

Constructions and Grammatical Explanation

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Abstract

I raise a number of issues here for especially the usage based variants of Construction Grammar defended by Goldberg, Tomasello and others. I point out that proponents of such varieties of Construction Grammar assume massive amounts of innate constraints on both learning mechanisms and on cognitive representations, many of which are specific to those capacities. They just take language to be unlike other cognitive capacities in that it does not involve such constraints. There is no a priori argument for this position. I also show that no empirical argument can be made on the basis of claims that semantics attaches to structures rather than words, given that both Construction Grammar and Generative Grammar allow this. Further, the evidence we have about language conflicts with the idea that it is unlike other cognitive capacities in having no innate domain-specific constraints.

Keywords Construction Grammar, innate constraints, learnability, syntax-semantics interface, theoretical explanation

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1 Introduction

No one denies that the development of a biological organism is highly constrained by properties of the organism's genetic endowment. This is obvious for gross physical properties such as number of limbs, but it holds also for cognitive properties, such as the capacity to perform dead reckoning calculations (see, e.g. Gallistel 1999 on insect navigation), the capacity of a bird species to learn its own song, even when there are many other bird songs in the environment (Marler 1991), or constraints on the capacity to cognitively represent space in rats (Cheng 1986). Reading the literature in Construction Grammar (hence CxG), it appears that proponents of that approach are, in Quine's phraseology, "knowingly and cheerfully up to [their] neck[s] in innate mechanisms of learning readiness" (Quine 1969). Indeed, going well beyond this, in her 2006 book, Goldberg identifies many different non-linguistic but innate cognitive constraints on both learning and representation, which are brought to bear in language learning, comprehension and production: abilities to make statistical generalisations, cognitively represented semantic structures and pragmatic strategies, general cognitive relations between form and meaning such as iconicity, and constraints on processing information and structure (Goldberg 2006). To this we might add human-specific special social cognitive capacities (Tomasello 2003) as well as more general capacities connected to memory and abstraction. The CxG hunch is that, although the human mind is teeming with innate cognitive capacities, none of these are specific to language: that is, every capacity that is used in acquiring language has a function elsewhere in human cognition.

This proposal comes in a weak and a strong form. The strong form denies that human cognition is specialized for language: that is, there is no specific subset of particular capacities such that the human mind is configured to bring just these to bear when acquiring language. The strong form denies the existence of a faculty of language tout court.

To clarify, imagine that the brain has a number of innate cognitive capacities used for various tasks (call these C, and assume nothing about whether they are modularly structured). If the relevant brain is placed in an environment where there is temporal presentation of linguistic data, and it attempts to adapt to that environment by acquiring a language, then, under the strong form of the CxG proposal, it should attempt to use all the innate cognitive capacities in C to do so. Perhaps some will fail (for example, perhaps olfactory cognition will simply have no purchase on the linguistic data), but others should succeed. Learners of a language should be trying to see whether, for example, face recognition is relevant to acquiring word order, or figure ground relations are relevant to acquiring phonotactics. Obvious Piercean issues arise about the hypothesis space.

If, however, some organisation of the brain only makes a subset of the capacities in C available for the processing of the linguistic data in the organism's environment (call these L), then, a fortiori,

*Thanks to Noam Chomsky and Daniel Harbour for comments on an earlier draft

there is a domain (L) of cognitive capacities which the organisation of cognition makes available for the brain's adaptation to its linguistic environment. Ergo, there is a cognitive specialization for language since there may be some capacity in C but not in L which logically could be used to analyse the linguistic environment, but which is not so used and its unusability is due to the structure of human cognition. This denies the strong claim. Examples of this might be that social cognition, perhaps, cannot be used to analyse word order effects in the primary linguistic data; or perhaps the capacity to make statistical generalisations is not usable for the construction of syntactic rules; or perhaps the core units of colour categorization are not accessible for organizing elements into grammatical categories, etc. Under this view there is a set of innate capacities which are used for language but, equally importantly, there is a set which cannot be so used, not because linguistic data does not fall within their purview, but because the structure of the brain makes their use impossible for this function. Hence there is a faculty of language (compare the FLB of Hauser, Chomsky, and Fitch 2002, which is yet more general than this).

The weak form of the CxG claim would accept that L exists but would deny a further possible, although not logically necessary claim: the existence of a subset of L (call it G) that is only used for developmental adaptation to the linguistic environment (perhaps in the way that olfactory discrimination capacities are, perhaps, only used for olfactory stimuli); G would not be usable during development to analyse other aspects of the environment. Elements in G might be adapted from L (for example, a particular kind of bias in statistical learning that is not used for non-linguistic analysis of sensory input, or a particular organization of the relationship between figure-ground representations in spatial cognition and hierarchical organization in syntactic structure) or they might be *sui generis* (for example, single-rootedness of tree structures, or structural conditions relating position and phonological exponence): both possibilities are available and have been proposed within Generative Grammar (GenG). The richness of G has, of course, been challenged by the idea, most famously adumbrated in Hauser, Chomsky, and Fitch (2002), that the only elements in G are (i) a cognitive capacity used to create recursive structures; (ii) a capacity which connects these structures to, on the one hand, systems that involve externalisation as physical linguistic acts (vocal, signs etc) and, on the other, systems that involve internal computations such as thinking, planning, etc.

The version of CxG developed in Goldberg's publications (usage-based CxG) seems to adopt both the weak and the strong claims: there is no L and no G. The hunch is that language, as a human capacity, is quite different from social cognition, vision, statistical processing, figure-ground schemata, face recognition, etc. These all have innate components that constrain their development, but language does not. Rather, language is the result of other cognitive capacities being applied to a particular task of adaptation to a social environment. The GenG hunch, in contrast, is that the human capacity for language, like other cognitive capacities, has innate components that

are brought to bear, as a reflex, in the organism's adaptation to its linguistic environment, hence that both L and G exist.¹ There seems to be no a priori reason why proponents of usage-based CxG like Goldberg and Tomasello single out the human linguistic capacity from other cognitive capacities, and one might well ask the question the other way around: if we are interested in explaining, say, visual perception, social cognition or face recognition, why should we not assume that these too are devoid of innate specifications? We know that there is some structure to human cognition, this issue is to find out what it is.

2 Form and Interpretation

2.1 Interpretation

Perhaps, though, in the absence of any a priori reason to adopt the usage-based CxG perspective, there are good empirical reasons. Goldberg, in a series of works, has proposed the existence of Argument Structure Constructions, which are pairings of abstract meanings with abstract arrays of grammatical relations. For example, Goldberg takes the ditransitive construction in (1) to be associated with a meaning of actual or potential transfer and the Caused-Motion construction in (2) to be associated with a meaning whereby an agent causes some object to move along a trajectory. The core idea is that the meaning of the sentences can be specified as a property of the structure, rather than as a property of any lexical item. Goldberg 2006, especially, brings forward much empirical evidence to bolster this conclusion (which is not, of course novel in its essence: it is obvious that structure contributes to meaning, or else *Anson bit Lilly* would mean the same as *Lilly bit Anson*; the question is *how* structure contributes to meaning).

- (1) She gave him the apple.
- (2) He sneezed the bullet out of his right nostril

Both the form and the meaning of these sentences are abstracted away from particular verbs, and much experimental evidence is given consistent with this proposal, suggesting that there are a number of specific structures associated with specific meanings: these are called constructions, and, for CxG, are the fundamental units of linguistic analysis, consisting of “learned correspondences between form and function, at varying levels of complexity and abstraction” (Goldberg

¹However, there are proponents of versions of CxG that take some abstract constructions to be innately specified, thus guiding the acquisition of more specific constructions. This seems to be the view of proponents of Simpler Syntax (Culicover and Jackendoff 2005).

2013).² GenG, in contrast, in its Minimalist incarnation at least (Chomsky 1995 et. seq), takes there to be only very general syntactic operations building structure, and these operations are not associated with specific meanings, these being sourced in elements of the lexicon rather than structures in the syntax. Perhaps, then, this kind of argument counts as empirical evidence for the CxG hunch; that is, since a CxG construction is a learned form-function pair, a superficial difference between GenG and CxG might be said to be the following:

- (3) a. CxG associates meanings with structures, while GenG associates meanings with lexical items.
- b. The evidence favours the association of meaning with structures.

More broadly, this kind of argument connects with issues of compositionality. CxG takes there to be meaning associated with structures which is not derivable from the meanings associated with the components of those structures. Empirical evidence that there are syntactically regular but non-compositional sentences is then taken by Goldberg to be an argument for the existence of constructions, since GenG is assumed to take all meaning to be driven by lexical items. One could then see this is an empirical argument for CxG and against GenG.

However, this requires a little more excavation. GenG, since the work of Abney, Stowell and others in the 1980s, has developed a theoretical understanding of the obvious fact that meanings are with grammatical lexical items such as determiners, complementizers, tense and even agreement (Abney 1987, Stowell 1982, Guéron and Hoekstra 1995, Adger 1994). Within more recent minimalist approaches to generative grammar, this is ubiquitous, as a glance at many of the recent volumes in the MIT Press Linguistic Inquiry Monograph series, or the contents of Linguistic Inquiry, Syntax, or other journals which publish such work, will show.

These elements (usually called functional categories) are taken to be syntactic atoms with semantic properties whose syntactic combination corresponds with semantic combination. Sometimes these elements are overt morphosyntactic units (e.g. *-ed* for past tense in English), sometimes they are not overt but are in paradigmatic opposition with overt units (e.g. the fact that *put* can be interpreted as past in English) and sometimes they are wholly covert (e.g. the silent subject in pro-drop languages, or in an English imperative, whose presence can be detected by reflexives etc., thus *know yourself!* but not **know himself*). Sometimes the meaning associated with the functional category is purely semantic, sometimes it involves conditions of use (e.g. Rizzi's (1997) Topic functional categories). There is, in fact, no bar, theoretically, to adding register or genre restrictions to functional categories, in the same way these can be added to non-functional

²Interestingly, a similar proposal, although different in execution, was made in the early 1990s by Hagit Borer (Borer 1994) and the idea that arguments are 'severed' from their verbs is by now fairly orthodox in many varieties of GenG.

elements such as *sofa* or *couch*, although these properties do not enter into the building of syntactic structure (see Adger 2007), only into interpretation, and hence are not grammatical properties of the expressions. Further, following Marantz (1984), Hale and Keyser (1993), Borer (1994), Kratzer (1996), and Chomsky (1995), these functional categories may also encode the semantics of argument structure, event structure, causation etc.

Functional categories are put together syntactically into Extended Projections (Grimshaw 1991) which effectively define different types of syntactic domains (we might even say constructions!) and the semantic and pragmatic content of the various heads gives content to the whole extended projection. So one very mainstream view of generative grammar takes there to be abstract structures with a particular grammatical form associated with a meaning. This is “a correspondence between [grammatical] form and [semantic and pragmatic] function”. One might even say that it is a “learned correspondence”: at least some aspects of the content and syntactic behaviour of functional categories are assumed to be derived from the input data (this is the idea, deriving from Borer 1983, that syntactic variation is restricted to properties of functional categories).

It follows then, that even if (3-b) is true, GenG can (and usually does) in fact associate meanings, including argument structure meanings and indeed potentially social meanings and information about style and register, with structure via (possibly unpronounced) functional categories: the two approaches are not to be distinguished in this way, so no empirical argument based on considerations like (3) is available. We have abstract functional categories on the one hand, or abstract constructions on the other. This conclusion renders large tracts of the argumentation in Goldberg (2006) *et seq* otiose.

2.2 Constraints on Grammatical Form

If we dig a little deeper in an attempt to distinguish the two approaches, we see that CxG itself bifurcates into two versions: when CxG is called upon to provide an account of structures of any linguistic complexity, it, quite rationally, adopts the position that there are language specific constraints (that is, G is non-empty), giving rise to Sign-Based versions of CxG (e.g. Sag 2012), or to the Simpler Syntax variety of CxG (Culicover and Jackendoff 2005). Usage-based varieties of CxG, however, simply sidestep the issue, and provide no account of the nature of linguistic structure at all.

In Goldberg’s version of CxG, constructions are emergent from the acquisition process. A construction is an abstraction from the surface form and it is associated with a meaning, giving “form function pairings”. These form-function pairings are organized into an inheritance network, with more specific constructions inheriting properties from more abstract ones. The whole network can then be used to license new form-function pairings not in the input. For example, Goldberg

(2013) gives:

(4) What did Aliza give Zach?

(4) is licensed as an expression of English because the network of constructions for English includes the following:

- (5) a. Ditransitive construction
- b. Non-subject question construction
- c. Subject-Auxiliary inversion construction
- d. VP construction
- e. NP construction
- f. *Aliza, give, Zach, what, do* lexical constructions

Goldberg says that the “same ditransitive construction is involved in the active declarative form as well as in topicalized, clefted, or questioned forms. The ‘valence’ or ‘subcat’ feature innovation in Pollard and Sag (1994) or Sag (2012) is intended to keep track of how arguments are expressed; on the constructionist approach, this feature can be associated with the phrasal construction instead of the lexical verb”.

But how? Presumably the ‘valence’ or ‘subcat’ feature has to be not specific to language. Taking a look at Sag (2012) and Sag, Boas, and Kay (2012), these theories assume a rich organization of grammatical features in constructions but neither give an indication of any non-linguistic (that is L external) reason for that organization. That there has to be some organization to the relation between form and meaning here follows from many arguments. Perhaps one of the sharpest is the old observation that syntax is ‘phonology-free’ (Zwicky 1969; Zwicky and Pullum 1986). Most trivially, within usage-based CxG it would be quite possible to link a particular phonological segment (or feature specification, say [coronal]) with a particular syntactic property (say, appearing in a fronted topic position) so that only elements beginning with coronals appear in the topic position, with all other topics being intonationally marked. No language is known to have such rules, while phonological rules that appeal to syntactic structures are rife (e.g. rules for contraction of auxiliaries in English refer to the syntactic position of those auxiliaries). This asymmetry between phonology and syntax requires that there be a constraint on the way that the form information is represented in a construction. The question then is where that constraint comes from. The argument can be made for other aspects of the organization of properties within a construction ad libitum. One could imagine that the various constraints on constructions are the result of historical, communicative or adaptive pressures, although no compelling cases are, or have been, presented.

The broad question for CxG in its usage-based form as put forward by Goldberg is: what is the allowable organization of information in a construction? The answer, as far as I can tell, has to

be “Anything”. But Generative Grammar has unearthed a vast array of phenomena over the years which are simply incompatible with that answer (see the next section).

Michaelis (2012), in response to criticisms like that just made (that is, that CxG is unconstrained), argues that the desire for a theory that embodies constraints on grammar is reflective of a methodological confusion which pervades linguistics. In her view, following Pollard (1996), a theory must be distinguished from the framework in which it is expressed, so one can seek explanations from “functional, communicative, historical and cognitive considerations” for properties of language “[b]ut no physicist would make the mistake of appealing to the expressive power of the formalism in which she writes her equations as an explanation for why the physical universe is the way it is. No cognitive scientist should make such a mistake either.” This apparently leaves no space open for explaining properties of language on the basis of its structure, a curious lacuna, given that in the very same paper Michaelis provides a hierarchy of types which, in fact, is a structural explanation for various properties of language.

The quote also betokens deep confusions both about the nature of the criticism (that CxG is unconstrained) and about the nature of a linguistic theory in general. The criticism of (usage-based) CxG is that there is *no theory* that constrains linguistic structure, so the issue of separating a theory and the framework within which it is expressed is entirely beside the point. In the same way that a physical theory provides an explanation for what possible physical structures exist in nature, a linguistic theory provides an explanation for what possible linguistic structures exist in human minds.

Just to be clear, Sign Based Construction Grammar as described by Michaelis, Sag and others, does have a theory of the possible relations between symbolic units: this is the hierarchy of types, the possible relations between types in the hierarchy, the internal organization of the types, etc. It needs to have these in order to work as a successful account of various syntactic and semantic facts. If this theory is constrained universally, so that, for example, coronality and topicality are uncorrelable, providing a structural explanation of why languages don’t have rules that topicalize constituents beginning with a coronal but not a labial, for examples, fine (although a reading of Sag 2012 doesn’t lead ineluctably to such a conclusion). Goldberg’s usage-based version of construction grammar, however, provides, as far as I can see, no way of stating such general constraints on the organization of linguistic information because there is no analogue of a type hierarchy, hence there is, in effect, no theory of language. This is intimately related to the denial of the existence of L and G. In GenG, in contrast, there are ways to constrain the model and hence make claims about the nature of the structure of language; one common proposal, for example, is that functional categories have no phonology until the syntactic rules have run their course, and since functional categories are the locus of grammatical specification, no grammatical rules can involve phonological features. Properties of the real world object are modelled by a specification of the

theory.

3 Grammar of the Gaps

Generative syntacticians tend to be impressed by absences; structures which, in virtue of analogy etc. should be present in the grammar but are not. This is, of course, the meat (if not the potatoes) of the Poverty of the Stimulus argument: why do languages have systematic gaps in the ways that form and meaning relate? Analogy generally works to fill gaps, so the learning process must go beyond analogy in some way.

The CxG response to this is that human language learners learn some quite complicated and tortuous facts about irregular, idiosyncratic and exceptional structures, and hence, whatever learning theories allow humans to do this will also do very nicely for the deeper and broader generalizations that syntacticians tend to focus on (for an extended version of this argument see Culicover 1999). Culicover suggests a particular kind of conservative learning algorithm and Goldberg 2006 follows suit, proposing that the learner initially learns combinations of items, generalising from these via an unspecified learning strategy that is stated to achieve just the right results (that is, CxG assumes that the learner learns set expressions, abstracting from these to more general constructional patterns in a conservative way). However, It is worth noting that in a book-length computational exploration of such a conservative learner (Culicover and Nowak 2003), a very rich language-specific component has to be assumed to learn even simple patterns. In fact, when any specificity is given to such proposals, L and G are given content. L and G are needed specifically to constrain the kinds of structures (and associated meanings) that are part of what every language user knows, and general pattern-finding techniques (such as those sketched by Tomasello (2003)) are insufficient to explain even basic facts about language.

Further, as Yang (2010) has pointed out recently, evidence for productivity in even the most general of syntactic rules is sorely lacking in the input to the learner, as a general outcome of the fact that pattern frequencies are governed by Zipf's law, so that the second most frequent pattern is half as frequent as the most frequent one, with the third being a third as frequent, and so on. A conservative, usage-based, CxG learner of the sort envisaged by Goldberg and other will never generalize from item combinations to productive rules, simply because there is not enough data in the input to give evidence for generalization. But real learners do generalize to productive syntactic rules, as Yang shows.

This means that CxG proponents have to provide a theory of how learning takes place so as to give rise to a constructional hierarchy, but even book length studies on this, such as Tomasello (2003), provide no theory beyond pattern-matching combined with vague pragmatic principles of intention-reading and analogy. Tomasello's book, in particular, claims to provide a 'usage-based

theory of language acquisition' but no theory is ever given, just evidence for truisms such as that children can detect patterns and that they want to communicate.

Further, even if, contra Yang, generalization from sparse data were possible, the types of general rules adopted in usage based CxG are well known within linguistics to be inadequate for human language, as a cursory literature search would reveal; Bannard, Lieven, and Tomasello (2006) developing the usage-based CxG proposal state that 'the grammars we propose are formally equivalent to context-free grammars (CFGs), which Chomsky (1956) recognized as the minimal power necessary to account for most human languages including English', a quite astounding quote since the abstract of Chomsky 1956 states, about CFPSG, that 'it is successful only when limited to a small subset of simple sentences'. Even putting this aside, this type of grammar was proved, as far back as the 1980s, to be inadequate as a mathematical model for human languages, which contain structures which simply cannot be modelled by CFPSGs (see Shieber 1985).

Compare the inability of CxG to even provide a theory of how to learn simple syntactic rules to the actual challenges that learning theories must face. As an example, why is it that a wh-element can question the positions Z and X in English but not position Y:

- (6) a. Z teased X before she devoured Y.
- b. [Which cat]_Z teased [the mouse]_X before she devoured [her food]_Y?
- c. What did [the cat]_Z tease X before she devoured [her food]_Y?
- d. *What did [the cat]_Z tease [the mouse]_X before she devoured Y?

Further, why is it that a wh-element can question position Y just in case it also questions position X:

- (7) What did [the cat]_Z tease X before she devoured Y?

Further, why is it that the same pattern does not hold for position Z: that is, why is it that a wh-element cannot question positions Z and Y in the same way that it can question X and Y?³

- (8) *[Which cat]_Z teased [the mouse]_X before she devoured Y

These constructions are known as parasitic gap constructions (Engdahl 1983). Populations of English speakers reliably show the same patterns of judgments on these constructions (Phillips

³For syntactic afficianados, we can make the examples completely parallel by overtly extracting the subject Z, rather than just replacing it with a wh-expression thus:

- (i) a. [Which cat] did you say Z teased [the mouse]_X before she devoured [her food]_Y?
- b. *[Which cat] did you say Z teased [the mouse]_X before she devoured Y?

The patterns remain the same.

2006) even though they are close to non-existent in spoken discourse. Pearl and Sprouse (2012) report zero parasitic gaps across 9 child-directed speech corpora containing 675,000 words.

The patterns of judgments just sketched are facts that relate the syntax-semantics interaction and facts call for an explanation.

The typical GenG response to such patterns is to provide a theory of how syntactic forms connect with semantic interpretations (for the case in point, parasitic gaps, see Culicover and Postal 2001 for an overview). It is important to say that there are many distinct ways to build a generative grammar that will respond to this kind of pattern, hence the range of different generative theories (GPSG, early HPSG, varieties of Categorical Grammar, LFG, and, indeed, non-usage based varieties of CxG, such as Sign-Based Construction Grammar). All of these take the task to be one of constructing theoretical explanations of such facts and the theoretical explanations, when the facts reach even low levels of descriptive complexity, include domain-specific abstract principles.

The CxG response is to say that no such theory is needed beyond a language specific statement of the regularities that obtain between form and meaning. No theory relating form and meaning is required beyond a taxonomy of form-meaning pairs which is organized so as to capture the pattern. How that taxonomy is learned is never made explicit.⁴ From such a perspective, these patterns do not reveal underlying principles of the form-meaning system, and a human language where each grammaticality judgment was reversed would be perfectly learnable. The fact that, in language after language, the same descriptive regularities arise has nothing to do with the linguistic capacity of human beings (because there is none) but is a result of accidents of history, language independent processing strategies, or the exigencies of communicative function. I have yet to see any half-way successful analysis of this kind of pattern which does not assume the existence of G (see, for example, the Sign Based CxG approach to wh-dependencies in Sag (2012)). A usage based variant of CxG of the sort Goldberg proposes is of no help in understanding these fundamental and general properties of human linguistic cognition.

4 Conclusion

I have briefly raised a number of issues here for especially the usage based variants of CxG defended by Goldberg, Tomasello and others (see Lidz and Williams 2009 for further criticisms). I first pointed out that proponents of such varieties of CxG assume massive amounts of innate con-

⁴A more sophisticated view might be that questions like (7) are licensed by the presence in the grammar of another construction, which allows multiple questions in coordinate constructions (Williams 1990, Culicover 1999).

- (i) What did Lilly both tease and devour?

However, such an explanation does not extend to cases like that in (8).

straints on both learning mechanisms and on cognitive representations, many of which are specific to those capacities. They just take language to be unlike other cognitive capacities in that it does not involve such constraints. There is no a priori argument for this position.

Second, I pointed out that no empirical argument can be made on the basis of claims that semantics attaches to structures rather than words, given that both CxG and GenG allow this. Further, the way that CxG executes the idea that function attaches to structure (via an inheritance network) does not allow us to jettison language specific properties (e.g. valence features used to track long distance dependencies), and moreover, also requires universal structure if we are to provide theoretical explanations of the ways that linguistic information is organized universally.

Third, the actual evidence we have about language conflicts with the idea that it is unlike other cognitive capacities in having no innate domain-specific constraints. Yang's results on Zipfian distribution of word and construction frequencies raise an old but huge problem of learnability: when does a learner generalize, and when does a learner not? CxG has provided us with no answer to this question. Further, given the sparseness of the data, how do learners of, say, English, come to have the same constraints on structures, such as parasitic gaps, which they barely ever encounter.

These learnability issues are serious challenges for usage based variants of CxG, and they are challenges that have either been met, or are being tackled in variants of GenG of all different types. It is unclear to me that proponents of usage based versions of CxG even recognise these challenges.

Because this paper appears in a journal whose readership includes philosophers and psychologists, I have not spent time on a critique of the CxG proposal that adopts the GenG idea that both L and G exists, modelling aspects of these in a default inheritance hierarchy. I think that there are problems here too (not least the explanatory problem: when one has a taxonomy, one wants to find the deeper principles that answer the question: why this taxonomy, rather than another). These theories, however, at least allow evaluation on the basis of depth and reach of analysis, cross-linguistic predictive capacity, etc.

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