax kshe-margizim oto (HEBREW)
 dog bark when-annoy-PL it
 “a dog barks when annoyed” (generic)
 b. kelev navax kshe-nixnasnu
 dog barked when-entered-1PL
 “a dog barked when we entered” (existential)

Independently of these facts, Hebrew subjects may optionally appear in post-verbal positions (Costa and Friedmann 2012; Kastner 2020). This is illustrated by the following examples with the unaccusative verb *nishbar* ‘broke’:

- (16) a. ha-lev nishbar li
 the-heart broke to-me
 “my heart broke”
 b. nishbar li ha-lev
 broke to-me the-heart
 “my heart broke”

Taken together, these facts give us an opportunity to look at the effects of N-conservativity on categorial identification. Let us consider the following sentence, where both SV and VS orders are available, and both relevant heads are morphologically underspecified as N/V:

- (17) eclenu ba-xevra oved metaxnet
 at-us in-the-company work/er program/er
 (i) “in our company, a worker programs”
 ≈ “most workers program” (generic)
 (ii) “in our company, some programmer is employed”
 ≈ “some programmer works” (existential)

As the gloss indicates, sentence (17) is ambiguous. Without analyzing this ambiguity there is no way to disambiguate the category of the words *oved* (‘work/er’) and *metaxnet* (‘program/er’) in (17): each of these words might syntactically function as either N or V. This can be shown using similar sentences with an adjacent unambiguous word:

- (18) a. eclenu ba-xevra oved fisikai
 at-us in-the-company work physicist(N) – *oved* is V-like
 “in our company, some physicist is employed”
 b. eclenu ba-xevra oved mita’mec
 at-us in-the-company worker labor(V) – *oved* is N-like
 “in our company, a worker labors”
 c. eclenu ba-xevra mistovev metaxnet
 at-us in-the-company hang(V) programmer – *metaxnet* is N-like
 “in our company, some programmer hangs around”

- d. eclenu ba-xevra fisikai metaxnet
 at-us in-the-company physicist(N) program – *metaxnet* is v-like
 “in our company, a physicist programs”

Although from a morpho-syntactic point of view, each of the words *oved* and *metaxnet* in sentence (17) might be analyzed as either N or V, its semantics reveals a curious asymmetry. As the gloss above indicates, the only generic reading of (17) is ‘most workers program’. There is no reading like ‘most programmers work’. According to Principle 2, this means that only when the word *oved* is interpreted as a noun (‘worker’) can the sentence be generic. To see why, suppose that we analyzed *oved* as the verb ‘work’. That could only lead to the correct generic reading ‘most working ones act as programmers’ if we described the quantification in the sentence as being conservative on the hypothetical verb *oved* (‘work’), and not on the hypothetical noun *metaxnet* (‘programmer’). According to Principle 2, such an analysis is not available for any natural language.

We see that Principle 2 predicts specified categories for sentence (17) under its generic reading: *oved* is N (‘worker’) and *metaxnet* is presumably V with the meaning ‘to program’. Is there any independent evidence for this prediction? Surprisingly enough, there is. In situations where V/N categories are lexically or morphologically specified, Hebrew – similarly to other languages – has severe restrictions on generic readings of sentences with post-verbal subjects. This is illustrated by the following sentences:

- (19) a. mamtakim te’imim nigmarim li maher (HEBREW)
 sweet-PL tasty-PL end-PL to-me quickly
 “I run out of tasty sweets quickly” – generic
 b. ?nigmarim li maher mamtakim te’imim
 end-PL to-me quickly sweet-PL tasty-PL

In (19), the words *mamtakim* (‘sweets’) and *nigmarim* (‘end’) are categorically specified: as a noun and unaccusative verb in the present tense, respectively. The generic sentence (19a) has the noun preceding the verb, and it is perfectly acceptable. By contrast, inverting the verb and the subject as in (19b) leads to an unacceptable sentence.⁸ Similar semantic effects are well-known in other languages, under the heading of the *Mapping Hypothesis* (Diesing, 1992). For example, let us consider the following examples from German (Diesing) and Italian (Longobardi, 2000):

- (20) a. ...weil Kinder ja doch auf der Straße spielen (GERMAN)
 ...since children indeed in the street play
 “...since (typically) children play in the street” – generic
 b. ...weil ja doch Kinder auf der Straße spielen
 ...since indeed children in the street play
 “...since there are children playing in the street” – existential

⁸Sentence (19b) is here marked as questionable and not as downright unacceptable, since with a very specific intonation (heavy stress on *maher* and a clear break afterward) it might become acceptable. This is similar to the effect that Longobardi (2000) describes for the Italian example in (21) below, though in the Hebrew example (19) the effect is somewhat clearer due to the lack of an existential reading.

- (21) vengono chiamati spesso medici del reparto di pronto intervento (ITALIAN)
 are called up often doctors of department of early intervention
- (i) with an intonational break between V *chiamati* and N *medici*:
 ‘typically, doctors of the first aid department are called up often’ – generic
 - (ii) without an intonational break between V *chiamati* and N *medici*:
 ‘some doctors of the first aid department are often called up’ – existential

To summarize, we have seen that Hebrew allows sentences like (17), which can be described as completely vague in terms of N/V categorization: ‘work/er program/mer’. However, the semantic Principle 2 on N-conservativity leads us to deduce that the only available generic reading, ‘most workers program’, must be derived from a specified N-V structure. This prediction is supported by the fact that in Hebrew sentences where V and N are morpho-syntactically distinguished, post-verbal subjects do not show generic readings, similarly to German and Italian.

4 Nouns as individuator

As mentioned above, some typological works distinguish nouns from other categories in terms of their intuitive referential properties (Croft, 1991; Hengeveld, 1992). In a bold attempt to transcend informal classifications, Baker (2003) sets up to provide a cross-linguistic semantic criterion that explicitly *defines* what characterizes noun meanings. Baker builds on the semantic intuitions of Geach (1962, p.39,54) and Gupta (1980), who address specialized aspects of noun meanings using the philosophical notion of *identity criteria*. Informally, such criteria are taken to be “a component of meaning that makes it legitimate to ask whether some X is the same (whatever) as Y” (Baker, 2003, p.96). This property of nouns is assumed to be responsible for the fact that we can refer to *the same giant* but not to **the same huge*, or to *the same bride* but not to the **the same marry*. According to Baker, such contrasts are syntactic effects that point to a “deeper truth”: noun meanings involve identity criteria whereas meanings of other categories do not. Baker proposes that identity criteria is what allows nouns to support referential expressions, which according to the conventions of Government and Binding theory, he annotates using referential indices.

There is no reason to deny the intuitive appeal of identity criteria as a basis for the semantics of nouns, or to contend their usefulness for descriptive studies (see e.g. Abner et al. 2019). However, incorporating identity criteria into the exact theoretical machinery of formal semantics is a harder enterprise than what Baker assumes. Indeed, most current works in formal semantics adopt the simple extrinsic typing reviewed in section 1, which does not distinguish nouns from other predicative categories. As we saw, intransitive nouns, verbs and adjectives are all treated using the extrinsic type $\langle e, t \rangle$. Adapting Geach’s approach to conform with the massive literature that emerged from this type system is a major task, and there is little agreement on the motivation for such an enterprise. Two major stumbling blocks are discussed below.

4.1 The elusiveness of sameness 1: co-predication

A noun may intuitively refer to very different kinds of objects. For example, a *newspaper* may be a physical object, an informational object, or an institution:

- (22) a. My cat sat on the newspaper.
- b. The newspaper contains a lot of fake news.
- c. The newspaper fired the editor.

Similar multi-functionality is observed with *book*, *lunch*, *sonata* and many other nouns (Pustejovsky, 1995). This on its own is not necessarily problematic for Geach’s approach: we might adopt the inelegant assumption that such nouns are ambiguous between different readings. Each of those readings might involve different identity criteria and surface with predicates of different selectional restrictions. Thus, while in (22a) the “physical reading” is manifest, the informational and institutional readings are absent: it is hard to “sit on” an institution or an abstract piece of information. However, the problem has other aspects that cannot be simply analyzed by the ambiguity approach. To see that, let us consider the following scenario (Chomsky, 2000, p.16):

- (23) In the municipal library there are two copies of *The Man Without Qualities*: one copy with a red cover and another with a blue cover. Samantha borrowed the red copy and Annabel borrowed the blue copy.

Now let us consider the following sentences:

- (24) Samantha and Annabel borrowed the same book.
- (25) a. Samantha borrowed a well-written book with a red cover.
- b. The book that Annabel borrowed is well-written and has a blue cover.

Sentence (24) is judged as true when we consider *book* as referring to an informational unit, but false if *book* refers to physical copies. This may again be attributed to a putative ambiguity of *book*, and to two different sets of identity criteria. However, these criteria cannot work separately from one another, as the sentences in (25) show. In these sentences, the same occurrence of the noun *book* is used with an “informational” predicate and a “physical” predicate simultaneously. This so-called *co-predication* requires a much more complex semantic analysis than ambiguity of nouns. In one way or another, we need to allow nouns to refer to abstract objects with both “physical” and “informational” aspects. These aspects may be invoked separately from one another, as the ambiguity of (24) suggests, while in other cases they are invoked simultaneously (25). A general analysis of such contrasts is required before the “deeper truth” about the semantics of nouns can be fathomed. For some proposals see (Gotham, 2017) and the references therein.

4.2 The elusiveness of sameness 2: stage-referring nouns

Gupta (1980, p.23) pointed out the following example:

- (26) National Airlines served at least two million passengers in 1975.

Sentence (26) can be true although the number of different *people* taking National Airlines flights was less than two million. In semantic jargon, we say that in (26), different *stages* of the same individual may be counted separately. Gupta proposes to account for this fact by assuming different identity criteria for the nouns *passenger* and *person*.

This proposal is problematic for at least two reasons. First, as Krifka (1990) points out, the kind of reading that Gupta illustrates using the “stage noun” *passenger* also appears with nouns that typically refer to individuals. Krifka’s example is:

- (27) Four thousand ships passed through the lock last year.

Sentence (27) may describe a situation with less than four thousand individual ships. Its most prominent reading counts stages of ships: snapshots of ships as they were passing through the lock. Barker (2010) illustrates the same point for the noun *people*:

- (28) Newton has a new, state-of-the-art, award-winning Library which served 602,951 people in 1993.

As Barker points out, the prominent reading of (28) counts stages of book borrowers rather than individual people. The accepted conclusion is that stage readings may appear with any noun, including nouns like *ship* and *people* that intuitively refer to “temporally rigid” entities. Conversely, Barker discusses examples like the following (see also Gotham 2021):

- (29) How many of National Airlines’s passengers live in your house?

Barker considers a situation where your household only has three people, each of them flew National Airlines twice. He points out that in such a situation it would be odd to give the answer “six” to the question in (29). Thus, in (29), the noun *passenger*, which intuitively refers to stages of people, is most prominently used for counting individuals. Thus, we cannot lexically encode the intuitive ‘individual’ reading of *person* and ‘stage’ reading of *passenger* in their identity criteria. The same point applies to many other nouns. This is an obstacle for using Geach’s idea as a semantic criterion that distinguishes nouns from other predicates, as suggested by Gupta, Baker, and more recent work (see Chatzikyriakidis and Luo 2020 and references therein). Against proposals along these lines, we find alternative semantic proposals, as described by Barker:

...criteria of identity are not exclusively part of lexical meaning, but depend also on compositional or pragmatic variability. [...] variability in tolerance for degrees of similarity, is a pervasive, systematic feature of language use, and should not be encoded in information associated with specific lexical items. Rather, this variability is a matter of semantic interpretation (e.g., Nunberg 1984) or pragmatics (e.g., Lasnik 2000).

Given this on-going controversy, at this point it is too early to judge if Geach’s approach to nouns can be adapted to conform with the bulk of work in formal semantics. Without denying the intuitive appeal and potential usefulness of Geach’s approach, at this point the semantic properties of “sameness” that Baker relies on are not understood well enough to serve as a definition of the category “noun” in a cross-linguistic formal semantics.

5 Mass meanings cross-linguistically

So far we have discussed nouns as if they were a unified semantic category, ignoring the critical distinctions between mass nouns and count nouns. This section reviews two important contributions to the cross-linguistic semantics of mass terms and its connection to the

distinction between the N and A categories. Chierchia (1998) proposes a cross-linguistic generalization which aims to describe major classes of languages in terms of their treatment of bare nouns and the count/mass distinction. Francez and Koontz-Garboden (2017) introduce a related cross-linguistic generalization about the N/A distinction and the common use of mass nouns across languages (‘Dan has wisdom’) for conveying “adjectival” meanings (‘Dan is wise’).

5.1 Chierchia (1998): bare nouns and the mass/count distinction

Many languages allow nouns to appear without articles or determiners in argument positions. The conditions under which such *bare nouns* are licensed vary dramatically between languages: from languages like French with strong prohibitions against bare nouns (30), to languages like Mandarin Chinese where bare nouns are freely licensed (31):

- (30) J’ai acheté (un/le/* ϕ) livre / (des/les/* ϕ) livres / (FRENCH)
 I-have bought (a/the/* ϕ) book / (INDEF.PL/the/* ϕ) books /
 (du/le/* ϕ) lait
 (INDEF.MASS/the/* ϕ) milk
 “I have bought a book/the book/books/the books/milk/the milk”
 (Le Bruyn et al., 2017)

- (31) zuotian wo mai le shu (MANDARIN CHINESE)
 yesterday I buy ASP book
 “Yesterday, I bought one or more books”

 gou jintian tebie tinghua
 dog today very obedient
 “The dog/s was/were very obedient today”
 (Rullmann and You, 2006)

In between these two extremes there lie many other options. English shows a rather liberal use of bare plural and mass nouns, but with a general prohibition against bare singular count nouns. Italian uses bare nouns more restrictively than English, but not as restrictively as French (Longobardi, 1994).

Chierchia’s proposal makes a cross-linguistic connection between the licensing of bare nouns and the count/mass distinction. In many languages, numeric expressions can only combine with nouns by adding a classifier expression, without an obvious mass/count distinction. For instance, let us consider the following examples in Mandarin Chinese (Cheng and Sybesma 1999):

- (32) ba tou/* ϕ niu san wan/* ϕ tang (MANDARIN CHINESE)
 eight CL-head/* ϕ cow three CL-bowl/* ϕ soup
 “eight cows” “three bowls of soup”

According to Chierchia, the apparent similarity between count nouns and mass nouns in Chinese is related to the licensing of bare nouns. Languages like Chinese, which generally

Parameter	N-type	bare nouns?	classifiers?	plural marking?	example
A	e (mass)	+	general	—	Chinese
P	$\langle e, t \rangle$ (mass/count)	— (w. empty D)	only mass	+	Romance
A/P	e or $\langle e, t \rangle$	+ (restricted)	only mass	+	Germanic

Table 2: Chierchia’s cross-linguistic classification of noun meanings

allow bare nouns, are assumed not to have $\langle e, t \rangle$ nouns to begin with. Chierchia proposes that in Chinese and other languages without a clear mass/count distinction, nouns languages are lexically of type e . Such nouns lexically refer to *kinds* of entities (Carlson, 1977). According to Chierchia, nouns like *niu* (‘cow’) and *tang* (‘soup’) in Chinese refer to ‘kind entities’ that describe general semantic properties of the noun: being a domestic animal for *cow*, being liquid for *soup*, etc. By contrast, the $\langle e, t \rangle$ meanings of *cow* and *soup* in English describe individual cows or specified quantities of soup, not the general kind.

On top of this cross-linguistic distinction between the types and the meanings of nouns, Chierchia adopts some fairly standard formal semantic assumptions on mass terms and plurality. From these assumptions, two prototypical types of languages are deduced:

Languages with argumental (A) nouns: Languages like Chinese, where the e type of nouns allows them to appear as bare arguments. Chierchia’s semantics deals with all e -type nouns as kinds of mass entities, hence such nouns are expected not to have plural marking, and to require classifiers for counting.

Languages with predicative (P) nouns: Languages like French, where the $\langle e, t \rangle$ of nouns disallows them to appear as bare arguments. Nouns of type $\langle e, t \rangle$ may have countable or non-countable meanings. Countable meanings support plural marking and counting without classifiers, whereas non-countable meanings support a mass term behavior.

These deductive considerations about two extreme ‘prototypical’ kinds of languages leave room for some variation. English and other Germanic languages are classified as *A/P*-languages. These are languages where nouns may be of either type e or type $\langle e, t \rangle$, hence they are (correctly) expected to show a mixed behavior: a count/mass distinction together with licensing of bare nouns.⁹ Italian, as well as other Romance languages, is classified as a *P*-language, but with a complex set of additional syntactic assumptions regulating a postulated empty determiner position (Longobardi 1994, Chierchia 1998, p.383-394). This theoretical picture is summarized in Table 2.

Chierchia’s assumptions about the possible types of noun meanings across languages have been hotly debated in recent work. It is widely agreed that only a small part of the massive cross-linguistic data on bare nouns, classifiers, plural marking and the mass/count distinction is formally derived as resulting from the cross-linguistic parameter that Chierchia postulated. Notwithstanding, Chierchia’s approach marked an important step in formal semantics by showing how the type system reviewed in section 1 can be used for addressing major cross-linguistic puzzles about the meaning and distribution of nouns. Accordingly,

⁹Germanic languages do not have bare singulars, which Chierchia tries to account for on general considerations, but see (Doron, 2003; Dayal, 2004, 2021) for problems and further considerations.

HAUSA	<i>àkawai s da kyâu!</i> exists 3PL with beauty	lit. ‘there is them with beauty’ = ‘they’re really beautiful!’
HUITOTO	<i>rozillâ naimé-re-de</i> pineapple sweet-HAVE-3SG	lit. ‘the pineapple has sweetness’ = ‘the pineapple is sweet’
BISA	<i>a gwilli ta-w</i> 3SG weight exists-in	lit. ‘there is its weight’ = ‘it is heavy’
ULWA	<i>yâka û-ka yâka yûh-ka</i> that house-3SG.POSS that long-3SG.POSS	lit. ‘that house has length’ = ‘that house is long’

Table 3: Languages with a productive possessive strategy (FKG 2017,p.25-32)

elements of Chierchia’s proposal are adopted in many recent works on the cross-linguistic semantics of nouns. For these developments, see (Doron, 2003; Dayal, 2004; Rothstein, 2017; Dayal and Sağ, 2020; Dayal, 2021), and the references therein.

5.2 Francez and Koontz-Garboden (2017): mass terms and predicates, nouns and adjectives

Francez and Koontz-Garboden (FKG) address a major cross-linguistic variation in the way an entity’s properties are expressed. In English, as in many other languages, the most natural way of saying that an entity has a certain property is to use predication as in ‘he is hungry’. Other languages prefer possessive constructions like ‘he has hunger’, which are only occasionally used in European languages (cf. French *il a faim*). Some examples for languages that extensively use the possessive construction are reproduced in Table 3.

FKG’s semantic study aims to account for the cross-linguistic aspects that regulate the relations between predication/possession constructions and the use of an adjectival/nominal category. FKG analyze meanings of nouns like *wisdom* and *beauty* on a par with ‘concrete’ mass terms like *milk* and *sugar* (cf. Moltmann 2009). They point out the linguistic similarity between such mass terms in terms of disjointness (milk is disjoint from sugar, wisdom is disjoint from beauty, etc.) and *ordering*: two people can be compared in terms of their wisdom or beauty, whereas two cakes can be compared in terms of the milk or sugar that they contain. Meanings of ‘abstract’ mass terms like *wisdom* and *beauty* are referred to as *qualities*, and FKG propose the following generalization:

- (33) *A/N property meanings*: Cross-linguistically, *adjectives* can only refer to properties of entities through predicates, but not using qualities. By contrast, *nouns* can refer to properties using either predicates or qualities.

Generalization (33) is proposed as a language universal on the matching between property meanings and categories. It describes both European languages, where the adjectival-predicative strategy is widespread, and languages like Hausa, which prefer using qualities in the nominal-possessive strategy (Table 3). Importantly, (33) also describes the uncommon strategy where nouns express properties not using qualities, but using predicative meanings, similarly to adjectives. FKG rely on an early version of work by Jenks et al. (2018), who

study ‘adjectival nouns’ in Basaá. These are Basaá items that syntactically behave like other nominals (Hyman et al., 2013). Jenks et al. observe that adjectival nouns are licensed in predicative constructions like (34a) below, which are also characteristic of adjectives and locatives in Basaá. This is contrasted with other predicate nominals that describe properties, which ascribe these properties to entities in possessive constructions as in (34b):

- (34) a. hí-nuní híí hí yé li-múgê (BASAÁ)
 19-bird 19.that 19.SUB be 5-quiet
 ‘that bird is quiet’
- b. a gweé ma-sódá
 1.AGR have 6-luck
 lit. ‘he/she has luck’ = ‘he/she is lucky’

FKG account for such differences between nouns by letting that the noun in (34a) denote a property of entities (similarly to the English adjectives ‘quiet’ and ‘silent’), while the noun in (34b) denotes a quality (similarly to the English noun ‘luck’). Further, FKG point out that adjectival nominals behave like count nouns. Thus, the noun in (34a) describes ‘quiet entities’. By contrast, quality nominals as in (34b) behave like uncountable mass terms that describe quantities (e.g. of ‘luck’). This distinction corresponds to Chierchia’s distinction between predicative count nouns of type $\langle e, t \rangle$ and kind-denoting mass terms of type e . In this way, FKG’s principle (33) describes the cross-linguistically flexible kind/predicate meaning of nouns, as opposed to a rigid predicative analysis of adjectives.

6 Conclusions

This paper has reviewed basic principles and recent proposals in formal semantics that bear on the relationships between word classes and meaning. The core assumption is that expressions have *extrinsic types*, which describe the function-argument relations that words give rise to. Intersective meaning composition regulates the semantics of *modification* across categories, with a major distinction between nouns and other categories. While nominal modifiers predominantly target the extrinsic entity argument of the noun, modification with other categories involves intrinsic aspects of the category’s meaning. One of the main contributions of nouns to sentential meaning is their support of *conservative quantification*, which restricts the way quantificational determiners interact with the rest of the sentence. Other important aspects of nominal meaning concern their ability to individuate entities, their specification of mass and count properties, and the division of labor between nominal meanings and adjectival meanings in different languages. On-going research in formal semantics aims to give precise shape to our understanding of the connections between categorical identity of words and their contribution to sentential meaning. At the same time, these developments are reshaping formal semantics itself, including its relationships with research in language typology, historical linguistics, philosophy of language and psycholinguistics.

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